DOE/WIPP-10-2225

Waste Isolation Pilot Plant Annual Site Environmental Report for 2009 Errata

U.S. Department of Energy

September 2010

2009 Annual Site Environmental Report

To our readers:

This Waste Isolation Pilot Plant (WIPP) Annual Site Environmental Report for 2009 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 the DOE Environmental Sustainability Goals.

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

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CHANGE HISTORY SUMMARY

REVISION NUMBER	DATE ISSUED	DESCRIPTION OF CHANGES
0	Xx/xx/xx	This is a new report.

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ACRONYMS, ABBREVIATIONS, AND UNITS OF MEASURE

ALARA	as low as reasonably achievable
Am	americium
ANOVA	analysis of variance
ANSI	American National Standards Institute
AOC	Area of Concern
ASER	annual site environmental report
ASME	American Society of Mechanical Engineers
ASQ	American Society for Quality
BCG	biota concentration guide
BLM	U.S. Department of the Interior, Bureau of Land Management
Bq	becquerel(s)
Bq/l	becquerels per liter
Bq/m^3	becquerels per cubit meter
CAO	Carlsbad Area Office (now Carlsbad Field Office)
CAP88	computer code for calculating both dose and risk from radionuclide emissions
CBFO	Carlsbad Field Office
CCl_4	carbon tetrachloride
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CEMRC	Carlsbad Environmental Monitoring and Research Center
CFR	*Code of Federal Regulations*
CH	contact-handled
Ci	curie
cm	centimeter
Co	cobalt
CRA	compliance recertification application
Cs	cesium
CY	calendar year
d	day
DMP	detection monitoring program
DOE	U.S. Department of Energy
DOELAP	DOE Laboratory Accreditation Program
DP	discharge permit
EDE	effective dose equivalent
EH	DOE Environment, Safety, and Health
EIS	Environmental Impact Statement
EMS	Environmental Management System
EO	Executive Order
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act

ft	foot/feet
ft^3	cubic feet
FY	fiscal year
GAC	granular activated carbon
GSA	General Services Administration
GWQB	Ground Water Quality Bureau
HEAL	Hall Environmental Analysis Laboratory
HEPA	high-efficiency particulate air (filter)
HPSB	high-performance sustainable building
HWFP	Hazardous Waste Facility Permit
IAEA	International Atomic Energy Agency
ID	identification
in.	inch(es)
ISMS	Integrated safety management system
ISO	International Organization for Standardization
K	potassium
kg	kilogram(s)
km	kilometer(s)
km^2	square kilometers
l	liter(s)
LANL	Los Alamos National Laboratory
LCS	laboratory control sample
LCSD	laboratory control sample duplicate
LEPC	Local Emergency Planning Committee
LMP	Land Management Plan
LWA	Land Withdrawal Act
LWB	land withdrawal boundary
m	meter(s)
m^2	square meters
m^3	cubic meters
m/d	meters per day
m/s	meters per second
MAPEP	Mixed Analyte Performance Evaluation Program
MCD	maximum concentration detected
MDC	minimum detectable concentration
MEI	maximally exposed individual
mg	milligram(s)
mg/l	milligrams per liter
mGy	milligray(s)
mGy/d	milligrays per day
mi	mile(s)
mi^2	square miles
mL	milliliter(s)

MOC	management and operating contractor
MOU	memorandum of understanding
mph	miles per hour
mrem	millirem/millirem
MRL	method reporting limit
mSv	millisievert(s)
N/A	not applicable
NCRP	National Council on Radiation Protection and Measurements
NELAC	National Environmental LAboratory Accreditation Associates Conference
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NIST	National Institute of Standards and Technology
NMAC	New Mexico Administrative Code
NMED	New Mexico Environment Department
NMIMT	New Mexico Institute of Mining and Technology
NMSA	New Mexico Statutes Annotated
NPDES	National Pollutant Discharge Elimination System
NQA	Nuclear Quality Assurance
NRC	U.S. Nuclear Regulatory Commission
NRIP	National Institute of Standards and Technology Radiochemistry Intercomparison Program
ODS	ozone-depleting substance(s)
oz	ounce(s)
P2	pollution prevention
PABC	Performance Assessment Baseline Calculation
PCB	polychlorinated biphenyl
PE	performance evaluation
pH	measure of the acidity or basicity of a solution
PIP	production-injection packer
ppmv	parts per million by volume
ppbv	parts per billion by volume
Pu	plutonium
Pub. L.	Public Law
QA	quality assurance
QC	quality control
rad	radiation absorbed dose
RBL	room-based limits
RCRA	Resource Conservation and Recovery Act
rem	Roentgen equivalent man
RER	relative error ratio
RH	remote-handled
RPD	relative percent difference

SEIS	Supplemental Environmental Impact Statement
SERC	State Emergency Response Commission
SNL	Sandia National Laboratories
SOP	standard operating procedure
SOW	statement of work
SPDV	site and preliminary design validation
Sr	strontium
SR/DL	Santa Rosa/Dewey Lake
SSEB	Salt Storage Extension Basin
SSW	shallow subsurface water
SWMU	solid waste management unit
SVOC	semivolatile organic compound
TDS	total dissolved solids
TOC	total organic carbon
TOX	total organic halogen
TPU	total propagated uncertainty
TRU	transuranic (waste)
TSCA	Toxic Substances Control Act
TSDF	treatment, storage, and disposal facility
TSS	total suspended solids
U	uranium
U.S.	United States
U.S.C.	*United States Code*
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
USFWS	U.S. Fish and Wildlife Service
UST	underground storage tank
UTLV	Upper Tolerance Limit Value
VOC	volatile organic compound
WIPP	Waste Isolation Pilot Plant
WQSP	WIPP Groundwater Quality Sampling Program
WTS	Washington TRU Solutions LLC

Symbols

C	degrees Celsius
F	degrees Fahrenheit
<	less than
≤	less than or equal to
µCi	microCurie
µg	microgram
µmhos	micromhos
%	percent
±	plus or minus
[RN]	radionuclide concentration
σ	sigma

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EXECUTIVE SUMMARY

Purpose

The purpose of the Waste Isolation Pilot Plant Annual Site Environmental Report for 2009 (ASER) is to provide information required by U.S. Department of Energy (DOE) Order 231.1A, *Environment, Safety, and Health Reporting*. Specifically, the ASER presents summary environmental data to:

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

The DOE Carlsbad Field Office (CBFO) and the management and operating contractor (MOC), Washington TRU Solutions LLC (WTS), maintain and preserve the environmental resources at the Waste Isolation Pilot Plant (WIPP). DOE Order 231.1A; DOE Order 450.1A, *Environmental Protection Program*; and DOE Order 5400.5, *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 231.1A, which requires that DOE facilities submit an ASER to the DOE Headquarters Chief Health, Safety, and Security Officer. The WIPP Hazardous Waste Facility Permit (HWFP) Number NM4890139088-TSDF (treatment, storage, and disposal facility) further requires that the ASER be provided to the New Mexico Environment Department (NMED).

Major Site Programs

Mission

The WIPP mission is to safely dispose of transuranic (TRU) radioactive waste generated by the production of nuclear weapons and other activities related to the national defense of the United States. In 2009, 6,631 cubic meters (m^3) of TRU waste were disposed of at the WIPP facility, including 6,564 m^3 of contact-handled (CH) TRU waste and 67 m^3 of remote-handled (RH) TRU waste. From the first receipt of waste in March 1999 through the end of 2009, 64,503 m^3 of TRU waste had been disposed of at the WIPP facility.

Monitoring and Surveillance

It is the policy of the DOE to conduct its operations at the WIPP facility in compliance with applicable environmental laws and regulations; to protect human health and the environment; and to implement sustainable practices for enhancing environmental, energy, and transportation management. This is accomplished through an effective EMS. A key element of the EMS is measuring and monitoring environmental performance. At the WIPP facility, this consists of radiological and nonradiological environmental monitoring, surveillance, and assessment to ensure compliance with applicable environmental regulations. As part of the EMS, 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) (WIPP Environmental Monitoring Plan) outlines major environmental monitoring and surveillance activities at the WIPP facility and 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 dose rates, 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.

The *Waste Isolation Pilot Plant Land Management Plan* (DOE/WIPP-93-004) (LMP) was created in compliance with the WIPP Land Withdrawal Act of 1992 (LWA) (Public Law [Pub. L.] 102-579, as amended by Pub. L. 104-201, National Defense Authorization Act for Fiscal Year 1997). This plan 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. WIPP personnel also conduct surveillance in the region surrounding the site to protect the WIPP facility from trespass.

In this report, the WIPP facility environmental monitoring and surveillance programs are grouped as follows:

Environmental Radiological Programs

- Airborne particulates
- Biota
- Effluent
- Groundwater
- Sediments
- Soil
- Surface water

Environmental Nonradiological Programs

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

Groundwater Protection Programs

- Groundwater levels
- Groundwater quality
- Pressure density surveys
- Shallow subsurface water levels
- Shallow subsurface water quality

Sustainable Practices

- Energy use
- Use of environmentally preferred products
- Water use
- Waste generation/recycling

In 2009, the results of each of these monitoring and surveillance programs, observations, and analytical data, demonstrated that (1) compliance with applicable environmental requirements was achieved; (2) the operations at the WIPP facility have not had a negative impact on human health or the environment; and (3) sustainable practices are being implemented.

Environmental Compliance

The WIPP facility is required to comply with applicable federal and state laws and DOE orders. In order to accomplish and document compliance with certain requirements, the following submittals, which are required on a routine basis, were among those prepared in 2009:

New Mexico Submittals

A. Hazardous Waste Facility Permit

- 2008 Annual Site Environmental Report
- Semiannual VOC, Hydrogen, and Methane Data Summary Report
- Mine Ventilation Rate Monitoring Report

- Waste Minimization Statement
- WIPP Groundwater Detection Monitoring Semiannual Groundwater Monitoring Reports
- Geotechnical Data Report
- Monthly Water Level Reports

B. Discharge Permit (DP-831)

- Semiannual Discharge Monitoring Reports

C. Superfund Amendments and Reauthorization Act of 1986

- Emergency and Hazardous Chemical Inventory Report
- Toxic Chemical Release Inventory Report
- 2009 Annual Polychlorinated Biphenyls Report

Environmental Protection Agency Submittals

- Delaware Basin Monitoring Annual Report
- WIPP Subsidence Monument Leveling Survey
- 2008/2009 Annual Change Report
- Toxic Chemical Release Inventory Report

Other correspondence, regulatory submittals, monitoring reports, and the results of the U.S. Environmental Protection Agency (EPA) Annual Inspection, as well as other inspections, are described in Chapters 2 and 3 of this report.

In addition, the DOE maintains an in-depth, integrated evaluation program that consists of audits, assessments, surveillances and inspections. In fiscal year (FY) 2009, 160 evaluations were conducted that incorporated compliance checks. This system, coupled with the WIPP corrective action system, assures that potential compliance issues are identified, and corrective/preventive actions are tracked formally through completion.

During 2009, one compliance issue was identified. This issue was failure to post a link to transmittal letters that requested the NMED perform an evaluation of Acceptable Knowledge Sufficiency Determination Preliminary Evaluations and inform those on the email notification list that letters had been posted. The HWFP requires the notifications to occur within five calendar days of submitting them to the NMED. The NMED issued a Compliance Order for this occurrence on July 24, 2009. The Stipulated Final Order was finalized on November 23, 2009. Corrective and preventative actions have been completed.

Environmental Management System

The WIPP EMS provides the mechanism for achieving the WIPP policy to maintain compliance with applicable requirements, be a good environmental steward and continually improve environmental performance. The EMS is described in the *Waste Isolation Pilot Plant Environmental Management System Description* (DOE/WIPP-05-3318). The EMS was certified as conforming to the International Organization for Standardization (ISO) 14001, Environmental Management Systems - Specifications with Guidance for Use (ISO, 2004). Declaration of Conformance to the requirements of DOE Order 450.1A was based on achieving ISO 14000 certification and was provided to DOE Headquarters in June 2009. The EMS continues to be integrated with the safety management system as described in the Integrated Safety Management System Description (WP 15-GM.03).

Environmental performance is monitored through the environmental data generated from implementation of WIPP major environmental programs, EMS system indicators, and progress toward accomplishing DOE Environmental Sustainability Goals. Monitoring results and analysis, and management review, demonstrate that the EMS continues to be suitable and effective for achieving the WIPP environmental policy.

Highlights of the EMS for 2009 are as follows:

- The EMS earned ISO 14001:2004(E) certification.
- WIPP had no reportable, unauthorized contaminant releases to the environment in 2009.
- The 2009 environmental monitoring data continued to demonstrate that there has been no adverse impact to human health or the environment from WIPP facility operations.
- The WIPP HWFP Renewal Application was successfully submitted after two plus years of development, which included multiples interaction with stakeholders.
- The WIPP Compliance Certification Application was successfully prepared and submitted after a multiple-year development project.
- The DOE recognized WIPP's integration of sustainable practices in pond construction with a Best in Class Environmental Award in the Alternative Fuels and Fuel Conservation category.

- Prudent conservation practices continue to result in energy use increases at rates significantly less than increases in waste emplacement and mining rates.

- WIPP earned a "green" score for nine of the eleven DOE Sustainability Goals.

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 has been calculated from WIPP facility effluent monitoring results and demonstrates compliance with federal regulations.

Dose Limits

The regulatory limit for the WIPP facility is established in Title 10 *Code of Federal Regulations* (CFR) Part 191, Subpart A, "Environmental Standards for Management and Storage." The referenced standard requires 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) ("rem" is roentgen equivalent man) to the whole body and 75 mrem to any critical organ. In addition, in a 1995 memorandum of understanding (MOU) between the EPA and the DOE, the DOE agreed that 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 NESHAP (National Emissions Standards for Hazardous Air Pollutants). 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

There are several sources of naturally occurring 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 radioactive material in our bodies). In addition to natural radioactivity, small amounts of radioactivity from aboveground nuclear weapons tests and from the 1986 Chernobyl nuclear accident are present in the environment. A potential source of radiation in the environment near and at the WIPP site is the result of Project Gnome. Under Project Gnome, a nuclear device was detonated in bedded salt on December 10, 1961, approximately 9 kilometers (km) (5.4 miles [mi]) from the WIPP site. The Project Gnome shot vented into the atmosphere; therefore, environmental samples taken at the WIPP site may contain residual contamination from this occurrence. Together, natural radiation and residual fallout are called "background" radiation. Exposure to radioactivity from weapons testing fallout is quite small compared to natural radioactivity. Site-specific background gamma measurements on the surface, conducted by Sandia National Laboratories (SNL), showed an average dose rate of 7.65 microR/hour (Minnema and Brewer, 1983), which would equate to the background gamma radiation dose of 0.67 millisieverts (mSv)

(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 Program 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 used the emission monitoring and test procedure for DOE facilities (40 CFR §61.93, "Emission Monitoring and Test Procedure"), which requires the use of the EPA-approved CAP88-PC (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.

Total Dose From WIPP Facility Operations

The dose to an individual from the ingestion of WIPP facility-managed radionuclides transported in water is nonexistent because drinking water for communities near the WIPP site comes from groundwater sources that are too far away to be affected by WIPP facility operations.

Game animals sampled during 2009 were deer, quail, fish, javelina, and rabbit. The radionuclides detected were not different from baseline levels. By extrapolation, no dose from WIPP facility-related radionuclides has been received by any individual from this pathway (e.g., the ingestion of meat from game animals) during 2009.

Based on the results of the WIPP effluent monitoring program, concentrations of radionuclides in air emissions did not exceed regulatory dose limits set by 40 CFR Part 191, Subpart A, "Environmental Standards for Management and Storage"; or by 40 CFR Part 61, Subpart H, "National Emission Standards for Hazardous Air Pollutants." The results indicate that the hypothetical maximally exposed individual (MEI) who resides year-round at the fence line, 350 meters (m) from the exhaust shaft, receives a dose that is less than 1.71E-05 mSv (1.71E-03 mrem) per year for the whole body and less than 2.10E-05 mSv (2.10E-03 mrem) per year to the critical organ. These values are in compliance with the Subpart A requirements specified in 40 CFR §191.03(b). For NESHAP (40 CFR §61.92) standards, the EDE potentially received by the MEI residing 7.5 km (4.66 mi) west-northwest of WIPP was calculated to be less than 7.80E-07 mSv (7.80E-05 mrem) per year for the whole body. This value is in compliance with the 40 CFR §61.92 requirements.

Chapter 4 of this report presents figures and tables that provide the EDE values from calendar years (CYs) 1999 through 2009. These EDE values are below the EPA limit specified in 40 CFR Part 191, Subpart A, and 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 (NCRP) and the International Atomic Energy Agency. These absorbed dose limits are:

- Aquatic Animals — 10 milligray/day (mGy/d) (1 radiation absorbed dose per day [rad/d])
- Terrestrial Plants — 10 mGy/d (1 rad/d)
- Terrestrial Animals — 1 mGy/d (0.1 rad/d)

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 2009. The screening results indicate that radiation in the environment surrounding the WIPP site does not have a deleterious effect on populations of plants and animals.

Release of Property Containing Residual Radioactive Material

There was no release of radiologically contaminated materials or property in 2009.

CHAPTER 1 – INTRODUCTION

The purpose of this report is to provide information needed by the DOE to assess WIPP facility environmental performance and to make WIPP Project environmental information available to members of the public. This report has been prepared in accordance with DOE Order 231.1A, *Environment, Safety, and Health Reporting*. This report documents the WIPP facility environmental monitoring and results for CY 2009.

The WIPP facility is authorized by the DOE National Security and Military Applications of Nuclear Energy Authorization Act of 1980 (Public Law [Pub. L.] 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 TRU radioactive and mixed waste generated through defense activities and programs. TRU waste is defined in the WIPP LWA (Pub. L. 102-579) as radioactive waste containing more than 100 nanocuries (3,700 becquerels [Bq]) of alpha-emitting TRU isotopes per gram of waste, with half-lives greater than 20 years except for high-level waste; waste that has been determined not to require the degree of isolation required by the disposal regulations; and waste the U.S. Nuclear Regulatory Commission (NRC) has approved for disposal. Most TRU waste is contaminated industrial trash, such as rags and tools, sludges from solidified liquids, glass, metal, and other materials. The waste must also meet the criteria in *Transuranic Waste Acceptance Criteria for the Waste Isolation Pilot Plant* (DOE/WIPP-02-3122).

TRU waste is disposed of 655 m (2,150 ft) below the surface in excavated disposal rooms in the Salado Formation, which is a thick sequence of Permian Age 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, 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 Formation. A detailed description of the WIPP geology and hydrology may be found in Chapter 2 of *Title 40 CFR Part 191 Subparts B and C Compliance Recertification Application 2004* (DOE/WIPP-04-3231).

1.1 WIPP Mission

The WIPP mission is to provide for the safe, environmentally sound disposal of defense TRU radioactive 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 initiated an evaluation of stable geological formations to contain radioactive wastes for thousands of years. In 1955, after extensive study, 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 stable geological areas with very little earthquake activity, assuring the stability of a waste repository. Salt deposits also demonstrate the absence of water that could move waste to the surface. Water, if it had been or were present, would have dissolved the salt beds. In addition, salt is relatively easy to mine. Finally, rock salt heals its own fractures because it is relatively plastic. This means salt formations will slowly and progressively move in to fill mined areas and will safely seal radioactive waste from the biosphere.

Government scientists searched for an appropriate site for the disposal of radioactive waste throughout the 1960s, and finally tested the area of southeastern New Mexico in the early 1970s. Salt 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, the same substance as table salt. However, the salt is not granular, but in the form of solid rock. The main salt formation 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 (CAO), subsequently redesignated as the CBFO, to lead the TRU waste disposal effort. The CBFO coordinates the TRU program at waste-generating sites and national laboratories.

In 1999, the WIPP facility received its first waste shipment. On March 25, the first waste bound for the WIPP facility departed Los Alamos National Laboratory (LANL) in New Mexico; it arrived at the WIPP facility the following morning, and the first wastes were placed underground later that day. On April 27, the first out-of-state shipment arrived at the WIPP site from the Idaho National Engineering and Environmental Laboratory. Later in the year, on October 27, the Secretary of the NMED issued the WIPP HWFP (NM4890139088-TSDF), which allowed CH TRU mixed waste to be managed, stored, and disposed at the WIPP facility. Mixed waste is waste that contains both hazardous and radioactive waste. CH TRU mixed waste is TRU mixed waste with a maximum surface dose rate of 200 mrem per hour. The surface dose rate is the measurable amount of radioactivity from neutrons and gamma rays at the external surface of the container.

On October 16, 2006, the Secretary of the NMED approved a revision to the HWFP allowing the WIPP facility to receive RH TRU mixed waste. RH TRU waste allowable at the WIPP facility has a surface dose rate greater than or equal to 200 mrem per hour and up to 1,000 rem per hour.

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 km^2, or 16 mi^2. This part of New Mexico is relatively flat and is sparsely inhabited, with little surface water. The site is 42 km (26 mi) east of Carlsbad, New Mexico, in a region known as Los Medaños (the Dunes).

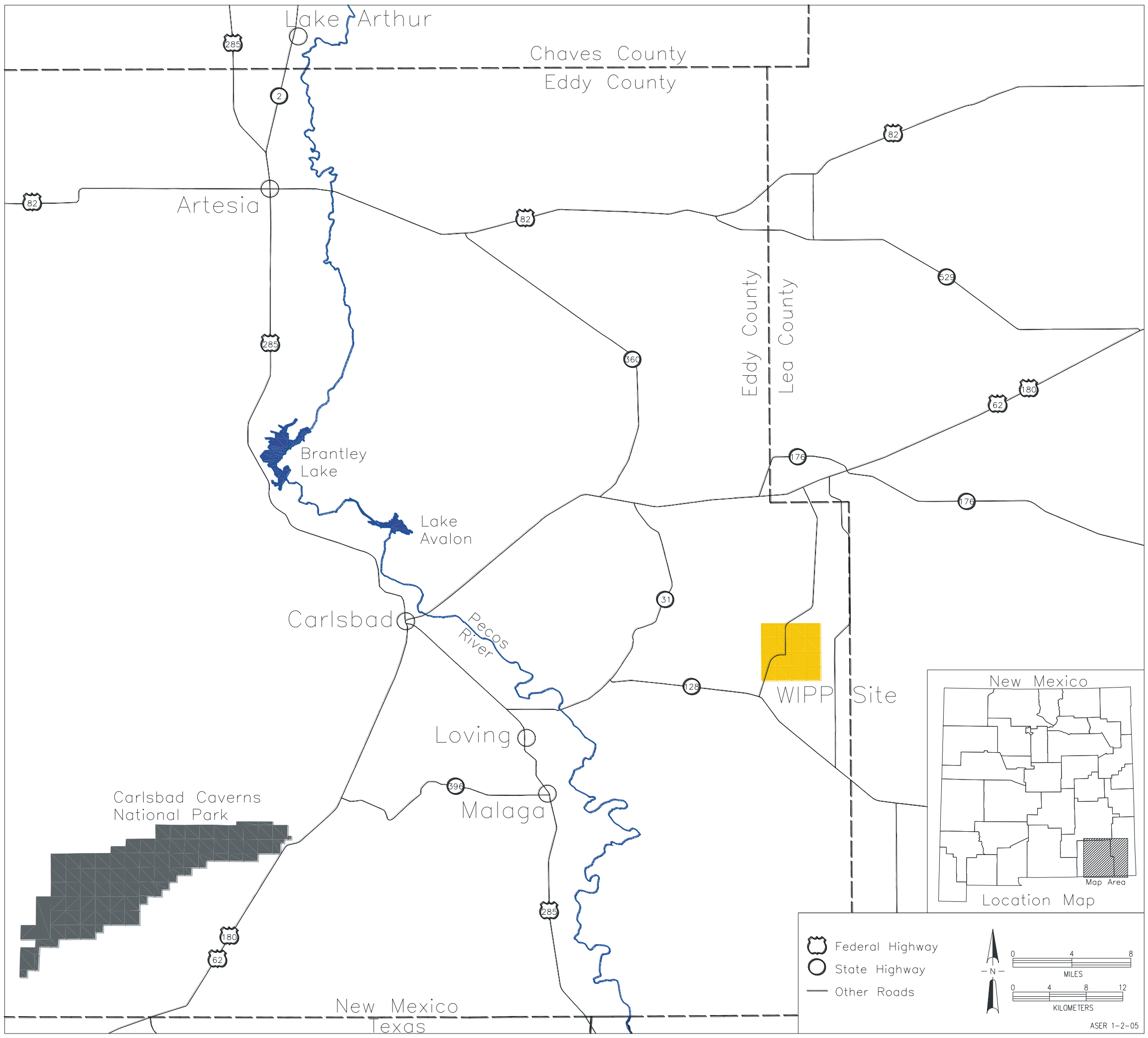

Figure 1.1 – WIPP Location

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 1.2 km^2 (0.463 mi^2) Exclusive Use Area, the surface land uses remain largely unchanged from pre-1992 uses, and are managed in accordance with accepted practices for multiple land use. However, mining and drilling for purposes other than those which support the WIPP Project are prohibited within the WIPP site, with the exception of two mineral leases.

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 is comprised of 1.1 km^2 (.43 mi^2) (277 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 (e.g., "no trespassing") signs and is patrolled by WIPP facility security personnel to prevent unauthorized activities or uses.

Off-Limits Area

The Off-Limits Area is an area where unauthorized entry and introduction of weapons and/or dangerous materials are prohibited. The Off-Limits Area includes 5.9 km^2 (2.3 mi^2) (1,454 acres). Pertinent prohibitions are posted along the perimeter. 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.

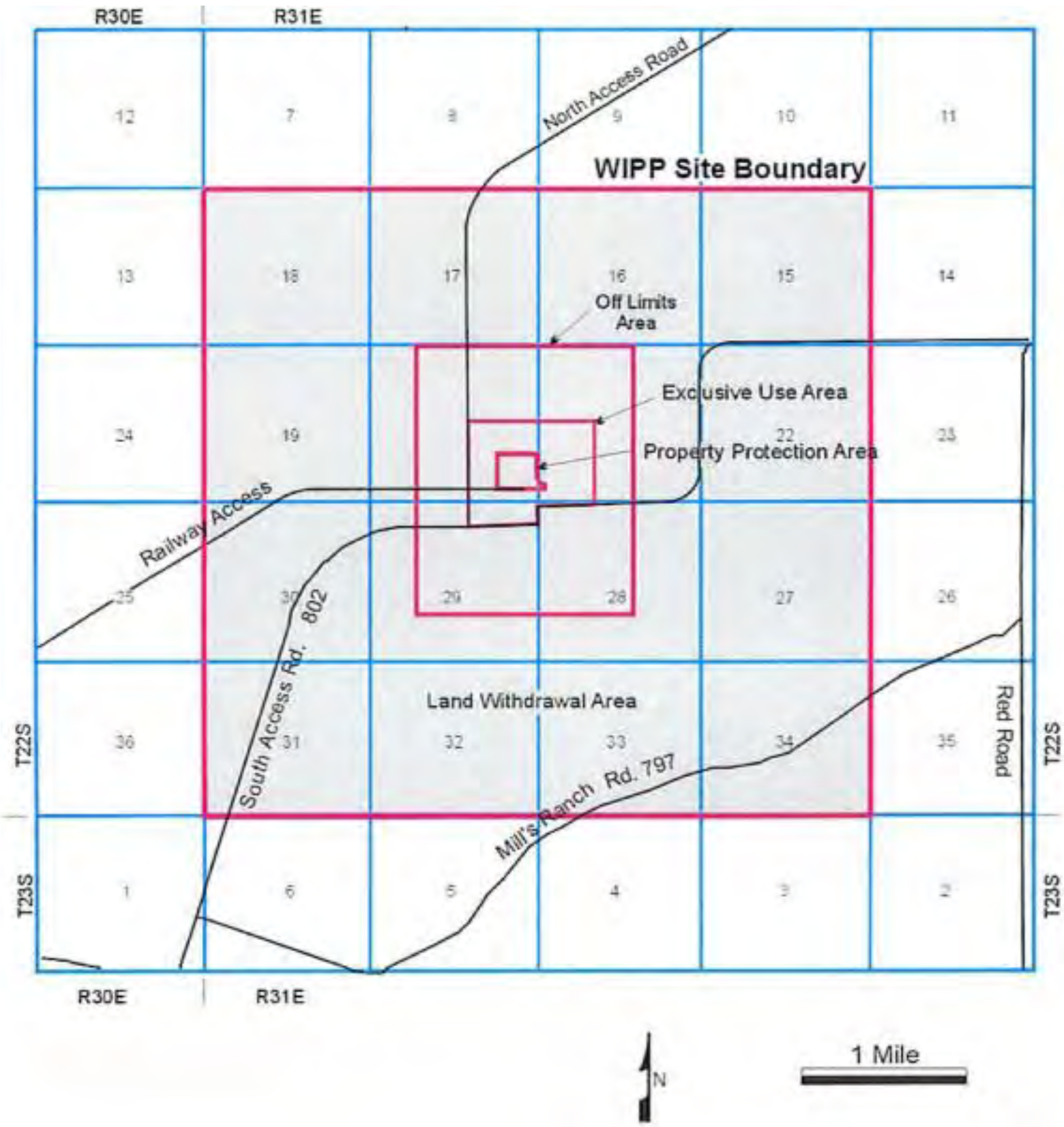

Figure 1.2 – WIPP Property Areas

Special Management Areas

Certain properties used in the execution of the WIPP Project (e.g., reclamation sites, well pads, roads) are, or may be, identified as Special Management Areas in accordance with the WIPP LMP (DOE/WIPP-93-004), which is described further in Section 5.2. A Special Management Area designation is made due to values, resources, and/or circumstances that meet 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 may receive an unanticipated elevated security status would be suitable for designation as a Special Management Area. In 2009, there were no areas designated as Special Management Areas.

1.3.2 Population

There are 25 permanent residents living within 16 km (10 mi) of the WIPP site (DOE/WIPP-93-004). The population within 16 km (10 mi) of WIPP is associated with ranching, oil and gas exploration/production, and potash mining.

The majority of the local population within 80.5 km (50 mi) of WIPP is concentrated in and around the communities of Carlsbad, Hobbs, Eunice, Loving, Jal, Lovington, and Artesia, New Mexico. According to 2000 census data, the estimated population within this radius is 100,944. The nearest community is the village of Loving (estimated population 1,326), 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 2000 census reported the population of Carlsbad as 25,675.

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 also discusses the WIPP Project QA/QC program as it relates to environmental monitoring. The purpose of the plan is to specify how the effects of WIPP facility operations on the local ecosystem are to be determined. Effluent and environmental monitoring data are necessary to demonstrate compliance with applicable environmental protection regulations. The frequency of 2009 sampling is provided in Table 1.1.

Table 1.1– Environmental Monitoring Sampling

Table 1.1 – Environmental Monitoring Sampling[1]

Program	Type of Sample	Number of Sampling Locations	Sampling Frequency
Radiological	Airborne effluent	3	Periodic/confirmatory
	Airborne particulate	7	Weekly
	Sewage treatment system (DP-831)[2]	3	Semiannual
	H-19 (DP-831)[2]	1	Semiannual
	Liquid effluent	1 (WHB sump)	If needed
	Biotic		
	• Quail • Rabbits • Beef/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; 13 if sediment is present at sewage lagoon outfall	Annual
	Groundwater	7	Semiannual
Nonradiological	Meteorology	1	Continuous
	Volatile organic compounds (VOCs)		
	• VOCs – Repository • VOCs – Disposal Room	2 # of active panel disposal rooms	Semiweekly Biweekly
	Hydrogen and methane	18 per closed panel	Monthly
	Groundwater	7	Semiannual
	Shallow subsurface water (SSW)	11	Semiannual
	Surface water (DP-831)	5	After a major storm event or annually, whichever is more frequent

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

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1 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 also 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.

2 Includes a nonradiological 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, select 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 also 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 exposure 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 Carlsbad and nearby ranches.

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

1.5 Environmental Performance

DOE Order 450.1A, *Environmental Protection Program*, 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 450.1A are implemented by the WIPP Project environmental policy and EMS.

In 2009, WIPP maintained compliance with applicable environmental laws, regulations, and permit conditions, except as noted. Furthermore, analyses of the WIPP environmental monitoring data have demonstrated that WIPP operations have not had an adverse impact on the environment. Implementation of the WIPP Environmental Monitoring Plan fulfills the environmental monitoring requirements of DOE Order 450.1A. Detailed information on WIPP programs are contained in the remaining chapters.

1.6 Organization of this Annual Site Environmental Report

This ASER is organized as follows:

- Chapter 2 - Compliance Summary
- Chapter 3 - Environmental Management System
- Chapter 4 - WIPP Facility Environmental Radiological Protection Program and Information
- Chapter 5 - Environmental Nonradiological Program Information
- Chapter 6 - Site Hydrology, Groundwater, Monitoring, and Public Drinking Water Protection
- Chapter 7 - Quality Assurance

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CHAPTER 2 – COMPLIANCE SUMMARY

The WIPP facility is required to comply with the applicable regulations promulgated pursuant to federal and state statutes, DOE orders, and Executive Orders (EOs). 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 personnel accountability. The following sections list the environmental statutes/regulations applicable to WIPP, and describe significant accomplishments and ongoing compliance activities. A detailed breakdown of the WIPP facility's compliance with environmental laws is available in the *Waste Isolation Pilot Plant Biennial Environmental Compliance Report* (DOE/WIPP-08-2171).

A summary of the WIPP facility's compliance with major environmental regulations is presented below. 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 (CERCLA) (42 U.S.C. §§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 CERCLA 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."

<u>Superfund Amendments and Reauthorization Act of 1986</u>

The WIPP facility is required by the Superfund Amendments and Reauthorization Act of 1986 Title III (42 U.S.C. §11001) (also known as the Emergency Planning and Community Right-to-Know Act [EPCRA], 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 hazardous chemicals and the Tier II Form are also submitted to the regional fire departments.

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 chemicals is a one-time notification unless new chemicals in excess of 10,000 pounds, or new information on existing chemicals, are received. The last notification was made in 1999.

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

The Tier II Form, due on March 1 of each year, provides information for 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 each fire department with which the CBFO maintains a memorandum of understanding and to the LEPC and the SERC.

Title 40 CFR Part 372, "Toxics Release Inventory," identifies requirements for facilities to submit a toxic chemical release report to the EPA and the resident state if toxic chemicals are used at the facility in excess of established threshold amounts. The Toxic Chemical Release Report was submitted to the EPA and to the SERC prior to the July 1, 2009, reporting deadline. Table 2.1 presents the 2009 EPCRA reporting status. A response of "yes" indicates that the report was required and submitted.

Table 2.1 – Status of EP CRA Reporting

Table 2.1 – Status of EP CRA Reporting

EP CRA 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	Toxics Release Inventory Reporting	Yes

Accidental Releases of Reportable Quantities of Hazardous Substances

There were no releases of hazardous substances exceeding the reportable quantity limits during 2009.

2.2 Resource Conservation and Recovery Act

The Resource Conservation and Recovery Act (RCRA) (42 U.S.C. §§6901, et seq.) was enacted in 1976. 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 (P.L. 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 transuranic mixed waste designated by the Secretary of Energy for disposal at the WIPP facility from treatment standards. Such waste is not subject to the land disposal prohibitions of the Solid Waste Disposal Act (42 U.S.C. §§6901-6992, et seq.).

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

Hazardous Waste Facility Permit

The NMED issued the WIPP HWFP on October 27, 1999, and it became effective November 26, 1999. The HWFP authorizes DOE and WTS (known as the Permittees) to receive, store, and dispose of CH TRU mixed waste at the WIPP facility. The NMED approved a modification to the HWFP on October 16, 2006, to also allow receipt, storage, and disposal of RH TRU mixed waste. Two storage units (the parking area container storage unit and the Waste Handling Building container storage unit) are permitted for storage of TRU mixed waste. Seven underground hazardous waste disposal units are currently permitted for the disposal of CH and RH TRU mixed waste.

A drum, discovered in 2008 by the Permittees as being shipped with an open nonconformance report, became the subject of a July 2009 compliance order. The CBFO and WTS received an Administrative Compliance Order for the LANL drum alleging the Permittees violated the HWFP because the drum exceeded the HWFP liquid prohibition. A Partial Final Stipulated Order was approved on December 21, 2009.

As a condition of the settlement agreement, a Class 2 permit modification clarifying language regarding the liquid prohibition, visual examination, and nonconformance reporting was delivered to the NMED on January 7, 2010.

On July 24, 2009, the CBFO and WTS received an Administrative Compliance Order for not posting Acceptable Knowledge Sufficiency Determination Preliminary Evaluation letters (five waste streams) to the stakeholder e-mail notification system in a timely manner. The HWFP requires the Permittees to notify stakeholders who subscribe to the e-mail notification system that a letter transmitting the Permittees request to the NMED to evaluate Acceptable Knowledge Sufficiency Determination Preliminary Evaluation has been sent. The notifications are to occur within five calendar days of transmitting the letters to the NMED. There were five separate waste streams. The letters were transmitted to NMED for two waste streams on May 20, 2009, and three waste streams on June 12, 2009. The Permittees notified the stakeholders subscribing to the e-mail notification system on July 6, 2009. The Stipulated Final Order was finalized on November 23, 2009.

Modification Requests

In 2009, the Permittees submitted four HWFP modification notification/requests to the NMED consisting of Class 1 change notifications. Class 1 notifications must be submitted to the regulator within seven days of implementation. Table 2.2 provides details on the modification requests submitted to the NMED in 2009.

Table 2.2 – Permit Modification Notifications and Requests Submitted in 2009

Table 2.2 – Permit Modification Notifications and Requests Submitted in 2009

Class	Description	Date Submitted
1	Permit Modification Notification consisting of: • Revise Panel Figures to Include Panel 5 • Revise Firewater Distribution System Figures	January 2009
1	Permit Modification Notification consisting of: • Revise Closure Dates • Revise B6 Checklist (audit checklist) • Allow Use of Pallet Stands	February 2009
1	Permit Modification Notification consisting of: • Clarify Text Regarding Fire Water Tank Usage • Revise Document Numbers and Procedures • Update Pre-Fire Survey Figures • Revise Title of WWIS User's Manual • Revise Area Codes • Revise the Emergency Coordinator List	December 2009
1	Permit Modification Notification consisting of: • Install Bulkheads in Underground Waste Disposal Rooms	December 2009

Permit Renewals

On September 25, 2009, the Applicant submitted to the NMED a permit renewal application to manage, store, and dispose of TRU mixed waste at WIPP under the HWA. The NMED has determined the renewal application to be administratively complete. In accordance with Permit Condition I.E.4, Continuation of Expiring Permits, the current HWFP shall remain in effect until the effective date of the new permit because the NMED will not have issued a new permit on or before November 26, 2009, which is the expiration date of the current permit.

Underground Storage Tanks

Title 40 CFR Part 280, "Technical Standards and Corrective Action Requirements for Owners and Operators of Underground Storage Tanks (UST)," addresses USTs containing petroleum products or hazardous chemicals. Requirements for UST management pertain to the design, construction, installation, and operation of USTs, as well as notification and corrective action requirements in the event of a release and actions required for out-of-service USTs. The NMED has been authorized by the EPA to regulate USTs, and implements the EPA program through 20.5 NMAC, "Petroleum Storage Tanks." The New Mexico regulations underwent a change in June 2009 to reflect the new federal regulations. According to the new regulations, an operations and maintenance plan is to be developed for all storage tank systems. Because the WIPP facility maintains two petroleum USTs registered with the NMED, an operations and maintenance plan was developed, submitted, and approved in October 2009.

The NMED conducted an inspection of the USTs on March 24, 2009. The tanks were determined to be maintained in compliance with the applicable regulations.

Hazardous Waste Generator Compliance

Nonradioactive hazardous waste is currently generated through routine facility operations, and is managed in satellite accumulation areas, a "less-than-90-day" accumulation area on the surface, and a "less-than-90-day" accumulation area underground.

Hazardous waste generated at the WIPP facility is accumulated, characterized, packaged, labeled, and manifested to off-site treatment, storage, and disposal facilities in accordance with the requirements codified in 20.4.1.300 NMAC, which adopts, by reference, 40 CFR Part 262, "Standards Applicable to Generators of Hazardous Waste."

In 2007, a leaking cesium-137 (^{137}Cs) source contaminated some lead shot that was previously used as shielding. The mixed waste, which was generated from the cleanup operations of this leaking source, was disposed of at an off-site disposal facility permitted for the disposal of mixed waste. The leaking source with the lead shielding was shipped for disposal in August 2009.

Program Deliverables and Schedule

WIPP is in compliance with the HWFP conditions related to reporting as noted below.

- The annual Waste Minimization Certification Statement was completed and placed in the operating record as of November 2009 and was transmitted to the NMED.
- HWFP Module IV, Section F, Maintenance and Monitoring, requires annual reports evaluating the geomechanical monitoring program and the mine ventilation rate monitoring. The WIPP facility continued to comply with these requirements by preparation and submission of annual reports in October 2009, representing results for July 1, 2008, through June 30, 2009.
- Semiannual reports are required describing the implementation and results (data and analysis) of the confirmatory VOC monitoring. The WIPP facility continued to comply with these requirements by preparation and submission of semiannual reports in April 2009, representing results for July 1, 2008, through December 31, 2008, and another semiannual report in October 2009 representing results for January 1, 2009, through June 30, 2009. Reporting of hydrogen and methane program data was included with the seminannual reports in 2009.

- HWFP Module V, Section V.J.2.a, requires reports of the analytical results for semiannual detection monitoring program (DMP) well samples and duplicates, as well as results of the statistical analysis of the samples showing whether or not statistically significant evidence of contamination is demonstrated. These reports for Sampling Rounds 28 and 29 were submitted to the NMED in 2009. Sampling results are also summarized in Appendices E and F of this ASER.

- HWFP Module V, Section V.J.2.b. requires monthly submittal of groundwater surface elevation results. This includes groundwater surface elevations calculated from field measurements and fresh-water head elevations calculated as specified in Permit Attachment L, Section L-4c(1). Twelve monthly reports were submitted to the NMED in 2009 as required.

- HWFP Module V, Section V.J.2.c. requires that radionuclide sampling results and groundwater flow rate and direction be included in the ASER by October 1 of each year. These 2009 data are presented in Chapter 4, Environmental Radiological Program Information; and Chapter 6, Site Hydrology, Groundwater Monitoring, and Public Drinking Water Protection, respectively.

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 practicable means to consider potential environmental impacts of proposed projects as part of the decision-making process. The NEPA also dictates that the public shall be allowed to review and comment on proposed projects that have the potential to significantly affect the environment.

NEPA requirements are detailed in the Council on Environmental Quality regulations in 40 CFR Parts 1500-1508. The DOE codified its requirements for implementing the council's regulations in 10 CFR Part 1021, "National Environmental Policy Act Implementing Procedures." Title 10 CFR §1021.331 requires that, following completion of each environmental impact statement (EIS) and its associated record of decision, the DOE prepare a mitigation action plan that addresses mitigation commitments expressed in the record of decision. The first WIPP mitigation action plan was prepared in 1991. Additionally, the CBFO tracks the performance of mitigation commitments in the WIPP annual mitigation report. This report was issued July 2, 2009.

Day-to-day operational compliance with the NEPA at the WIPP facility is achieved through implementation of a NEPA compliance plan and procedure. One categorical exclusion and one supplement analysis were issued in 2009. The categorical exclusion was for pond construction and the supplement analysis was a periodic analysis to examine whether the sitewide analysis contained in the WIPP SEIS-II (*Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement*, DOE/EIS-0026-S-2) remains adequate, or whether significant new circumstances or information exists that would require preparation of a new EIS or SEIS for WIPP operations. Fifty-four projects were reviewed and approved by the CBFO NEPA Compliance Officer through the NEPA screening and approval process in 2009. These projects were primarily upgrades to the facilities and equipment at the WIPP site. These approvals were in addition to routine activities which have been predetermined to be bounded by existing NEPA documentation and which do not require additional evaluation by the CBFO NEPA Compliance Officer. The CBFO NEPA Compliance Officer also routinely participates in the development of NEPA documents from the DOE and other federal agencies for actions that may have environmental impacts on WIPP.

2.4 Clean Air Act

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

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.

Based on the initial 1993 air emissions inventory, the WIPP site is not required to obtain Clean Air Act permits. In 1993, the DOE did obtain a New Mexico Air Quality Control Regulation 702 Operating Permit (recodified in 2001 as 20.2.72 NMAC, "Construction Permits") for two backup diesel generators at the WIPP facility. There have been no activities or modifications to the operating conditions of the diesel generators that would require reporting under the conditions of the permit in 2009.

VOC emissions from containers of TRU and TRU mixed waste that are vented to prevent the buildup of gases generated by radiolysis do not approach permitting thresholds or the 10 pounds per hour or 10 tons per year requiring a Notice of Intent to be submitted to NMED under 20.2.72 NMAC. These emissions have exceeded estimated emissions in the SEIS-I (*Final Supplement Environmental Impact Statement for the Waste Isolation Pilot Plant*, DOE/EIS-0026-FS) and SEIS-II; however, they remain considerably less than 5 tons per year for all VOCs monitored under the Hazardous Waste Facility Permit. WIPP is excluded from compliance with 40 CFR §63.680, "Applicability and Designation of Affected Sources," because the waste contains radionuclides regulated under the Atomic Energy Act.

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 NPDES program requires permits for the discharge of 'pollutants' from any 'point source' into 'waters of the United States." The WIPP facility does not have any discharges of waste water or storm water runoff into waters of the United States and is not subject to regulation under the NPDES program. Waste waters 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 basins. The management of waste water and storm water runoff is regulated under the New Mexico Water Quality Act (NMSA 1978, §§74-6-1, et seq.); those permits are discussed further 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 and tasked the commission 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 have any discharges to surface water, but does have a discharge permit designed to prevent impacts to groundwater.

The DOE was issued a discharge permit (DP-831) from the NMED Ground Water Quality Bureau (GWQB) for the operation of the WIPP sewage treatment facility in January 1992. The discharge permit 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 the mine ventilation system's duct work. The discharge permit was modified in December 2003 to incorporate the infiltration controls for salt contact storm water run-off and in December 2006 to provide a more detailed closure plan. The discharge permit was renewed on September 9, 2008.

A discharge permit modification to incorporate the construction of the Salt Storage Extension Basin II (SSEB-II) to provide additional capacity for the storage and evaporation of salt contact run-off from the Salt Storage Extension was submitted to the GWQB in November of 2009. The GWQB determined the permit modification to be administratively complete on December 31, 2009. Construction of this pond began in the fall of 2009 based on the GWQB's approval of the design in July 2009.

A plan for the control of storm water runoff and minimization of erosion required by Condition III.6 of the discharge permit was submitted to and approved by the GWQB in May 2009. The plan involves grading the surface contours of the covered Salt Storage Area to direct run-off to run-off chutes that will be lined with high-density polyethylene. The conceptual design was submitted to and approved by the GWQB in October 2009.

Evaporation ponds B and C were relined with high-density polyethylene in accordance with a commitment the DOE made to the GWQB in 2005.

In accordance with the discharge permit requirements, WIPP monthly inspections are conducted on each of the infiltration control ponds and each salt storage area to ensure that the infiltration controls are maintained in good condition. When deficiencies are observed (e.g., liner tears or significant erosion), the 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. Freeboard is monitored at the sewage lagoons, the H-19 evaporation pond, and all infiltration control ponds daily.

The discharge permit requires the sewage lagoons and H-19 evaporation pond to be sampled semiannually and analyzed for nitrate, total Kjeldahl nitrogen, total dissolved solids, sulfate, and chloride. The infiltration control ponds must be sampled annually for total dissolved solids, sulfates, and chlorides. The results of this monitoring is reported in Table 5.5 and Table 5.6 in Section 5.7, Liquid Effluent Monitoring. Additionally, the permit requires annual groundwater level monitoring and semiannual groundwater monitoring for sulfate, chloride, and total dissolved solids. There are no regulatory limits associated with the analytes. Subsurface shallow water monitoring results are discussed in Chapter 6.

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 nontransient, noncommunity water system subject to the New Mexico drinking water regulations.

The WIPP facility qualifies for a reduced monitoring schedule under 40 CFR §141.86(d)(4), and is required to sample for lead and copper every three years. Lead and copper in drinking water were last sampled in August 2008. All samples were below action levels as specified by New Mexico monitoring requirements for lead and copper in tap water. The next lead and copper samples will be collected between June and September 2011.

Bacterial samples are collected and residual chlorine levels tested monthly. Chlorine levels are reported to the NMED monthly. All bacteriological analytical results have been below the Safe Drinking Water Act regulatory limits. Disinfectant byproducts testing per 40 CFR §141.132 is conducted annually by the state of New Mexico. All results have been 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 to support the WIPP facility in 2009.

2.9 Toxic Substances Control Act

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

Polychlorinated biphenyls (PCBs) are one of the compounds regulated by the TSCA. 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.

On April 2, 2009, the DOE notified the EPA by phone of an instance in which PCB waste was disposed at the WIPP facility on April 20, 2008, without Certificates of Disposal being sent back to the generator site within 30 days as required by 40 CFR §761.218(b). Also on April 2, 2009, Certificates of Disposal were prepared and submitted to the generator for Shipment IN080131. Written notification to the EPA of this instance followed on April 8, 2009.

The required PCB annual report, containing information on PCB waste received and disposed of at the WIPP facility in 2008, was submitted to EPA Region VI on June 30, 2009.

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 discarded by WIPP facility personnel into satellite accumulation area containers and managed as hazardous waste.

2.11 Endangered Species Act

The Endangered Species Act (16 U.S.C. §§1531, et seq.) was enacted in 1973 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, this act prohibits activities that could impact protected species, unless a permit is granted from the U.S. Fish and Wildlife Service (USFWS). A biological assessment and "formal consultation," followed by the issuance of a "biological opinion" by the USFWS, may be required for any species that is determined to be in potential jeopardy.

There are no known species of plants or animals at the WIPP site that are protected by the Endangered Species Act. The Lesser Prairie Chicken, which is a candidate for listing under the act, does have favorable habitat within the WIPP LWA and surrounding areas impacted by WIPP operational activities (e.g., drilling boreholes). Therefore, the DOE, in consultation with the BLM, has instituted measures to protect the Lesser Prairie Chicken and its habitat. During the Lesser Prairie Chicken's breeding season, there are BLM-established time periods in effect for the WIPP facility during which off-site well drilling and well plugging activities may not be performed. No instances associated with WIPP activities that had any adverse implications associated with the act were recorded in 2009.

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 these actions (50 CFR Part 20, "Migratory Bird Hunting").

The WIPP facility holds a migratory bird permit that allows for the relocation of certain bird species which are found nesting on equipment and which could be in danger due to routine operations. In 2009, WIPP reported the taking of one curve-billed thrasher nest containing three eggs. The event was reported to the USFWS within 48 hours of the occurrence as required by the permit and was reported on the Migratory Bird Annual Report to the USFWS for 2009. No other activities involving migratory birds took place at the WIPP facility during the reporting period.

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 all 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. 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 a water pipeline, 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. A list of active environmental permits for the WIPP facility, including rights-of-way, is in Appendix B of this report.

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. 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 NRC, which regulates the use of nuclear energy for domestic civilian purposes.

The statutory authority for the EPA to establish and implement the regulatory standards applicable to the operation, closure, and long-term performance of the WIPP facility can be 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 regulations affecting the radioactive waste disposal operations that will occur at the WIPP are found in 40 CFR Part 191, Subpart A. The EPA's final rule, 40 CFR Part 191, was first published on September 19, 1985. This standard was vacated and remanded to the EPA by a Federal Court of Appeals in 1987. The Land Withdrawal Act (LWA), Public

Law 102-579, as amended, reinstated the 1985 disposal standard except for the aspects of the standard that were specifically questioned by the court (i.e., 40 CFR §191.15, Individual Protection Requirements; and 40 CFR §191.16, Ground Water Protection Requirements). On December 20, 1993, the EPA promulgated, effective January 19, 1994, final disposal standards, which consist 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 monitoring and dose calculations have confirmed that there have been no releases of radionuclides that may adversely impact the public. WIPP personnel have conducted periodic confirmatory monitoring since receipt of waste began in March 1999. Results of the monitoring program demonstrate compliance with the dose limits discussed above and are addressed in further detail in Chapter 4.

WIPP is subject to EPA inspections in accordance with 40 CFR §194.21, "Inspections." During the week of July 14, 2009, the EPA conducted an inspection to assess the implementation of monitoring programs developed by the DOE to monitor emissions and geomechanical, hydrological, waste activity, drilling-related, and subsidence parameters. No findings or concerns resulted from this inspection. Additional information concerning this inspection can be found in EPA Docket A-98-49, Item II-B3-111.

The LWA establishes the regulatory authority of the EPA by specifying that the underground emplacement of TRU waste for disposal at WIPP could not commence until the DOE submitted a Compliance Certification Application (CCA) demonstrating compliance with the EPA radioactive waste disposal standards found in Subparts B and C of 40 CFR Part 191. The LWA further requires the EPA to conduct periodic recertification of continued compliance beginning five years after the initial receipt of TRU waste for disposal and at five-year intervals thereafter until the end of the decommissioning phase. The second Recertification Application for the WIPP facility was submitted to the EPA on March 24, 2009 (DOE/WIPP-09-3424).

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 WIPP. 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 training program, the emergency readiness program, the records management program, and the RCRA Contingency Plan. Chapter 3, Environmental Management System, provides details on the WIPP emergency management system.

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

This order specifies collection and reporting of information on 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 NEPA reporting, 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 414.1C, Quality Assurance

This order provides the criteria for establishing, implementing, and maintaining programs, plans, and actions to ensure quality achievement in DOE programs. This order is implemented at WIPP through the CBFO *Quality Assurance Program Document* (DOE/CBFO-94-1012), which establishes QA program requirements for all quality-affecting programs, projects, and activities sponsored by the CBFO. Chapter 7, Quality Assurance, of this ASER provides additional details on the WIPP QA programs.

2.15.4 DOE Order 435.1, Radioactive Waste Management

The objective of this order is to ensure that all DOE radioactive waste, including TRU waste that is disposed of at the WIPP site, is managed in a manner that is protective of workers and the public. 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 Waste Acceptance Criteria, and procedures governing the management and disposal of off-site-generated TRU radioactive waste.

2.15.5 DOE Order 450.1A, Environmental Protection Program

This order, issued on June 4, 2008, requires that each DOE site develop and implement an EMS that is integrated into the site integrated safety management system. The system must also reflect the elements and framework of the ISO 14001:2004(E) standard for EMS; contribute to DOE sustainable environmental stewardship goals; and assure compliance with environmental legal requirements. The scope of the EMS must address sustainable practices for energy and transportation functions and promote the long-term stewardship of a site's natural and cultural resources.

The CBFO issued the Declaration of Conformance on June 18, 2009. This declaration confirms that the EMS meets the requirements of DOE Order 450.1A. The declaration was due by June 30, 2009, and will be required every three years thereafter. The basis for the declaration was the completion of the ISO 14001 EMS certification audit, with DOE and MOC senior management addressing the findings from the audit.

The scope of the WIPP EMS includes environmental aspects of WIPP operations and activities (including energy and transportation) at the WIPP site and supporting buildings in Carlsbad, New Mexico. The EMS incorporates DOE sustainable environmental stewardship goals into the EMS environmental goals. Sustainable practices for energy and transportation functions are also incorporated in this way and are informed by the WIPP Executable Plan, which was originally completed in December 2008 and is now reviewed and updated as appropriate. Progress in these areas is shown in Chapter 3, Section 3.3.3. Relative to the DOE sustainable environmental stewardship goal to phase out use of ozone-depleting substances (ODS); WIPP uses no Class I ODS and chemical purchases are reviewed by Site Environmental Compliance to assure that other ODS are minimized or eliminated.

A fundamental purpose of the WIPP EMS is to provide a structured and sustainable method for maintaining compliance with environmental requirements. This includes a system of programs and procedures within the full EMS cycle of Plan, Do, Check, Act. Table 2. 3 highlights how the DOE requirement for an environmental compliance management plan is implemented at WIPP.

Table 2. 3 – Implementation of the WIPP Environmental Compliance Management Plan

Table 2.3 – Implementation of the WIPP Environmental Compliance Management Plan

Phase	WIPP EMS
Environmental Policy	• Contains clear commitment to maintain compliance by CBFO and WTS senior managers.
Planning	• Monthly regulatory reviews assure that new or changed requirements are identified. • Compliance activities (targets) are included in annual budgets. • Programs and procedures are implemented to ensure compliance.
Operating	• Training clearly communicates employee responsibility for compliance. • Specific compliance responsibilities are included in compliance programs/procedures. • Operational controls are integrated into procedures.
Checking	• Environmental compliance audits are routinely conducted. • WIPP Issues Management Program ensures that causal analysis and corrective and preventive actions are implemented.
Management Review	• Annual EMS management review includes review of compliance audit results and compliance status. • Ongoing review and adjustment occur as significant issues arise.

2.15.6 DOE Order 451.1B, Chg. 1, National Environmental Policy Act Compliance Program

This order establishes DOE requirements and responsibilities for implementing the NEPA, the Council on Environmental Quality Regulations Implementing the Procedural Provisions of NEPA (40 CFR Parts 1500-1508), and the DOE NEPA implementing procedures (10 CFR Part 1021). This order is implemented by the DOE for the WIPP facility through 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.

2.15.7 DOE Order 5400.5, Chg. 2, Radiation Protection of the Public and the Environment

This order, along with portions of DOE Order 231.1A, establishes standards and requirements for operations of the DOE and its contractors with respect to protecting members of the public and the environment against undue risk from radiation. 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 ALARA (as low as reasonably achievable) program manual, the records management program, and the radiation safety manual.

2.16 Executive Orders

Executive Orders generally are used to direct federal agencies and officials in their execution of congressionally established laws or policies. Compliance with the EOs in this section is accomplished through the WIPP programs, plans, and procedures that comply with the EO's implementing DOE order. Compliance is confirmed through the WIPP assessment process.

2.16.1 Executive Order 13423, *Strengthening Federal Environmental, Energy, and Transportation Management*

In January 2007, EO 13423 was issued, replacing five prior EOs that established requirements for greening the government (EOs 13101,13123, 13134, 13148, and 13149) relative to waste prevention, recycling, federal acquisition, energy management, use of biobased products and energy, fleet and transportation efficiency and EMSs. Requirements from the EO are mapped out in the WIPP EMS and are implemented into operations through energy management, fleet and vehicle management, affirmative procurement, and pollution prevention (P2) programs. Annual EMS goals have been established in one or more of these areas and are discussed in Chapter 3.

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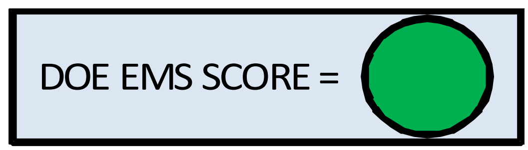
CHAPTER 3 – ENVIRONMENTAL MANAGEMENT SYSTEM

The CBFO and the MOC consider the protection of workers, the public, and the environment to be the highest priority of all activities at WIPP. This commitment is made in the WIPP Environmental Policy jointly issued by the CBFO and WTS senior management and is carried out by conducting operations through the WIPP EMS. The result of this commitment is the minimal environmental effect of operations demonstrated through ongoing monitoring program results, and the WIPP longstanding record of strong compliance and progress toward sustainability.

Performance of the EMS continued to be strong for 2009. A major milestone was achieved when the WIPP EMS was certified on May 28, 2009, as having met the requirements of ISO 14001:2004, *Environmental Management Systems – Requirements with Guidance for Use*. The certification was earned by successfully completing an audit of the EMS by an ISO-accredited registrar. Advanced Waste Management Systems is the ANSI–ASQ [American National Standards Institute/American Society for Quality] National Accreditation Board EMS Accredited Registrar for the WIPP EMS. A recertification audit will be repeated every third year, with semiannual surveillance audits during the intervening years.

The WIPP EMS also earned a "green" score from the DOE based on the 2009 Facility EMS Annual Data Report. The green score indicated that the EMS is fully implemented.



WIPP personnel, by carrying out their daily responsibilities in accordance with operational controls and the conduct of operations system, ensure that the positive environmental aspect of providing safe, environmentally sound TRU waste disposal is realized and that potentially significant negative environmental impacts from WIPP operations are eliminated or minimized. The extensive environmental monitoring conducted during 2009 continues to indicate there are no significant radiological or nonradiological environmental impacts from operation of the WIPP facility.

The level of commitment associated with assuring that there is no significant environmental impact from WIPP operations to personnel or the environment was demonstrated from recent circumstances related to our VOC monitoring program. In the fall of 2009, increased levels of carbon tetrachloride (CCl_4) were detected in weekly VOC underground samples. These values, though below the WIPP HWFP action levels (parts per billion by volume range) and below industrial health action levels (parts per million by volume range), were of interest to WIPP. If the values continued to increase, they could, over time, require actions including premature room closure and potentially, panel closure and thus affect WIPP facility's positive environmental aspect. WIPP immediately took proactive steps to understand the source of the CCl_4 and identify mitigating actions. Resources were then applied to implement actions to minimize CCl_4 emissions from the disposal panels. Mitigating actions taken included additional bulkheads and application of sealant material to reduce migration of CCl_4 into the underground ventilation air stream. Because the waste placed in closed panel 4 was from a CCl_4 waste stream, an additional bulkhead was erected on the exhaust side. In conjunction with this bulkhead, a recirculation fan was placed with a granular activated carbon (GAC) filter to collect VOCs that might be emitted from the closed exhaust side of panel 4. This GAC filter system was installed as a prototype test. At the end of the test, a determination will be made to either continue with this filter system and make it a permanent installation, modify and keep it operational due to the knowledge gained during the test, or remove it from service. These decisions will not be made until approximately mid calendar year 2010. Currently, there have been no exceedances of CCl_4 values that require actions to be taken, other than notifications, in accordance with the WIPP HWFP.

A core commitment element in the WIPP Environmental Policy Commitment is to comply with environmental requirements applicable to operation of the facility through implementation of programs, plans, practices and procedures. The CBFO and WTS completed detailed projects for submittal of the 2009 compliance recertification application to the EPA and the HWFP renewal application to the NMED. Both projects were successful and the applications are currently in the process for review by agencies and the public.

The DOE, on March 24, 2009, submitted the second compliance recertification application (CRA) to the EPA, initiating the recertification process. Recertification of the WIPP facility is required every five years by the 1992 WIPP Land Withdrawal Act. The certification demonstrates that WIPP protects human health and the environment and complies with strict requirements for the disposal of transuranic radioactive wastes, which allows WIPP to continue operation. The CRA provides information to document WIPP's continued adherence to the EPA disposal standards. The CRA includes new geotechnical and scientific data that project underground repository performance 10,000 years into the future. It is not a reconsideration of the decision to open WIPP, but rather a process to verify that changes at the facility in the preceding five-year period comply with EPA disposal standards for radioactive waste.

The CBFO and WTS submitted the HWFP renewal application in September 2009. Early in the renewal application development process, a determination was made that it was essential that the NMED and other stakeholders be engaged early and throughout application development. Many meetings were conducted with the NMED and stakeholders to inform them on content and format. Several meetings with the stakeholders during development were extra-regulatory. These early and frequent discussions with both regulators and the public have been the key to progress on the renewal of the HWFP.

Supporting the commitment to compliance, WIPP uses compliance performance goals and performance indicators in the EMS. In FY 2009, the goal of having no reportable, unauthorized contaminant releases was achieved. The second goal, having no external agency compliance issues, was not met because the WIPP facility received three compliance actions from the NMED. Although accounted for in the FY 2009 EMS performance indicator and measurement of goal achievement, two of the three actions were for occurrences in 2008, with only one occurrence being identified during 2009. The CBFO and WTS take any compliance or potential compliance issue very seriously and thus, after each occurrence, promptly performed causal analysis and implemented sustainable corrective actions for the underlying causes. Corrective actions for occurrences in 2008 were implemented prior to receipt of the agency compliance actions and those for the 2009 occurrence were completed by year's end. The compliance actions were an Administrative Compliance Order received in July 2009 for emplacing a LANL drum exceeding the liquid prohibition in 2008 and a Notice of Violation relative to the discharge permit (DP-831) for a spillway not being synthetically lined as required by the permit, also occurring in 2008. The third was an Administrative Compliance Order for not posting Acceptable Knowledge Sufficiency Determination Preliminary Evaluation letters for five waste streams to the stakeholder e-mail notification system within five calendar days. Aside from these external agency actions, WIPP's extensive compliance assurance program indicated there were no other noncompliances in 2009.

Progress in sustainable operations is also achieved through the WIPP EMS. Two projects stand out during 2009 as demonstrations of WIPP's commitment to sustainability. The first project encompassed improvements in the method for construction of a storm water pond. WIPP is very proud to have been the recipient of a DOE 2009 Best in Class Environmental Award for this project. While construction of the pond fulfilled a compliance requirement, the manner in which it was accomplished is a demonstration of sustainability in action. Fuel consumption was reduced by 50 percent as a result of eliminating the need to move roughly 140,000 tons of soil 6,500 miles. Also, improvements were made in the overall project time line and cost, and safety of the work environment. In addition, the project eliminated the use of over three million gallons of potable water by using clean storm water for construction needs.

Left Photo: Construction of New Pond

Right Photo: Completed Pond

The second project culminated in an agreement for the sale of 300,000 tons of run-of-mine salt from WIPP to Magnum Minerals LLC of Hereford, Texas. The buyer will convert the salt to a feed supplement. The Carlsbad Soil and Water Conservation District will administer the contract with revenues generated by the sale staying in Southeast New Mexico and benefitting area public works projects. The buyer will begin hauling salt from WIPP in 2010. This accomplishment provides an excellent example of perseverance in pursuit of a reuse opportunity as similar attempts made in the past had not been successful.

3.1 Key EMS Elements - 2009 Highlights

The WIPP EMS uses the continuous improvement cycle and system elements in the ISO 14001:2004 EMS standard. This continuous improvement cycle and the associated elements are depicted in Figure 3.1.

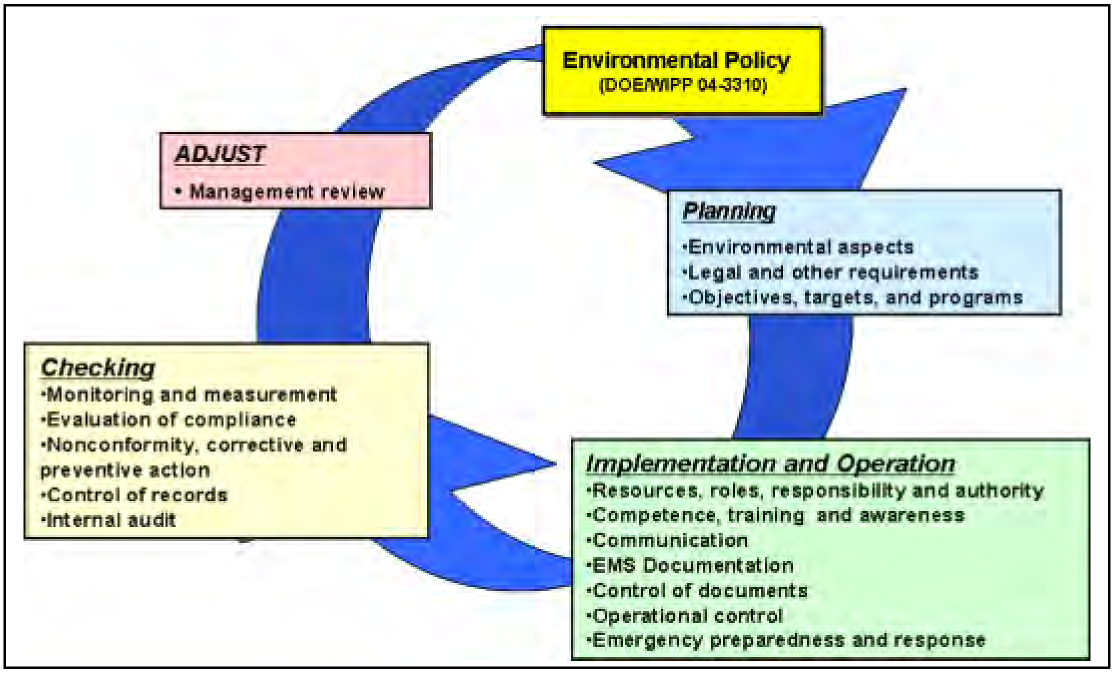


Figure 3.1 - WIPP EMS Continuous Improvement Cycle

Table 3.1 identifies key elements and highlights from the WIPP EMS for FY 2009.

Table 3.1 – Key EMS Elements and 2009 Highlights

Element	2009 Highlights
Environmental Policy	— The Environmental Policy was updated to reflect CBFO and WTS managers' direction. Policy commitments are to: • Comply with applicable laws and regulations. • Prevent harm to the environment. • Implement safe, responsible, and cost-effective pollution prevention practices. • Engage Stakeholders and be transparent. • Continually improve environmental performance.
Environmental Aspects	— WIPP facility activities were reviewed for significant impacts and the list of significant aspects and impacts continue to be appropriate.

Table 3.1 – Key EMS Elements and 2009 Highlights

Element	2009 Highlights
Legal and Other Requirements	— Proposed environmental requirements (rules, regulations, orders, directives) were reviewed for impact on WIPP facility activities. Changes in requirements that were most significant and their implementation status are: • Revised rules on underground storage tanks. The NMED has approved the site's Operations and Maintenance Manual and its requirements are being incorporated into technical procedures. • Issuance of Executive Order 13514. This order establishes requirements for sustainability and greenhouse gas reductions and specifically requires federal agencies to develop Strategic Sustainability Plans. WIPP has supplied all necessary WIPP facility data to support development of the DOE's department-wide Strategic Sustainability Plan. The 2009 EMS Management Review directed an FY 2010 goal for developing a site greenhouse gas inventory. • New DOE Policy requiring posting of certain NEPA categorical exclusions by DOE Program and Field Offices. WIPP-facility related categorical exclusions are posted at http://www.wipp.energy.gov/Documents_NEPA.htm.
Objectives, Targets, and Program(s)	— Zero reportable, unauthorized contaminant releases. — Constructed additional storm water evaporation pond for collection of runoff from salt storage area. — Relined sewage lagoon ponds. — Completed and submitted Compliance Certification Application, which initiated recertification of the WIPP disposal of TRU waste as compliant with EPA disposal standards for radioactive waste. — Two plus years of application development led to successful submission of HWFP Renewal Application in September 2009. — Energy efficiency improvements were made to the Safety Building. — Provided technical support (engineering and environmental – NEPA) for pursuit and evaluation of an industrial photovoltaic energy generation project at the WIPP facility. — Implemented improved process for reporting purchases of environmentally preferred products. — Developed a general user interface that enables any WIPP employee to identify partially used materials rather than purchase additional stock. — Completed Pollution Prevention Opportunity Assessment on the WIPP facility mobile groundwater monitoring laboratory, which resulted in elimination of five solid chemicals and one concentrated acid.
Communications	— The DOE continues proactive program for engaging stakeholders and being transparent in communications including quarterly stakeholder meetings. — Extensive stakeholder input sought during development of the HWFP renewal application. — Key stakeholder representative described the WIPP public interaction process as being the gold standard for public participation.
Competence, Awareness and Training	— EMS Briefing Pamphlet designed and issued to improve EMS knowledge requirements for managers. — Designed and issued a EMS poster that incorporates key sustainability areas to improve all employee awareness of the EMS. — Designed and began use of the EMS logo to improve recognition of the EMS through branding (see table header).
Operational Control	— The WIPP facility, as a Class 2 Nuclear Facility, operates using a disciplined Conduct of Operations system. Environmental controls are integrated into relevant functional procedures and are implemented in accordance with the Conduct of Operations system. Conduct of Operations continued to be a primary focus for operations throughout 2009.

Table 3.1 – Key EMS Elements and 2009 Highlights

Element	2009 Highlights
Emergency Preparedness and Response	— The underground adds full-time emergency service technician, decreasing response time in emergency situations and increasing the level of medical care available. — There has been an increase in volunteers to support medical activities by completing a first responder program and instituting an in-progress watch bill. — Emergency Management performed a total of 27 exercises/drills/events in FY 2009 compared to 15 in FY 2008.
Monitoring and Measurement	— The DOE WIPP facility earned a green score in 2009 for progress in nine of eleven DOE sustainability goals (Section 3.3.3). — The WIPP facility VOC monitoring program identified slightly elevated levels of CCl4 and took proactive steps to understand conditions, plan for and implement controls to minimize CCL4 release into underground. — Monitoring program results demonstrated no environmental impact from operations.
Evaluation of Compliance	— No noncompliance issues were identified from the over 160 evaluations of WIPP facility operations that focused on one or more facets of compliance and the systems that support compliance. Of these, 31 evaluations focused primarily on environmental compliance. — Weekly walk-around inspections for environmental compliance continued.
Nonconformity, Corrective Action, and Preventative Action	— The effectiveness review led by the QA Department for the corrective actions related to the 2008 discharge of water in the H-19 evaporation pond resulted in zero findings and observations.
Control of Records	— A system for maintaining online, electronic HWFP operating records was developed and testing performed. Adjustments were made and implementation of the system will begin in FY 2010.
Internal Audit	— The internal audit of the WIPP EMS was completed with zero findings.
Management Review	— The annual management review was completed with CBFO and WTS senior management directing system improvements and FY 2010 environmental goals.

3.2 Significant Environmental Programs

Fundamental to protecting the environment and achieving environmentally sustainable operations are WIPP programs through which operations are conducted. Programs, with supporting procedures, translate the environmental policy's higher order commitments to practical actions for individual employees to take to protect the environment as they work. Following is a list of significant, ongoing WIPP environmental programs.

Affirmative Procurement – This program provides a systematic and cost-effective structure for promoting and procuring environmentally preferable products. It facilitates consideration of environmentally preferable factors and products during the development of purchase requisitions and solicitations for offers. Environmentally preferable factors include bio-based, recycled content, energy conservation (including Energy Star) and energy and water efficiency.

Delaware Basin Drilling Surveillance – Active surveillance of drilling activities within the Delaware Basin with specific emphasis on the nine-township area that includes the WIPP site are conducted within this program. The surveillance of drilling activities builds on the data used to develop modeling assumptions for performance assessment for the EPA's Compliance Certification. The collection of additional information on drilling patterns and practices in the Delaware Basin are used to define whether the drilling scenarios in the application continue to be valid at each five-year recertification cycle.

Environmental Monitoring – A core ongoing program at the WIPP facility, the Environmental Monitoring Program includes radiological and nonradiological monitoring, land management monitoring, and oil and gas surveillance. Radiological constituents are monitored in airborne effluent and particulates, sewage treatment and water disposal evaporation pond, biotics, soils, surface water, sediment and groundwater. Nonradiological monitoring includes meteorology, VOCs, groundwater surveillance, and shallow subsurface water monitoring.

Environmental Compliance Audit Program – Environmental compliance audits and reviews as required by DOE 450.1A are conducted under the MOC's environmental department's Environmental Compliance Walk Around and Assessment program as well as the CBFO and MOC QA assessments program.

Groundwater Protection Program – 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 Program – The Land Management Program provides for management and oversight of WIPP lands under the jurisdiction of the DOE, and lands outside the WIPP boundary that are used in the operation of the WIPP facility. The program provides protocols that are used for managing 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 WIPP land.

Meteorological Monitoring – The meteorological monitoring program provides on-site meteorological data. A variety of data is collected through an array of instrumentation from a meteorological tower. Data collected are used for modeling of potential accidental radionuclide releases, effluent monitoring, assessing waste shipment transportation safety, and evaluating employee safety traveling to and from the WIPP site, and for monitoring real-time meteorological conditions for responding to events involving spills or releases of hazardous materials.

NEPA Compliance – This program ensures requirements of the NEPA and its implementing regulations are met prior to making decisions to implement work at or on behalf of the WIPP facility. It also assures that necessary changes to or new permits are obtained and sufficient compliance guidance is available to those implementing work at or on the behalf of the WIPP facility.

Pollution Prevention – Promoting and integrating energy and water efficiency, environmentally preferred purchasing (EPP), waste minimization, and recycling and reuse, as well as maintaining awareness for pollution prevention in WIPP operations are carried out through this program.

Waste Stream Profile – This is a critical program for ensuring compliance requirements are met. It ensures that profiles for each waste stream to be disposed at the WIPP facility are reviewed to verify that generator waste stream characterization information provided is complete and accurate, and that waste streams comply with the HWFP, Waste Acceptance Criteria, and Waste Analysis Plan.

Waste Confirmation – The DOE demonstrates compliance with the HWFP by ensuring that the waste characterization processes performed by generator/storage sites (sites) produce data compliant with the Waste Analysis Plan through waste screening and verification processes. 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.

Waste Management – Site-generated hazardous, universal, special, low-level and mixed low-level radioactive wastes are managed in accordance with the protocols established in this program. The program ensures that wastes are properly handled, accumulated, and transported to approved disposal facilities in accordance with legal and internal requirements.

3.3 Environmental Performance Measurement

Environmental performance is extensively monitored to assure that the WIPP mission is carried out in accordance with its environmental policy. This includes measuring environmental conditions for impacts to environment, for EMS effectiveness, and for sustainability progress. Each of these is discussed in the following subsections.

3.4 EMS Awards

As noted earlier in this chapter, WIPP earned a DOE 2009 EM Best in Class Environmental Award in the Alternative Fuels and Fuel Conservation category. The award was for integrating sustainable practices into the construction of an additional storm water pond. The WIPP management and staff are particularly proud of this award as the project provides a model for how sustainability and successful project execution are mutually beneficial.

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CHAPTER 4 – ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

DOE Order 450.1 states that the DOE must "conduct environmental monitoring, as appropriate, to support the site's integrated safety management system; to detect, characterize, and respond to releases from DOE activities; assess impacts; estimate dispersal patterns in the environment; characterize the pathways of exposures and doses to members of the public; characterize the exposures and doses to individuals and to the population; and evaluate the potential impacts to biota in the vicinity of the DOE activity."

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

Personnel at the WIPP facility sample air, groundwater, surface water, soils, sediments, and biota to monitor the radiological environment around the WIPP 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/EH-0173T, *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance*.

The WIPP facility is regulated under 40 CFR §191.03, Subpart A, which applies to management and storage of radioactive waste at disposal facilities operated by the DOE. The standards in 40 CFR §191.03(b) state that management and storage of transuranic waste at the DOE facilities shall be conducted in such a manner as to provide 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 major pathway of concern. For that reason, the EPA concluded that the only plausible pathway for radionuclide transport during receipt and emplacement of waste at the WIPP facility is by air emissions.

The regulatory limits for the WIPP effluent monitoring program can be found in 40 CFR Part 191, Subpart A. Radionuclides being released from WIPP operations, including the underground TRU waste disposal areas and the Waste Handling Building, are monitored through the WIPP effluent monitoring program. The referenced standard 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 mrem to the whole body and 75 mrem to any critical organ. In addition, in a 1995 memorandum of understanding (MOU) between the EPA and the DOE, the DOE agreed that the WIPP facility would comply with 40 CFR Part 61, "National Emissions Standards for Hazardous Air Pollutants" (NESHAP), Subpart H, "National Emissions Standards for Hazardous Air Pollutants 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 which would cause any member of the public to receive in any year an EDE of 10 mrem per year.

The radiological environment near the WIPP site includes natural radioactivity, global fallout and, potentially, radioactive contamination remaining from Project Gnome. Under Project Gnome, a nuclear device was detonated underground in bedded salt on December 10, 1961. The test site for Project Gnome is located 9 km (5.4 mi) southwest of the WIPP site. The Project Gnome detonation vented into the atmosphere. Therefore, environmental samples in the vicinity of the WIPP site may contain small amounts of fission products from fallout and residual contamination from Project Gnome, in addition to natural radioactivity.

Natural background radiation, global fallout, and remaining radioactive contamination from Project Gnome together comprise the radiological baseline for the WIPP site. A report titled *Statistical Summary of the Radiological Baseline Program 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 from 1985 through 1989, prior to the time that the WIPP facility 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 from the WIPP environmental monitoring program 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 ten radionuclides, including natural uranium ($^{233/234}$U, ^{235}U, and ^{238}U); potassium-40 (^{40}K); transuranic actinides expected to be present in the waste (plutonium [^{238}Pu], $^{239/240}$Pu, and americium [^{241}Am]), and major fission products (cesium [^{137}Cs], cobalt [^{60}Co], and strontium [^{90}Sr]). Environmental levels of these radionuclides could provide corroborating information on which to base conclusions regarding releases from WIPP facility operations.

Table 4.1 summarizes the list of target radionuclides along with their type of radiation, method of detection, and reason for monitoring at the WIPP site. The WIPP effluent monitoring program also monitors for these same radionuclides with the exception of ^{235}U, ^{40}K, and ^{60}Co.

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	Fission product/potential component of waste
^{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.

Radionuclides are considered "detected" in a 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 laboratories 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 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.

Measurements of radioactivity are actually probabilities due to the random nature of the disintegration process. A 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 determined by gamma spectroscopy (^{137}Cs, ^{60}Co, and ^{40}K), an additional factor considered in the determination of detectability is the identification (ID) confidence with which the peak or peaks associated with the particular radionuclide can be identified by the gamma spectroscopy software. In accordance with the statement of work (SOW) for the laboratory analyses, gamma spectroscopy samples with ID confidence less than 90 percent (< 0.90) are not considered "detects," regardless of their magnitudes compared to the TPU and MDC. Sample results are also normalized with the instrument background and/or the method blank. If either of those measurements have 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 all 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 concern. The MDCs attained by WIPP Laboratories were below the recommended MDCs specified in American National Standards Institute (ANSI) Standard N13.30, *Performance Criteria for Radiobioassay*.

Comparisons of radionuclide concentrations were made between years and locations using the statistical procedure, ANOVA (analysis of variance) for those data sets containing sufficient "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 significance level for ANOVA calculations. A p value >0.05 indicates no significant difference in the values from a data set, and a p value <0.05 indicates a significant difference in the values from a data set.

The p value is the probability under the null hypothesis of observing a value as unlikely or more unlikely than the value of the test statistic. 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 their 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 effluent monitoring program and the environmental monitoring program. Descriptions of these two programs are provided in the sections below.

Effluent Monitoring

The WIPP effluent monitoring program has three effluent air monitoring stations, known as Effluent Monitoring Stations A, B, and C. Each station employs one or more fixed air samplers, collecting particulate from the effluent air stream using a Versapor® filter. Fixed air samplers at Station A sample the unfiltered underground exhaust air. Samples collected at Station B sample the underground exhaust air after HEPA (high-efficiency particulate air) filtration and, sometimes, nonfiltered air during ventilation fan maintenance. Samples collected at Station C sample the exhaust air from the Waste Handling Building 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 2009, filter samples from all three effluent air monitoring stations were analyzed for ^{238}Pu, $^{239/240}$Pu, ^{241}Am, ^{90}Sr, ^{137}Cs, $^{233/234}$U, and ^{238}U.

In June 2010, the *Annual Periodic Confirmatory Measurement Compliance Report for Calendar Year 2009*, was submitted to the EPA as required by 40 CFR Part 61, Subpart H (NESHAP). The report provided descriptions of the ongoing CH and RH TRU and TRU mixed waste receipt and emplacement. For CY 2009, the CAP88-PC dose assessment computer model was used to calculate the EDE value of 7.80E-05 mrem/year to the MEI.

Environmental Monitoring

The purpose of the radiological environmental 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 to baseline data, to determine what, if any, impact WIPP 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 all ten of the target radionuclides listed in Table 4.1. 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 being analyzed.

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. Isotopes of plutonium and americium were analyzed because they are the most significant alpha-emitting radionuclides among the constituents of TRU wastes received at the WIPP site. 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 contaminants 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.

4.1 Effluent Monitoring

4.1.1 Sample Collection

Stations A, 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-µm, 47-mm diameter Versapor® membrane filter.

Daily (24-hour) filter samples were collected from Station A from the unfiltered underground exhaust stream. Each day at Station A, approximately 78 m^3 (2,747 cubic feet [ft^3]) of air was filtered through the Versapor® filter.

Weekly (24 hours/seven days per week) filter samples were collected at Stations B and C. Station B samples the underground exhaust air after HEPA filtration and, sometimes, nonfiltered air during maintenance. Each week at Station B, approximately 583 m^3 (20,603 ft^3) of air were filtered through the Versapor® filter. Weekly filter samples were also collected at Station C, which sampled the air from the Waste Handling Building after HEPA filtration. Each week at Station C, approximately 167 m^3 (5,913 ft^3) of air were filtered through the Versapor® filter. Based on the specified sampling periods, these air volumes were within ±10 percent of the volume derived using the flow rate set point of 0.057m^3/min (2 ft^3/min) for Stations A and B. The air volume for Station C was within ±10 percent of the volume derived using the flow rate required for isokinetic sampling conditions and the specified sampling period. The sample flow rate for Station C varied according to the exhaust air flow in the Waste Handling Building in order to maintain isokinetic sampling conditions.

The filter samples for Stations B and C were composited each quarter. Because of the large number of samples from Station A, these samples were composited monthly. All filter samples were analyzed radiochemically for ^{241}Am, ^{238}Pu, $^{239/240}$Pu, ^{90}Sr, $^{233/234}$U, ^{238}U, and ^{137}Cs.

4.1.2 Sample Preparation

The monthly and quarterly filter samples were composited. The composites were transferred to a Pyrex® beaker, spiked with appropriate tracers (^{232}U, ^{243}Am, and ^{242}Pu), and heated in a muffle furnace at 250°C (482°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 Teflon® beakers by rinsing with concentrated nitric acid and heated with concentrated hydrofluoric acid until completely dissolved. Hydrofluoric acid was removed by evaporating to dryness. Approximately 25 milliliters (mL) (0.845 fluid ounce [oz]) of concentrated nitric acid and 1 gram (0.0353 oz) of boric acid were added (to remove residual HF), 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

For 2009, out of 20 total composite samples, there were 140 analyses, as shown in Table 4.2. These analytes comprised of the following radionuclides: ^{241}Am, ^{238}Pu, $^{239/240}$Pu, ^{90}Sr, $^{233/234}$U, ^{238}U and ^{137}Cs.

Radionuclides are considered detected in a sample if the measured activity is greater than the 2σTPU and MDC. The detected radionuclides that met this definition were selected as the nuclide data for the CAP88-PC dataset report, as shown in Table 4.2. Another criteria was to have the 2σTPU added to the activity value. The final result was compared to the MDC. The highest result of the two was also selected for the nuclide data in the CAP88-PC dataset report.

Sampling was performed in the underground and at the WHB using fixed air samplers. The March 2009 and the April 2009 backup composite samples were reanalyzed to confirm results obtained in the initial March 2009 and the April 2009 (SDG 2009-400). The March 2009 and April 2009 composite samples were analyzed in the same batch and the April 2009 samples came up with activity above TPU and MDC, it was crucial to reanalyze both again to make sure the analysis was performed properly and there was no laboratory contamination involved.

Evaluation of the filter sample results indicated that there were no detectable releases from the WIPP facility 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 releases 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), from the WIPP facility.

Table 4.2 – Activity (Bq) of Quarterly Composite Air Samples From the WIPP Effluent Monitoring Stations A, B and C for 2009

Nuclide	Activity	2σTPU[a]	MDC[b]	Activity	2σTPU	MDC	Activity	2σTPU	MDC
		Station A			Station B			Station C	
					1st Quarter				
^{241}Am				-3.18E-04	5.29E-04	3.26E-03	6.07E-04	7.70E-04	3.15E-03
^{238}Pu				-1.55E-04	5.07E-04	2.45E-03	-2.16E-03	5.03E-04	2.34E-03
$^{239/240}Pu$				-9.29E-05	5.03E-04	1.63E-03	-4.00E-04	3.92E-04	1.51E-03
^{90}Sr		See below [c]		-2.45E-02	3.89E-02	1.75E-02	-1.58E-03	3.85E-02	1.74E-03
$^{233/234}U$				-3.59E-04	6.92E-04	8.47E-03	-8.21E-04	3.20E-04	8.44E-03
^{238}U				-3.67E-04	6.07E-04	7.70E-03	-6.25E-05	7.88E-04	7.66E-03
^{137}Cs				1.61E+00	2.31E+00	2.56E+00	2.79E-01	2.13E+00	2.33E+00
					2nd Quarter				
^{241}Am				7.25E-04	9.92E-04	2.05E-03	-3.92E-05	6.36E-04	2.04E-03
^{238}Pu				-1.30E-04	7.40E-04	1.61E-03	1.02E-04	7.18E-04	1.45E-03
$^{239/240}Pu$				-2.11E-04	4.51E-04	1.29E-03	-3.74E-04	5.48E-04	4.22E-05
^{90}Sr		See below		-2.43E-02	2.38E-02	1.12E-02	-2.52E-02	2.41E-02	1.12E-02
$^{233/234}U$				1.51E-03	1.90E-03	5.66E-03	-2.59E-05	1.06E-03	5.62E-03
^{238}U				1.24E-03	1.78E-03	5.44E-03	1.98E-04	1.31E-03	5.40E-03
^{137}Cs				5.33E-01	1.02E+00	1.18E+00	-1.50E+00	2.39E+00	2.48E+00
					3rd Quarter				
^{241}Am				-2.50E-04	5.88E-04	1.63E-03	5.48E-04	1.10E-03	1.72E-03
^{238}Pu				-1.68E-04	1.71E-04	7.62E-04	-9.95E-05	3.52E-04	7.84E-04
$^{239/240}Pu$				-6.96E-05	1.42E-04	7.59E-04	-1.62E-04	2.58E-04	7.81E-04
^{90}Sr		See below		2.11E-03	3.05E-02	8.51E-03	1.88E-03	2.74E-02	8.25E-03
$^{233/234}U$				-1.48E-03	7.33E-04	4.37E-03	2.74E-04	1.24E-03	4.40E-03
^{238}U				-7.14E-04	4.96E-04	3.85E-03	8.40E-04	1.07E-03	3.92E-03
^{137}Cs				-8.18E-01	1.18E+00	1.23E+00	-1.69E+00	8.77E-01	9.62E-01
					4th Quarter				
^{241}Am				7.96E-05	5.00E-04	8.25E-04	-6.18E-05	4.70E-04	8.33E-04
^{238}Pu				-4.70E-04	3.18E-04	6.25E-04	-4.07E-04	2.62E-04	6.22E-04
$^{239/240}Pu$				-5.00E-04	2.70E-04	5.77E-04	-1.99E-04	5.44E-04	6.03E-04
^{90}Sr		See below		6.29E-03	3.77E-02	4.11E-03	1.89E-02	3.64E-02	4.00E-03
$^{233/234}U$				4.22E-04	6.51E-04	2.38E-03	-2.93E-04	3.30E-04	2.38E-03
^{238}U				1.42E-04	4.85E-04	1.91E-03	-9.03E-05	4.48E-04	1.91E-03
^{137}Cs				-7.84E-01	1.23E+00	1.28E+00	-6.18E-01	8.62E-01	9.14E-01
		Station A			1st Quarter Monthly				
		January			February			March	
^{241}Am	-7.88E-05	7.03E-04	7.81E-04	4.66E-04	7.81E-04	3.77E-03	-7.36E-05	4.70E-04	3.08E-03
^{238}Pu	-3.37E-04	5.25E-04	4.59E-04	2.55E-04	5.37E-04	4.59E-03	-1.24E-04	2.35E-04	2.23E-03
$^{239/240}Pu$	-1.23E-04	3.64E-04	4.18E-04	5.88E-04	1.93E-02	3.33E-03	1.79E-05	2.78E-04	1.67E-03
^{90}Sr	-2.38E-02	4.26E-02	3.30E-03	-3.13E-03	2.89E-02	2.88E-02	-8.07E-04	4.40E-02	1.59E-02
$^{233/234}U$	1.56E-04	9.47E-04	1.21E-03	1.63E-03	1.37E-03	1.52E-02	1.27E-03	9.69E-04	7.81E-03
^{238}U	-8.77E-04	7.99E-04	9.99E-04	1.03E-03	1.10E-03	1.22E-02	4.44E-04	8.47E-04	7.44E-03
^{137}Cs	4.11E-02	1.09E+00	1.22E+00	-1.09E+00	1.19E+00	1.17E+00	1.11E+00	2.25E+00	2.49E+01

Table 4.2 – Activity (Bq) of Quarterly Composite Air Samples From the WIPP Effluent Monitoring Stations A, B and C for 2009

Nuclide	Activity	2σTPU[a]	MDC[b]	Activity	2σTPU	MDC	Activity	2σTPU	MDC
	Station A 1[st] Quarter Continued			2[nd] Quarter Monthly					
	March Backup			April			April Backup		
^{241}Am	-7.47E-04	6.11E-04	2.98E-03	4.26E-03	1.85E-03	3.23E-03	-2.37E-04	5.40E-04	2.71E-03
^{238}Pu	-6.14E-04	6.14E-04	2.41E-03	6.55E-04	9.10E-04	2.40E-03	-2.35E-04	5.33E-04	2.09E-03
$^{239/240}Pu$	-5.14E-04	6.33E-04	1.86E-03	1.96E-02	4.00E-03	1.83E-03	7.62E-05	6.96E-04	1.55E-03
^{90}Sr	N/R[d]	N/R	N/R	-8.18E-04	4.18E-02	1.57E-02	N/R	N/R	N/R
$^{233/234}U$	N/R	N/R	N/R	5.92E-03	2.35E-03	8.03E-03	N/R	N/R	N/R
^{238}U	N/R	N/R	N/R	4.66E-03	2.19E-03	7.62E-03	N/R	N/R	N/R
^{137}Cs	N/R	N/R	N/R	4.07E-01	2.24E+00	2.45E+00	N/R	N/R	N/R
	Station A 2[nd] Quarter Continued						3[rd] Quarter Monthly		
	May			June			July		
^{241}Am	-6.36E-05	4.22E-04	2.09E-03	1.20E-04	5.33E-04	2.14E-03	-2.50E-04	4.81E-04	1.79E-03
^{238}Pu	-1.22E-04	4.40E-04	1.24E-03	-3.15E-04	2.89E-04	1.35E-03	1.91E-04	2.03E-05	8.92E-04
$^{239/240}Pu$	7.99E-04	6.85E-04	1.04E-03	-9.66E-06	3.27E-04	1.14E-03	-2.25E-04	2.16E-04	8.88E-04
^{90}Sr	-5.33E-03	2.56E-02	1.14E-02	1.44E-04	2.52E-02	1.14E-02	-3.74E-05	1.72E-02	8.92E-03
$^{233/234}U$	1.07E-03	1.12E-03	6.48E-03	4.03E-03	3.34E-03	6.77E-03	2.02E-03	1.24E-03	4.26E-03
^{238}U	5.00E-04	7.59E-04	5.88E-03	4.03E-03	3.30E-03	6.22E-03	1.96E-03	1.23E-03	4.26E-03
^{137}Cs	2.77E-01	2.06E+00	2.25E+00	-3.36E-01	2.42E+00	2.62E+00	6.59E-01	1.12E+00	1.28E+00
	Station A 3[rd] Quarter Continued						4[th] Quarter Monthly		
	August			September			October		
^{241}Am	6.59E-04	7.73E-04	1.71E-03	-2.93E-04	5.66E-04	1.60E-03	1.77E-04	7.77E-04	1.59E-03
^{238}Pu	-2.66E-05	4.51E-04	9.25E-04	-8.81E-05	3.13E-04	7.55E-04	2.87E-04	5.11E-04	7.59E-04
$^{239/240}Pu$	7.92E-05	5.74E-04	9.25E-04	1.11E-04	3.85E-04	7.55E-04	-7.99E-05	3.66E-04	7.59E-04
^{90}Sr	-1.83E-03	1.64E-02	8.84E-03	2.13E-02	2.88E-02	8.33E-03	5.14E-03	2.84E-02	8.25E-03
$^{233/234}U$	2.78E-03	1.67E-03	4.29E-03	-9.18E-04	8.77E-04	4.37E-03	8.25E-05	1.18E-03	4.40E-03
^{238}U	2.62E-03	1.60E-03	4.29E-03	5.96E-04	9.47E-04	3.89E-03	2.50E-05	7.77E-04	3.92E-03
^{137}Cs	9.58E-01	1.57E+00	1.74E+00	-6.81E-01	1.20E+00	1.26E+00	3.20E-01	8.66E-01	9.77E-01
	Stations A 4[th] Quarter Continued								
	November			December					
^{241}Am	-1.67E-06	4.88E-04	8.58E-04	3.15E-04	8.58E-04	9.77E-04			
^{238}Pu	-4.77E-05	4.88E-04	8.55E-04	-3.74E-04	2.26E-04	6.40E-04			
$^{239/240}Pu$	3.92E-05	7.44E-04	8.36E-04	-4.74E-04	2.55E-04	6.25E-04			
^{90}Sr	1.71E-02	4.92E-02	5.40E-03	1.50E-02	4.77E-02	5.18E-03			
$^{233/234}U$	7.62E-04	7.77E-04	2.41E-03	1.23E-03	1.10E-03	4.08E-05			
^{238}U	4.22E-04	6.59E-04	1.94E-03	1.75E-03	1.24E-03	2.06E-03			
^{137}Cs	8.55E-01	1.13E+00	1.30E+00	6.99E-02	8.99E-01	1.00E+00			

[a] Total propagated uncertainty
[b] Minimum detectable concentration
[c] Station A - composited monthly due to the large number of samples
[d] N/R - Not Requested.

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. Location codes are shown in Appendix C. Each week at each sampling location, approximately 600 m^3 (21,187 ft3) of air were sampled through a 4.7-centimeter (cm) (1.85-inch [in.]) diameter glass microfiber filter using a continuous low-volume air sampler.

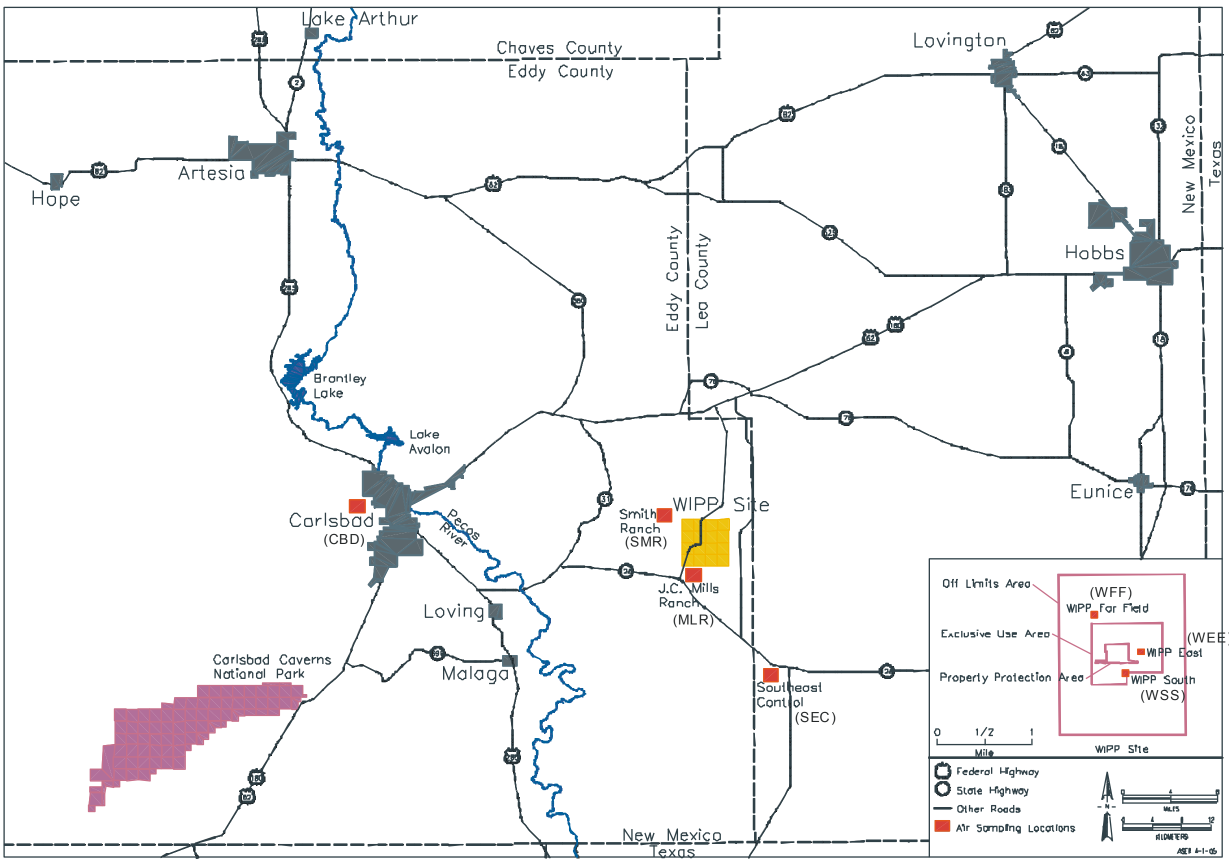

Figure 4.1 – Air Sampling Locations on and Near the WIPP Site

4.2.2 Sample Preparation

Weekly air particulate samples were composited for each quarter. The composite samples were transferred into a Pyrex® beaker, spiked with appropriate tracers (^{232}U, ^{243}Am and ^{242}Pu), and heated in a muffle furnace at 250°C for two hours, followed by heating for two hours at 375°C, and heating for six hours at 525°C.

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

Approximately 25 mL of concentrated nitric acid and one gram of boric acid were added, and the samples were heated and finally evaporated to dryness. The residues were dissolved in 8 M nitric acid for subsequent separation and analysis.

4.2.3 Determination of Individual Radionuclides

The 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 for the uranium/transuranic radioisotopes and ^{90}Sr by employing a series of chemical, physical, and ion exchange procedures to separate the radionuclides followed by mounting the sample residues on a planchet for counting. Uranium/ transuranics were counted by alpha spectroscopy and ^{90}Sr was counted for beta emissions using gas proportional counting.

4.2.4 Results and Discussion

The combined mean, minimum, and maximum concentrations (becquerels per composite air filter sample [Bq/sample]) of target radionuclides for all air sampling locations are reported in Table 4.3. Detailed sample analysis data for each station are reported in Appendix G (Table G.1). Whenever the word "sample" is used for air filter samples, it should be taken to mean "composite sample" and does not include blanks. The mean concentrations are reported for those locations where duplicate samples were collected.

Natural uranium isotopes consisting of $^{233/234}U$ and ^{238}U were detected in a few of the 2009 composite samples with a few more detections of ^{238}U than $^{233/234}U$ (Table G.1). However, these same isotopes were detected at similar concentrations in some of the air filter blank samples. The uranium isotopes were not detected in the 2008 samples and thus Analysis of Variance (ANOVA) comparisons between years and among locations were not performed.

Relative to the transuranics, ^{238}Pu, $^{239/240}Pu$, and ^{241}Am, the air filter composite sample taken at location WSS during the third quarter sampling contained detectable concentrations of both $^{239/240}Pu$, and ^{241}Am. The laboratory confirmed the detections three additional times by processing and analyzing the waste from the initial analysis, by analyzing the nondestructive gamma fraction (50 percent) of the composite filter sample, and by processing and analyzing the waste from the gamma fraction. All four analyses yielded firm detections of the two radionuclides. However, the concentrations were very low with the sample activities less than two times higher than 2σTPU, where the TPU is an estimate of the uncertainty in the measurements due to all sources including counting error, measurement error, chemical recovery error, detector efficiency error, the randomness of radioactive decay, and any other sources of uncertainty. Only about ten $^{239/240}Pu$ net counts and twelve ^{241}Am net counts were recorded over the 1,000-minute alpha spectroscopy count time. There were no net counts in the filter method blank for these radionuclides.

When the maximum Bq/sample concentrations of ^{241}Am and $^{239/240}$Pu in Table 4.3 are divided by the total volume of air sampled through the 14 composite samples at the WSS location (7,949 m^3), the corresponding concentrations are 3.65E-07 Bq/m^3 for ^{241}Am and 2.50E-07 Bq/m^3 for $^{239/240}$Pu. These concentrations are below the baseline concentrations of 5.30E-05 Bq/m^3 for ^{241}Am and 8.00E-06 Bq/m^3 for $^{239/240}$Pu. The individual samples that make up the composite sample are not analyzed for the radionuclides, but their maximum concentration can be calculated. The air volumes for the individual samples at WSS varied from about 470 m^3 to 650 m^3 during the third quarter of 2009. If all of the ^{241}Am and in the composite sample was collected during just one of the individual sampling events, the corresponding range of concentrations based on the air volume range would be 4.46E-06 Bq/m^3 to 6.17E-06 Bq/m^3. The range of concentrations is less than the baseline concentration of 5.30E-05 Bq/m^3. If all the $^{239/240}$Pu in the composite sample was collected during just one of the individual sampling events, the corresponding range of concentrations based on the air volume range would be 3.06E-06 Bq/m^3 to 4.23E-06 Bq/m^3. Again the range of concentrations is less than the baseline concentration for $^{239/240}$Pu of 8.00E-06 Bq/m^3.

Since the $^{239/240}$Pu, and ^{241}Am were not detected in the 2008 air filter composite samples, no ANOVA comparisons between years and among locations were performed.

There were no measurable concentrations of ^{40}K, ^{37}Cs, and ^{60}Co in any of the 2009 air filter composite samples. Thus, no ANOVA comparisons could be performed between years or among locations for these gamma radionuclides.

Table 4.3 – Mean, Minimum, and Maximum Radionuclide Concentrations (Bq/sample) in Air Filter Composite Samples From Stations Surrounding the WIPP Site. See Appendix G for Supporting Data.

Table 4.3 – Mean, Minimum, and Maximum Radionuclide Concentrations (Bq/sample) in Air Filter Composite Samples From Stations Surrounding the WIPP Site. See Appendix G for Supporting Data.

Radionuclide		[RN][a]	2σTPU[b]	MDC[c]
$^{233/234}$U	Mean[d]	5.98E-03	2.21E-03	2.67E-02
	Minimum[e]	7.06E-04	1.99E-03	1.19E-03
	Maximum[e, f]	1.33E-02	2.65E-03	6.79E-03
^{235}U	Mean[d]	4.88E-04	5.99E-04	3.48E-03
	Minimum[e]	-1.55E-04	3.21E-04	4.27E-04
	Maximum[e, f]	2.22E-03	1.27E-03	1.97E-03
^{238}U	Mean[d]	5.79E-03	2.07E-03	2.27E-02
	Minimum[e]	8.78E-04	1.84E-03	7.81E-04
	Maximum[e, f]	1.58E-02	2.99E-03	5.74E-03
^{241}Am	Mean[d]	9.37E-05	5.64E-04	3.10E-03
	Minimum[e]	-4.00E-04	4.98E-04	6.97E-04
	Maximum[e, f]	2.90E-03	1.86E-03	9.37E-04
^{238}Pu	Mean[d]	-6.41E-06	4.62E-04	6.45E-04
	Minimum[e]	-2.31E-04	3.30E-04	4.11E-04
	Maximum[e, f]	5.78E-04	7.55E-04	4.90E-04
$^{239/240}$Pu	Mean[d]	-2.23E-04	4.40E-04	1.85E-03
	Minimum[e]	-1.30E-03	2.07E-04	5.50E-04
	Maximum[e, f]	1.99E-03	1.40E-03	6.50E-04

Table 4.3 – Mean, Minimum, and Maximum Radionuclide Concentrations (Bq/sample) in Air Filter Composite Samples From Stations Surrounding the WIPP Site. See Appendix G for Supporting Data.

Radionuclide		[RN][a]	2σTPU[b]	MDC[c]
^{40}K	Mean[d]	4.66E+00	9.76E+00	9.88E+00
	Minimum[e]	-8.14E+00	1.34E+01	1.40E+01
	Maximum[e, f]	1.48E+01	1.24E+01	1.51E+01
^{60}Co	Mean[d]	1.58E-01	1.05E+00	1.03E+00
	Minimum[e]	-1.46E+00	1.54E+00	1.52E+00
	Maximum[e, f]	1.05E+00	9.58E-01	1.24E+00
^{137}Cs	Mean[d]	-3.79E-01	1.25E+00	1.16E+00
	Minimum[e]	-2.00E+00	1.72E+00	1.74E+00
	Maximum[e, f]	1.04E+00	1.33E+00	1.49E+00
^{90}Sr	Mean[d]	-1.64E-02	3.07E-02	1.57E-02
	Minimum[e]	-3.90E-02	4.37E-02	2.96E-03
	Maximum[e, f]	1.80E-03	2.05E-02	2.12E-03

a Radionuclide concentration.
b Total propagated uncertainty
c Minimum detectable concentration
d Relative error ratio
e Minimum detectable concentration
d Arithmetic average for concentration, 2σTPU and MDC
e Minimum and maximum reported concentrations for each radionuclide are based on [RN], while the associated 2σTPU and MDC are inherited with the specific [RN]
f ID confidence was zero even though the activity was greater than the 2σTPU and MDC.

During 2009, duplicate samples were taken from four air sampling locations including location SEC during the first quarter; location SMR during the second quarter; location WFF during the third quarter; and location WEE during the fourth quarter. The WFF duplicates from the third quarter contained detectable concentrations of both $^{233/234}U$ and ^{238}U. The RERs were 1.062 for $^{233/234}U$ and 0.706 for ^{238}U.

The WEE duplicates from the fourth quarter both contained detectable concentrations of 238U. The primary sample did not contain a detectable concentration of $^{233/234}U$. The RER for the ^{238}U detections was 0.339.

Note that this ASER reports the precision of duplicate field samples as relative error ratio (RER) for the radionuclides that were detected during analysis of the primary and duplicate samples. RER is equivalent to Duplicate Error Ratio (DER) for duplicate samples. The RER calculations are performed for all the matrices where duplicate samples are collected in the field such as the duplicate particulate filters discussed in this section, duplicate groundwater samples, and other duplicate matrices discussed later in this chapter. There is no firm established quality assurance objective for the precision of field duplicates since the composition of the field samples could be slightly different. One source (Rocky Flats Annual Report of Site Surveillance and Maintenance Activities-CY2008, Doc. No. S05247, U.S. Department of Energy, April, 2009) suggested that 85 percent of field duplicates should yield RERs (DERs) <1.96. Field duplicate RERs <1 indicate very good precision for the combined sampling and laboratory analysis procedures. Poorer precision suggests that there could be actual differences in the composition of the samples collected in the field.

The laboratory generates lab duplicate samples from a single field sample. In the case of laboratory duplicates, the quality assurance objective for precision is a RER (DER) of <1. The laboratory generates precision data for all the radionuclides in a sample whether the radionuclide was detected or not based on the activities and 2σTPUs measured in the samples. The laboratory duplicate RERs are not provided in the ASER, but >99 percent of all the laboratory RERs generated for this study were <1. The laboratory's Statement of Work indicates that "the Laboratory shall assess the need for corrective actions" if the laboratory duplicate precision yields RERs >1.

4.3 Groundwater

4.3.1 Sample Collection

Groundwater samples were collected twice in 2009 from seven different WIPP groundwater quality sampling program (WQSP) wells around the WIPP site, as shown in.Figure 6.1. During each of the resulting 14 sampling episodes, a primary sample and a duplicate sample were simultaneously collected from each well. Six of these wells are completed in the Culebra Member of the Rustler Formation (wells WQSP-1 through WQSP-6) and the seventh (well WQSP-6A) is completed in the Dewey Lake Redbeds Formation. Approximately three bore volumes of water were pumped out of each well before collecting approximately 38 liters (L) (10 gallons) of water samples. The water samples were collected from depths ranging from 180-270 m (591-886 ft) from the six wells (WQSP-1 to WQSP-6), and from a depth of 69 m (226 ft) from WQSP-6A. Approximately 8 L (2 gallons) of water per well were sent to the laboratory for the measurement of the target radionuclides. The remaining portions of the samples were used to analyze for nonradiological parameters or were placed in storage. The radiological samples were filtered during collection and acidified to pH ≤ 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 and transuranic 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 then 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 again, and the isotopic separation process was initiated.

4.3.3 Determination of Individual Radionuclides

The first portion of 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 was used for the sequential separation of the uranium isotopes, the transuranics and ^{90}Sr. The samples 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, and micro-precipitating the separated radionuclides onto planchets for counting uranium/transuranics 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 2009 as shown by the data in Table 4.4. The concentrations reported in Table 4.4 are from the primary samples collected from each WQSP well. A duplicate sample from each well was analyzed during each sampling episode. The data from the duplicate samples was used for the precision determinations as reported later in this section. The radionuclides were considered detected if the activity is greater than the 2σTPU and MDC.

The 2009 groundwater concentrations in the WQSP wells were compared with the concentrations from the same locations in 2008 using ANOVA. ANOVA calculations were performed using the mean uranium concentrations from the spring and fall sampling (Rounds 28 and 29) where all the uranium isotopes were detected in the samples from both rounds. During 2008, $^{233/234}U$ and ^{235}U were not detected in WQSP-6 in the Round 27 samples. Therefore, average concentrations from the two rounds were used for ANOVA calculations except that the single concentrations from Round 26 were used for $^{233/234}U$ and ^{235}U.

The concentrations of the uranium isotopes measured in 2009 did not vary significantly from the concentrations measured in the same wells in 2008, as demonstrated by the combined ANOVA of the wells with ANOVA, $^{233/234}U$ $p = 0.737$; ^{235}U $p = 0.818$; and ^{238}U $p = 0.878$, with all p values well above the significance level of 0.05.

The concentrations of the uranium isotopes measured in 2009 were also compared to the 2008 concentrations by location. There was significant variation by location between 2008 and 2009 as shown by the combined ANOVA results of $^{233/234}U$ $p = 0.00202$; ^{235}U $p = 0.000326$; and ^{238}U $p = 0.000463$, with all p values below the significance level of 0.05. The differences in the concentrations of the uranium isotopes at the various wells (locations) are likely due to the differences in the abundance of these naturally occurring isotopes in the earth's crust and associated concentrations in groundwater.

Concentrations of uranium isotopes were also compared with baseline concentrations measured between 1985 and 1989 (baseline values: $^{233/234}U$ = 1.30 Bq/L, ^{235}U = 3.10E-02 Bq/L, ^{238}U = 3.20E-01 Bq/L). For 2009, the concentrations of $^{233/234}U$, ^{235}U, and ^{238}U were all well within the 99 percent confidence interval ranges of baseline concentrations (DOE/WIPP-92-037). Therefore, it is concluded that WIPP operations have not resulted in changes in the radiological background in the vicinity of the WIPP site.

The other alpha spectroscopy radionuclides, ^{238}Pu, $^{239/240}Pu$, and ^{241}Am were also analyzed for in the groundwater samples (Table 4.4). These isotopes were not detected in any of the groundwater samples, so no ANOVA comparisons between years and among locations could be performed.

The beta emitter, ^{90}Sr, was not detected in any of the groundwater samples, and thus no ANOVA comparisons between years or among locations could be performed. With respect to the gamma isotopes, ^{137}Cs and ^{60}Co were also not detected in any of the groundwater samples and no ANOVA comparisons were performed.

The gamma isotope ^{40}K was detected in the Round 28 and Round 29 primary samples except for Round 28 at WQSP-6 and for both rounds at WQSP-6A. The Round 29 concentration was used for WQSP-6 ANOVA calculations.

During 2008, ^{40}K was detected in Round 26 but not Round 27 at WQSP-2; was not detected during either round in WQSP-3; and was not detected during either round at WQSP-6A. The Round 26 concentration was used for WQSP-2 ANOVA calculations. As a result, ANOVA comparisons for ^{40}K for 2008 and 2009 were made for WQSP-1, WQSP-2, WQSP-4, WQSP-5, and WQSP-6.

The 2009 concentrations did not vary significantly from the 2008 concentrations based on a p value of 0.552. The ^{40}K concentrations also did not vary significantly by location, but the p value was just above the 0.05 significance level at 0.0725. 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 at various locations in the earth's crust and the associated leaching into groundwater.

The measured concentrations of ^{40}K in 2009 are within the 99 percent confidence interval range of the baseline concentrations (baseline concentration: 6.30E+01 Bq/L).

Table 4.4 – Radionuclide Concentrations (Bq/L) of Groundwater From Wells at the WIPP Site. See Chapter 6 for Sampling Locations.

Location	Round	[RN][a]	2σTPU[b]	MDC[c]	[RN][a]	2σTPU[b]	MDC[c]	[RN][a]	2σTPU[b]	MDC[c]
		^{241}Am			^{238}Pu			$^{239/240}Pu$		
WQSP-1	28	5.81E-05	4.26E-04	5.38E-04	2.17E-05	3.75E-04	3.87E-04	9.75E-05	5.02E-04	4.29E-04
	29	9.21E-04	1.08E-03	7.87E-04	-4.22E-04	7.13E-04	8.59E-04	4.83E-05	8.35E-04	9.54E-04
WQSP-2	28	5.74E-05	4.21E-04	5.15E-04	1.81E-05	3.12E-04	3.28E-04	5.50E-04	6.22E-04	3.56E-04
	29	4.77E-04	5.99E-04	5.76E-04	-3.61E-06	3.05E-04	3.06E-04	-6.92E-05	1.70E-04	3.86E-04
WQSP-3	28	5.58E-04	6.66E-04	5.40E-04	1.29E-04	3.69E-04	3.31E-04	7.71E-05	3.97E-04	3.21E-04
	29	3.62E-04	6.88E-04	6.26E-04	8.51E-06	3.46E-04	3.73E-04	-8.51E-06	3.58E-04	4.29E-04
WQSP-4	28	-2.93E-05	4.27E-04	6.54E-04	2.76E-04	4.89E-04	3.59E-04	4.24E-04	5.39E-04	3.73E-04
	29	3.71E-04	6.02E-04	5.72E-04	-1.06E-04	2.04E-04	3.21E-04	1.40E-04	3.26E-04	3.68E-04
WQSP-5	28	-3.83E-05	3.44E-04	5.24E-04	2.26E-04	4.34E-04	3.30E-04	6.30E-05	2.61E-04	3.11E-04

Table 4.4 – Radionuclide Concentrations (Bq/L) of Groundwater From Wells at the WIPP Site. See Chapter 6 for Sampling Locations.

Location	Round	[RN][a]	2σTPU[b]	MDC[c]	[RN][a]	2σTPU[b]	MDC[c]	[RN][a]	2σTPU[b]	MDC[c]
	29	9.24E-05	6.50E-04	7.14E-04	1.67E-05	4.05E-04	4.69E-04	2.12E-04	4.74E-04	4.78E-04
WQSP-6	28	2.20E-04	4.03E-04	5.75E-04	-1.16E-04	2.14E-04	3.11E-04	1.37E-05	2.75E-04	3.02E-04
	29	4.51E-04	7.21E-04	6.74E-04	-2.32E-05	3.37E-04	3.28E-04	-1.16E-05	3.29E-04	3.80E-04
WQSP-6A	28	-4.40E-04	6.26E-04	6.03E-04	5.15E-04	6.75E-04	3.33E-04	-5.18E-05	1.44E-04	3.28E-04
	29	6.70E-04	8.83E-04	7.28E-04	-1.60E-05	3.43E-04	3.54E-04	2.64E-04	4.58E-04	3.49E-04
WQSP-1	28	5.81E-05	4.26E-04	5.38E-04	2.17E-05	3.75E-04	3.87E-04	9.75E-05	5.02E-04	4.29E-04
		$^{233/234}U$			^{235}U			^{238}U		
WQSP-1	28	6.69E-01	2.77E-02	1.01E-03	1.82E-02	3.19E-03	4.45E-04	1.10E-01	7.80E-03	7.23E-04
	29	6.66E-01	1.15E-01	1.14E-03	1.95E-02	4.84E-03	5.22E-04	1.15E-01	2.12E-02	9.35E-04
WQSP-2	28	1.16E-01	8.70E-03	1.06E-03	6.05E-03	2.00E-03	5.11E-04	6.39E-02	6.14E-03	7.71E-04
	29	4.84E-01	1.09E-01	1.27E-03	4.92E-03	2.33E-03	6.74E-04	7.48E-02	1.81E-02	1.06E-03
WQSP-3	28	1.20E-01	8.90E-03	1.07E-03	2.91E-03	1.40E-03	4.93E-04	1.96E-02	3.25E-03	8.19E-04
	29	1.51E-01	6.14E-02	1.26E-03	4.12E-03	2.46E-03	6.59E-04	2.35E-02	1.02E-02	1.01E-03
WQSP-4	28	2.20E-01	1.61E-02	1.34E-03	5.16E-03	2.34E-03	7.47E-04	3.90E-02	5.88E-03	1.06E-03
	29	2.58E-01	8.42E-02	1.20E-03	1.06E-02	4.30E-03	5.78E-04	4.64E-02	1.58E-02	9.98E-04
WQSP-5	28	2.84E-01	1.52E-02	1.15E-03	6.00E-03	1.91E-03	4.57E-04	4.42E-02	4.85E-03	8.84E-04
	29	3.20E-01	1.21E-01	1.24E-03	1.10E-02	5.03E-03	6.20E-04	4.73E-02	1.85E-02	9.67E-04
WQSP-6	28	2.56E-01	1.35E-02	1.13E-03	3.19E-03	1.33E-03	4.17E-04	3.62E-02	4.15E-03	8.47E-04
	29	2.54E-01	6.92E-02	1.03E-03	6.78E-03	2.64E-03	4.98E-04	3.51E-02	1.02E-02	8.63E-04
WQSP-6A	28	1.11E-01	7.95E-03	1.07E-03	3.80E-03	1.49E-03	4.43E-04	5.82E-02	5.49E-03	8.49E-04
	29	9.56E-02	4.27E-02	1.23E-03	8.96E-03	4.82E-03	7.22E-04	4.95E-02	2.25E-02	1.03E-03
		^{40}K			^{60}Co			^{137}Cs		
WQSP-1	28	1.29E+01	7.18E+00	1.04E+01	-2.31E-01	1.10E+00	1.20E+00	-2.21E-01	1.13E+00	1.27E+00
	29	1.86E+01	7.32E+00	9.58E+00	-3.04E-01	1.13E+00	1.22E+00	-1.46E+00	1.27E+00	1.27E+00
WQSP-2	28	1.89E+01	6.26E+00	5.78E+00	-1.40E-01	1.26E+00	1.39E+00	1.05E+00	1.19E+00	1.39E+00
	29	1.72E+01	5.37E+00	5.17E+00	6.87E-02	6.32E-01	7.58E-01	1.85E-01	5.26E-01	6.29E-01
WQSP-3	28	4.91E+01	1.15E+01	9.41E+00	-1.93E-01	1.35E+00	1.48E+00	-4.07E-01	1.31E+00	1.39E+00
	29	5.32E+01	1.04E+01	6.12E+00	4.37E-01	5.97E-01	7.93E-01	-4.86E-01	5.91E-01	5.73E-01
WQSP-4	28	2.09E+01	7.32E+00	7.97E+00	-8.78E-01	1.56E+00	1.58E+00	-6.05E-01	1.34E+00	1.40E+00
	29	2.43E+01	7.11E+00	6.59E+00	1.04E+00	5.27E-01	9.02E-01	7.62E-01	6.68E-01	8.48E-01
WQSP-5	28	1.41E+01	5.81E+00	6.63E+00	-6.91E-01	1.00E+00	9.35E-01	2.42E-03	5.79E-01	6.61E-01
	29	1.03E+01	4.38E+00	4.90E+00	-4.15E-01	6.58E-01	5.97E-01	1.92E-01	4.28E-01	5.29E-01
WQSP-6	28	5.90E+00	6.28E+00	9.98E+00	6.09E-01	8.45E-01	1.06E+00	-4.03E-01	1.15E+00	1.19E+00
	29	5.34E+00	3.76E+00	5.25E+00	2.84E-01	7.17E-01	8.88E-01	-3.80E-02	7.03E-01	7.54E-01
WQSP-6A	28	2.18E+00	5.14E+00	6.68E+00	-5.53E-01	6.20E-01	5.40E-01	-1.32E-01	4.52E-01	5.20E-01
	29	6.14E+00	5.16E+00	7.68E+00	-2.79E-01	6.57E-01	6.97E-01	-1.98E-01	5.46E-01	5.76E-01
		^{90}Sr								
WQSP-1	28	8.01E-03	3.45E-02	2.97E-03						
	29	3.28E-03	3.49E-02	3.17E-03						
WQSP-2	28	-4.36E-02	3.40E-02	3.17E-03						
	29	1.24E-03	2.13E-02	1.93E-03						
WQSP-3	28	2.33E-04	3.58E-02	3.07E-03						
	29	-5.24E-03	2.53E-02	2.28E-03						
WQSP-4	28	-1.28E-02	3.32E-02	3.10E-03						
	29	-5.04E-03	2.76E-02	2.59E-03						
WQSP-5	28	-1.33E-02	2.26E-02	2.18E-03						
	29	-1.82E-02	3.34E-02	2.99E-03						
WQSP-6	28	-8.48E-04	3.94E-02	3.38E-03						
	29	-1.38E-02	3.31E-02	3.29E-03						
WQSP-6A	28	-2.04E-02	2.75E-02	2.54E-03						
	29	-1.03E-02	5.00E-02	4.16E-03						

[a] Radionuclide concentration. Only radionuclides with activities greater than the 2σTPU and MDC are "detects."
[b] Total propagated uncertainty
[c] Minimum detectable concentration

This ASER reports the precision of the duplicate field sample analyses as RERs only for the radionuclides that were detected during analysis of the primary and duplicate samples collected at each WQSP well. The detected radionuclides in the 2009 groundwater samples included the uranium isotopes and ^{40}K. The analysis data and resulting RERs are shown in Table 4.5 for 2009 Sampling Round 28 and in Table 4.6 for 2009 Sampling Round 29.

The Round 28 RERs in Table 4.5 show two values greater than 1.96 and eight additional values greater than 1.0 out of the 26 values calculated. The activities for 233/234U and 238U were over two times higher in the primary sample than in the duplicate sample. The reason for the higher activities in the primary sample could not be determined from review of the raw data. Likewise, the reason for the poorer precision for the Round 28 samples (Table 4.5) compared to the Round 29 samples (Table 4.6) could not be determined from review of the raw data. Since the RER precision data for the laboratory duplicates were <1.0, it appears that there was a difference in the composition of the primary and duplicate groundwater samples.

The laboratory analyzed one of the duplicate samples from each well from each sampling round. All RERs calculated from analysis of laboratory duplicates were <1.0, which indicated good laboratory precision for measurement of the target radionuclides.

In theory, the primary and duplicate groundwater samples should have identical concentrations since the sample containers are filled simultaneously. However, the RER results show higher RERs for some of the uranium isotope and ^{40}K analysis results for field duplicates even though the objective was met for laboratory duplicates. The alpha spectroscopy sample preparation requires many different laboratory procedures, and all the steps combined can contribute to some lack of precision. The laboratory reanalyzed some batches of samples because of spectral interferences, and some samples contained relatively weak alpha spectra as evidenced by low tracer recoveries, although the laboratory's QA/QC criteria were met.

The greater imprecision of field duplicates compared to lab duplicates suggests that the imprecision could be associated more with the samples than with the analyses and may reflect actual differences in the composition of samples.

Table 4.5 – Results of Duplicate Groundwater Sample Analyses for Sampling Round 28. Units are in Bq/L. See Chapter 6 for Sampling Locations.

Table 4.5 – Results of Duplicate Groundwater Sample Analyses for Sampling Round 28. Units are in Bq/L. See Chapter 6 for Sampling Locations.

Location		Sample			Duplicate			
		[RN][a]	2σTPU[b]	MDC[c]	[RN][a]	2σTPU[b]	MDC[c]	RER[d]
WQSP-1	$^{233/234}U$	6.69E-01	2.77E-02	1.01E-03	7.41E-01	3.07E-02	1.06E-03	1.750
	^{235}U	1.82E-02	3.19E-03	4.45E-04	2.62E-02	4.12E-03	5.05E-04	1.529
	^{238}U	1.10E-01	7.80E-03	7.23E-04	1.24E-01	8.86E-03	7.71E-04	1.147
	^{40}K	1.29E+01	7.18E+00	1.04E+01	1.67E+01	6.27E+00	6.77E+00	0.399
WQSP-2	$^{233/234}U$	1.16E-01	8.70E-03	1.06E-03	9.61E-02	7.50E-03	1.04E-03	1.733
	^{235}U	6.05E-03	2.00E-03	5.11E-04	4.61E-03	1.70E-03	4.85E-04	0.549
	^{238}U	6.39E-02	6.14E-03	7.71E-04	5.48E-02	5.45E-03	7.50E-04	1.117
	^{40}K	1.89E+01	6.26E+00	5.78E+00	1.78E+01	6.04E+00	6.14E+00	0.126

Table 4.5 – Results of Duplicate Groundwater Sample Analyses for Sampling Round 28. Units are in Bq/L. See Chapter 6 for Sampling Locations.

Location		Sample			Duplicate			
		[RN][a]	2σTPU[b]	MDC[c]	[RN][a]	2σTPU[b]	MDC[c]	RER[d]
WQSP-3	$^{233/234}U$	1.20E-01	8.90E-03	1.07E-03	1.15E-01	9.08E-03	1.12E-03	0.425
	^{235}U	2.91E-03	1.40E-03	4.93E-04	2.77E-03	1.44E-03	5.51E-04	0.074
	^{238}U	1.96E-02	3.25E-03	8.19E-04	1.69E-02	3.20E-03	8.66E-04	0.575
	^{40}K	4.91E+01	1.15E+01	9.41E+00	4.65E+01	1.00E+01	6.19E+00	0.171
WQSP-4	$^{233/234}U$	2.20E-01	1.61E-02	1.34E-03	1.08E-01	1.10E-02	1.42E-03	5.744
	^{235}U	5.16E-03	2.34E-03	7.47E-04	2.56E-03	1.79E-03	8.38E-04	0.882
	^{238}U	3.90E-02	5.88E-03	1.06E-03	1.60E-02	3.92E-03	1.13E-03	3.258
	^{40}K	2.09E+01	7.32E+00	7.97E+00	9.04E+00	5.50E+00	7.71E+00	1.295
WQSP-5	$^{233/234}U$	2.84E-01	1.52E-02	1.15E-03	2.98E-01	1.49E-02	1.11E-03	0.633
	^{235}U	6.00E-03	1.91E-03	4.57E-04	3.40E-03	1.35E-03	4.10E-04	1.111
	^{238}U	4.42E-02	4.85E-03	8.84E-04	4.13E-02	4.42E-03	8.46E-04	0.434
	^{40}K	1.41E+01	5.81E+00	6.63E+00	1.01E+01	5.15E+00	6.95E+00	0.515
WQSP-6	$^{233/234}U$	2.56E-01	1.35E-02	1.13E-03	2.92E-01	1.67E-02	1.24E-03	1.664
	^{235}U	3.19E-03	1.33E-03	4.17E-04	4.79E-03	1.90E-03	5.48E-04	0.690
	^{238}U	3.62E-02	4.15E-03	8.47E-04	4.16E-02	5.14E-03	9.52E-04	0.814
WQSP-6A	$^{233/234}U$	1.11E-01	7.95E-03	1.07E-03	1.21E-01	8.94E-03	1.13E-03	0.870
	^{235}U	3.80E-03	1.49E-03	4.43E-04	4.90E-03	1.67E-03	4.36E-04	0.490
	^{238}U	5.82E-02	5.49E-03	8.49E-04	6.54E-02	6.29E-03	9.07E-04	0.865

[a] Radionuclide concentration. Only radionuclides with activities greater than the 2σTPU and MDC are "detects."
[b] Total propagated uncertainty
[c] Minimum detectable concentration
[d] Relative error ratio

Table 4.6 - Results of Duplicate Groundwater Sample Analyses for Sampling Round 29. Units are in Bq/L. See Chapter 6 for Sampling Locations.

Location		Sample			Duplicate			
		[RN][a]	2σTPU[b]	MDC[c]	[RN][a]	2σTPU[b]	MDC[c]	RER[d]
WQSP-1	$^{233/234}U$	6.66E-01	1.15E-01	1.14E-03	7.16E-01	1.38E-01	1.21E-03	0.277
	^{235}U	1.95E-02	4.84E-03	5.22E-04	1.69E-02	4.81E-03	6.14E-04	0.230
	^{238}U	1.15E-01	2.12E-02	9.35E-04	1.16E-01	2.36E-02	1.01E-03	0.017
	^{40}K	1.86E+01	7.32E+00	9.58E+00	2.09E+01	6.68E+00	6.69E+00	0.232
WQSP-2	$^{233/234}U$	4.84E-01	1.09E-01	1.27E-03	5.29E-01	1.26E-01	1.30E-03	0.270
	^{235}U	4.92E-03	2.33E-03	6.74E-04	8.22E-03	3.39E-03	7.08E-04	0.801
	^{238}U	7.48E-02	1.81E-02	1.06E-03	8.38E-02	2.11E-02	1.09E-03	0.324
	^{40}K	1.72E+01	5.37E+00	5.17E+00	1.41E+01	4.00E+00	4.31E+00	0.463
WQSP-3	$^{233/234}U$	1.51E-01	6.14E-02	1.26E-03	1.40E-01	6.23E-02	1.31E-03	0.128
	^{235}U	4.12E-03	2.46E-03	6.59E-04	4.57E-03	2.84E-03	7.15E-04	0.119
	^{238}U	2.35E-02	1.02E-02	1.01E-03	1.95E-02	9.29E-03	1.06E-03	0.290

Table 4.6 - Results of Duplicate Groundwater Sample Analyses for Sampling Round 29. Units are in Bq/L. See Chapter 6 for Sampling Locations.

Location		Sample			Duplicate			
		[RN][a]	2σTPU[b]	MDC[c]	[RN][a]	2σTPU[b]	MDC[c]	RER[d]
	^{40}K	5.32E+01	1.04E+01	6.12E+00	5.03E+01	1.13E+01	1.07E+01	0.189
WQSP-4	$^{233/234}U$	2.58E-01	8.42E-02	1.20E-03	2.69E-01	8.07E-02	1.15E-03	0.094
	^{235}U	1.06E-02	4.30E-03	5.78E-04	1.06E-02	4.03E-03	5.27E-04	0.006
	^{238}U	4.64E-02	1.58E-02	9.98E-04	4.81E-02	1.51E-02	8.95E-04	0.076
	^{40}K	2.43E+01	7.11E+00	6.59E+00	2.58E+01	7.04E+00	6.70E+00	0.150
WQSP-5	$^{233/234}U$	3.20E-01	1.21E-01	1.24E-03	3.28E-01	1.15E-01	1.21E-03	0.046
	^{235}U	1.10E-02	5.03E-03	6.20E-04	6.29E-03	3.03E-03	5.88E-04	0.807
	^{238}U	4.73E-02	1.85E-02	9.67E-04	4.69E-02	1.71E-02	9.42E-04	0.015
	^{40}K	1.03E+01	4.38E+00	4.90E+00	6.32E+00	6.13E+00	9.53E+00	0.528
WQSP-6	$^{233/234}U$	2.54E-01	6.92E-02	1.03E-03	3.04E-01	1.05E-01	1.11E-03	0.397
	^{235}U	6.78E-03	2.64E-03	4.98E-04	9.38E-03	4.09E-03	5.94E-04	0.533
	^{238}U	3.51E-02	1.02E-02	8.63E-04	3.81E-02	1.39E-02	9.40E-04	0.171
	^{40}K	5.34E+00	3.76E+00	5.25E+00	4.76E+00	3.27E+00	4.56E+00	0.116
WQSP-6A	$^{233/234}U$	9.56E-02	4.27E-02	1.23E-03	9.41E-02	3.47E-02	1.15E-03	0.026
	^{235}U	8.96E-03	4.82E-03	7.22E-04	3.81E-03	2.17E-03	6.24E-04	0.975

[a] Radionuclide concentration
[b] Total propagated uncertainty
[c] Minimum detectable concentration
[d] Relative error ratio

4.4 Surface Water

4.4.1 Sample Collection

Surface water samples were collected from various locations around the WIPP site as shown in Figure 4.2 (see Appendix C for location codes). If a particular surface water collection location was dry, only a sediment sample from the site was collected. Sediment sample analysis results are discussed in Section 4.5.

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 one gallon of water was collected from each location. The samples were acidified to pH ≤ 2 immediately after collection with concentrated nitric acid. Later, the samples were transferred to WIPP Laboratories for analysis. Chain of custody was maintained throughout the process.

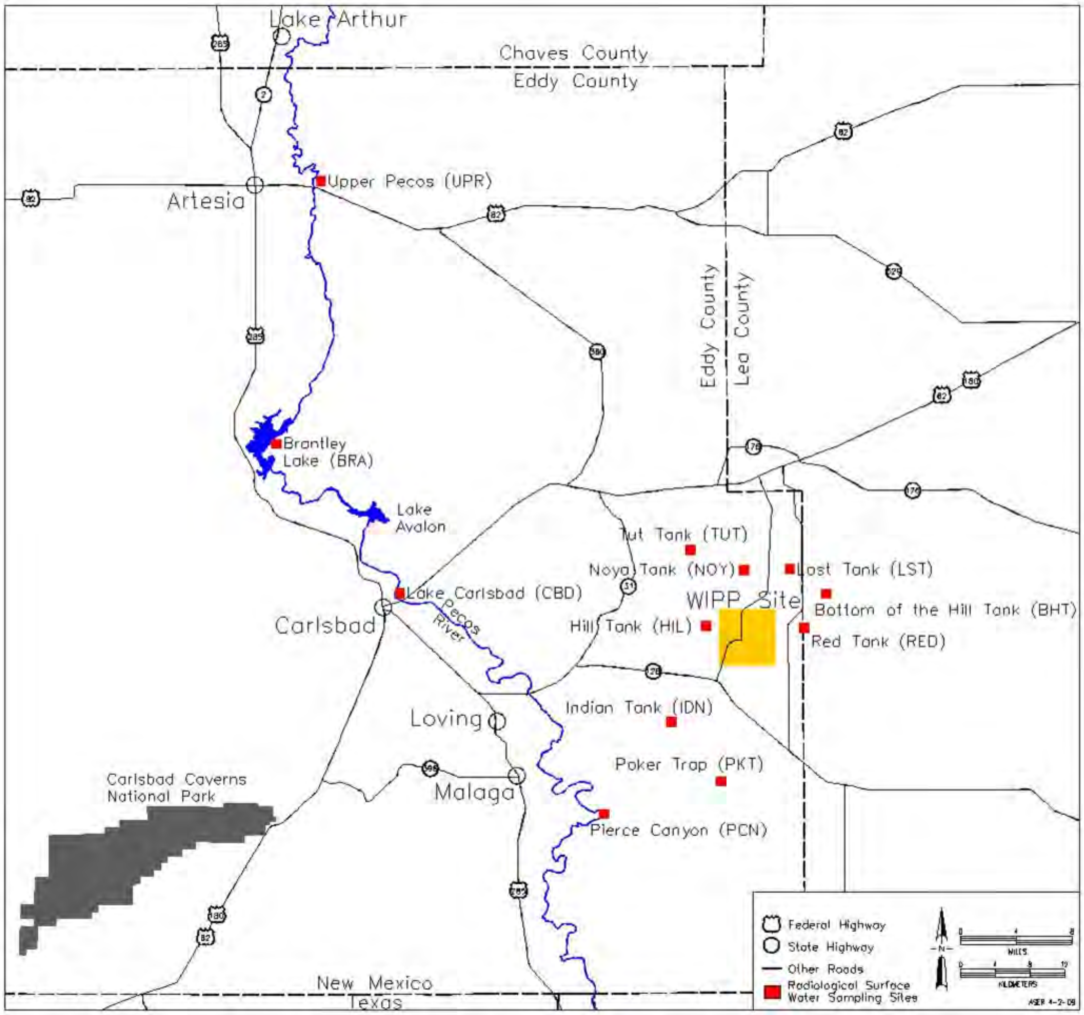

Figure 4.2 – Routine Surface Water Sampling Locations

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 again, and the isotopic separation steps were initiated.

4.4.3 Determination of Individual Radionuclides

A 0.5-L portion of the acidified water sample was used directly for the measurement of the gamma-emitting radionuclides ^{40}K, ^{60}Co, and ^{137}Cs, by gamma spectroscopy. 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, and micro-precipitating the separated radionuclides onto planchets for counting. The uranium isotopes and transuranics were counted using alpha spectroscopy, and ^{90}Sr was beta counted using a gas proportional detector.

4.4.4 Results and Discussion

Uranium isotopes were detected in most of the surface water samples, which included 14 separate samples, 2 duplicate samples, and a distilled water field blank (COW). The field blank sample (sample location COW) was submitted to the laboratory as a "blind" QC sample, and sample COY was submitted as a blind duplicate of Sample IDN. No radionuclides were detected in the field blank, while $^{233/234}$U was detected in all the samples except PCN and UPR; ^{235}U was detected in RED, SWL, BRA and BRA Dup; and ^{238}U was detected in all the samples except PKT, PCN, and UPR (Table 4.7).

The concentrations of uranium isotopes were compared between 2008 and 2009 and also among sampling locations using ANOVA for those locations where the uranium isotopes were detected both years, and using the mean concentration of duplicate samples when available. The $^{233/234}$U was detected in 12 common locations in 2008 and 2009; ^{235}U was not detected in any common locations in 2008 and 2009; and ^{238}U was detected in 11 common locations.

There was no significant variation in the concentrations of the uranium isotopes between 2008 and 2009 (ANOVA, $^{233/234}$U p=0.405 and ^{238}U p = 0.524).

There also was no significant variability among sampling locations between 2008 and 2009. The ANOVA, $^{233/234}$U p=0.394 and the ANOVA ^{238}U p = 0.552. There was greater variability in location of the uranium isotopes in 2008.

The 2009 uranium isotope surface water concentrations were also compared with the baseline concentrations measured between 1985 and 1989 (DOE/WIPP-92-037). The highest concentrations detected for $^{233/234}$U, ^{235}U, and ^{238}U in the Pecos River and associated bodies of water (BRA, CBD, PCN) were within the 99 percent confidence interval ranges of baseline levels (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).

Likewise, the highest concentrations of all three uranium isotopes for surface water samples taken from tanks and tank-like structures (BHT, HIL, PKT, RED, FWT, IDN, LST, NOY, and TUT) fell within the 99 percent confidence interval ranges of baseline concentrations (baseline levels: $^{233/234}$U = 1.00E-01 Bq/L, ^{235}U = 5.20E-03 Bq/L, and ^{238}U = 3.20E-02 Bq/L).

The uranium isotopes were not detected in the UPR surface water, so no comparison to the baseline surface water concentrations could be performed. The uranium isotopes were detected in the SWL samples, but there are no baseline sewage lagoon data with which to compare.

Table 4.7 – Uranium Concentrations (Bq/L) in Surface Water Taken Near the WIPP Site. See Appendix C for sampling location codes.

Location	[RN][a]	2σTPU[b]	MDC[c]	[RN][a]	2σTPU[b]	MDC[c]	[RN][a]	2σTPU[b]	MDC[c]
	$^{233/234}$U			^{235}U			^{238}U		
RED	1.63E-02	6.47E-03	1.10E-03	8.44E-04	8.40E-04	5.71E-04	1.11E-02	4.64E-03	9.16E-04
NOY	3.65E-03	1.42E-03	1.05E-03	2.60E-04	5.06E-04	5.20E-04	4.05E-03	1.48E-03	7.79E-04
HIL	2.67E-03	1.21E-03	1.04E-03	1.09E-04	3.68E-04	5.12E-04	2.04E-03	1.05E-03	7.73E-04
TUT	4.36E-03	1.75E-03	1.15E-03	-9.29E-05	2.75E-04	6.46E-04	3.39E-03	1.51E-03	8.81E-04
FWT	2.04E-02	3.75E-03	1.14E-03	1.19E-04	4.92E-04	6.39E-04	1.01E-02	2.61E-03	8.75E-04
COW	-9.52E-05	2.82E-04	1.27E-03	-1.01E-04	3.22E-04	7.98E-04	4.05E-05	5.71E-04	1.00E-03
PKT	2.40E-03	1.95E-03	1.29E-03	-9.63E-05	3.16E-04	8.06E-04	1.46E-03	1.47E-03	1.11E-03
IDN	4.44E-03	2.50E-03	1.19E-03	3.81E-04	6.43E-04	6.74E-04	4.23E-03	2.41E-03	9.99E-04
COY (IDN Dup)	4.58E-03	1.92E-03	1.03W-03	-6.10E-06	5.77E-05	4.79E-04	1.69E-03	9.95E-04	8.41E-04
PCN	4.68E-06	3.90E-04	1.07E-03	1.46E-04	3.71E-04	5.46E-04	-6.12E-05	1.82E-04	8.00E-04
SWL	9.49E-02	5.28E-02	1.35E-03	2.17E-03	2.04E-03	8.82E-04	3.62E-02	2.07E-02	1.17E-03
CBD	3.83E-02	5.64E-03	1.22E-03	8.53E-04	1.03E-03	7.38E-04	1.70E-02	3.68E-03	9.55E-04
BRA	6.03E-02	6.19E-03	1.08E-03	1.23E-03	9.50E-04	5.61E-04	2.96E-02	4.22E-03	8.12E-04
BRA Dup	7.26E-02	7.08E-03	1.10E-03	1.84E-03	1.20E-03	5.87E-04	3.66E-02	4.85E-03	8.34E-04
UPR	-4.11E-05	4.07E-04	1.05E-03	7.89E-05	4.10E-04	5.29E-04	-5.91E-05	1.76E-04	7.87E-04
LST	1.57E-03	1.10E-03	1.09E-03	1.13E-04	3.87E-04	5.56E-04	1.30E-03	9.79E-04	9.03E-04
BHT	3.45E-03	1.96E-03	1.13E-03	1.51E-04	4.09E-04	6.06E-04	2.38E-03	1.51E-03	9.43E-04

[a] Radionuclide concentration
[b] Total propagated uncertainty
[c] Minimum detectable concentration

The surface water samples were also analyzed for ^{238}Pu, $^{239/240}$Pu, and ^{241}Am (Table 4.8). None of these radionuclides were detected in the surface water samples in 2009 compared to one detection of ^{241}Am at UPR in 2008. Thus, no ANOVA comparisons between years and among locations could be performed.

Table 4.8 - Americium and Plutonium Concentrations in Surface Water Taken Near the WIPP Site. See Appendix C for sampling location codes.

Location	[RN][a]	2σTPU[b]	MDC[c]	[RN][a]	2σTPU[b]	MDC[c]	[RN][a]	2σTPU[b]	MDC[c]
	^{241}Am			^{238}Pu			$^{239/240}$Pu		
RED	1.59E-04	5.39E-04	6.67E-04	7.67E-05	9.64E-04	6.98E-04	1.53E-04	5.92E-04	7.25E-04
NOY	3.96E-04	5.09E-04	4.91E-04	-1.40E-04	8.51E-04	3.69E-04	2.79E-05	3.42E-04	3.96E-04
HIL	3.24E-04	4.41E-04	4.86E-04	8.93E-06	3.42E-04	3.46E-04	-3.60E-05	3.73E-04	3.84E-04
TUT	4.79E-04	5.10E-04	5.06E-04	-2.18E-04	3.45E-04	3.90E-04	-1.47E-04	2.83E-04	4.27E-04
FWT	3.24E-04	4.35E-04	4.83E-04	-1.45E-05	4.12E-04	3.98E-04	1.55E-04	4.87E-04	4.36E-04
COW	-1.37E-04	2.60E-04	5.58E-04	-1.54E-04	2.79E-04	3.62E-04	6.15E-05	3.20E-04	4.00E-04
PKT	2.87E-04	6.69E-04	8.06E-04	-1.35E-05	7.58E-04	7.37E-04	-1.35E-04	3.74E-04	7.65E-04
IDN	1.52E-04	4.85E-04	6.28E-04	-1.08E-04	5.96E-04	5.19E-04	1.27E-04	6.79E-04	5.47E-04
COY (IDN Dup)	4.14E-05	3.33E-04	5.92E-04	4.48E-04	1.24E-03	6.92E-04	-1.10E-04	7.75E-04	7.20E-04
PCN	1.47E-04	3.32E-04	4.93E-04	-1.65E-04	2.85E-04	3.52E-04	6.14E-06	3.50E-04	3.90E-04
SWL	2.65E-04	4.99E-04	5.85E-04	-1.39E-04	2.68E-04	3.70E-04	-1.17E-04	2.46E-04	3.98E-04
CBD	2.91E-04	5.27E-04	5.79E-04	2.15E-04	5.45E-04	3.65E-04	-8.22E-05	2.05E-04	4.03E-04
BRA	7.75E-05	3.65E-04	4.89E-04	-1.93E-04	3.02E-04	3.38E-04	1.46E-04	4.03E-04	3.75E-04
BRA Dup	2.98E-04	4.61E-04	4.90E-04	-1.99E-05	3.43E-04	3.27E-04	-1.43E-04	2.55E-04	3.65E-04

Table 4.8 - Americium and Plutonium Concentrations in Surface Water Taken Near the WIPP Site. See Appendix C for sampling location codes.

Location	[RN][a]	2σTPU[b]	MDC[c]	[RN][a]	2σTPU[b]	MDC[c]	[RN][a]	2σTPU[b]	MDC[c]
	^{241}Am			^{238}Pu			$^{239/240}$Pu		
UPR	1.10E-04	3.45E-04	4.88E-04	2.13E-04	4.45E-04	3.09E-04	6.73E-05	2.60E-04	3.47E-04
LST	1.48E-04	5.21E-04	6.51E-04	7.74E-04	1.45E-03	8.56E-04	-1.78E-04	4.63E-04	8.83E-04
BHT	5.01E-04	6.29E-04	5.88E-04	-4.79E-04	8.95E-04	6.14E-04	2.99E-04	7.18E-04	6.40E-04

[a] Radionuclide concentration
[b] Total propagated uncertainty
[c] Minimum detectable concentration

As shown inTable 4.9, ^{40}K was detected in only one of the surface water samples compared to seven surface water detections in 2008. The only common location where ^{40}K was detected in 2008 and 2009 was SWL, so there were not enough data to perform ANOVA comparisons.

Comparison of the detected ^{40}K (2.49E+02 Bq/L) in the SWL sample with the baseline data (baseline value: 7.60E+01 Bq/L) shows that the concentration was higher than the 99 percent confidence interval range of the baseline concentrations (DOE/WIPP-92-037). This is likely due to the varying concentrations of this ubiquitous radioisotope in crustal and surface rocks and soils.

Cesium-137, ^{60}Co, and ^{90}Sr, were not detected in any of the surface water samples (Table 4.9). Since these isotopes were not detected, no ANOVA comparisons between years and among locations was performed.

Table 4.9 - Selected Radionuclide Concentrations (Bq/L) in Surface Water Near the WIPP Site. See Appendix C for sampling location codes.

Location	[RN][a]	2σTPU[b]	MDC[c]	[RN][a]	2σTPU[b]	MDC[c]
	^{40}K			^{60}Co		
RED	1.18E+01	9.79E+00	1.24E+01	9.24E-01	9.18E-01	1.16E+00
NOY	8.80E+00	9.95E+00	1.22E+01	6.98E-01	9.82E-01	1.19E+00
HIL	-6.65E+00	1.24E+01	1.22E+01	-1.34E+00	1.40E+00	1.39E+00
TUT	1.85E+00	7.16E+00	9.01E+00	-4.28E-01	8.96E-01	8.84E-01
FWT	7.56E+00	9.62E+00	1.18E+01	1.12E-01	1.01E+00	1.15E+00
COW	1.19E+01	1.10E+01	1.43E+01	-2.32E-01	1.24E+00	1.34E+00
PKT	1.31E+01	1.06E+01	1.41E+01	-2.84E-01	1.28E+00	1.39E+00
IDN	-4.14E-01	7.79E+00	9.09E+00	6.29E-01	6.58E-01	9.04E-01
COY (IDN Dup)	-5.24E+00	1.22E+01	1.24E+01	-7.14E-02	1.14E+00	1.28E+00
PCN	1.16E+01	1.01E+01	1.35E+01	5.68E-01	1.01E+00	1.26E+00
SWL	2.49E+02	3.74E+01	1.26E+01	6.26E-01	1.62E+00	1.86E+00
CBD	9.48E+00	9.87E+00	1.22E+01	6.85E-01	1.06E+00	1.27E+00
BRA	1.29E+01	1.11E+01	1.44E+01	-2.88E-01	1.37E+00	1.48E+00
BRA Dup	-1.36E+00	7.49E+00	8.51E+00	-3.91E-01	7.31E-01	6.69E-01
UPR	2.02E+01	9.21E+00	1.27E+01	3.93E-01	1.05E+00	1.23E+00
LST	-4.52E+00	8.49E+00	8.76E+00	6.38E-01	6.70E-01	9.27E-01
BHT	7.72E-01	4.84E+00	6.07E+00	1.37E-01	5.41E-01	6.82E-01
	^{137}Cs			^{90}Sr		
RED	-1.06E+00	1.07E+00	1.19E+00	2.41E-02	3.91E-02	3.43E-03
NOY	-2.18E-01	1.12E+00	1.25E+00	-1.03E-02	2.60E-02	2.63E-03

Table 4.9 - Selected Radionuclide Concentrations (Bq/L) in Surface Water Near the WIPP Site. See Appendix C for sampling location codes.

Location	[RN][a]	2σTPU[b]	MDC[c]	[RN][a]	2σTPU[b]	MDC[c]
	^{40}K			^{60}Co		
HIL	1.65E-02	1.20E+00	1.33E+00	-6.67E-03	2.52E-02	2.62E-03
TUT	4.81E-01	5.96E-01	7.58E-01	-6.02E-03	2.60E-02	2.60E-03
FWT	-1.08E+00	1.21E+00	1.25E+00	-1.34E-02	2.66E-02	2.72E-03
COW	-4.19E-01	1.18E+00	1.25E+00	-8.60E-03	2.53E-02	2.64E-03
PKT	6.55E-02	1.17E+00	1.31E+00	-1.42E-02	3.70E-02	3.40E-03
IDN	7.13E-01	5.41E-01	7.41E-01	-1.51E-02	3.68E-02	3.43E-03
COY (IDN Dup)	2.52E-01	1.03E+00	1.16E+00	-4.35E-03	2.57E-02	2.68E-03
PCN	5.80E-01	1.05E+00	1.21E+00	-3.69E-03	2.56E-02	2.66E-03
SWL	1.58E+00	1.45E+00	1.68E+00	-1.43E-02	3.74E-02	3.45E-03
CBD	2.40E-01	1.09E+00	1.26E+00	-9.97E-03	2.74E-02	2.80E-03
BRA	-1.12E+00	1.27E+00	1.24E+00	-2.82E-02	3.78E-02	3.69E-03
BRA Dup	-2.09E-01	6.48E-01	6.90E-01	-1.55E-02	2.60E-02	2.66E-03
UPR	-2.09E-01	1.10E+00	1.23E+00	-1.19E-02	2.62E-02	2.79E-03
LST	3.16E-01	6.03E-01	7.41E-01	-2.05E-02	3.65E-02	3.49E-03
BHT	4.00E-01	4.50E-01	5.86E-01	-5.95E-03	3.65E-02	3.28E-03

[a] Radionuclide concentration
[b] Total propagated uncertainty
[c] Minimum detectable concentration

The reproducibility of the sampling and analysis procedures was assessed by collecting and analyzing duplicate samples from two locations (BRA, IDN). The IDN duplicate was blind to the laboratory and labeled "COY." The RERs were calculated for the isotopes with measurable concentrations of the target radionuclides in both the primary and duplicate samples. The RERs for the analysis results are presented in Table 4.10.

The RERs for $^{233/234}U$ and ^{238}U were <1 in the IDN duplicates. The RERs for the BRA duplicates were 1.301 and 1.102, respectively for $^{233/234}U$ and ^{238}U, while the RER for ^{235}U was 0.401.

Table 4.10 - Results of Duplicate Surface Water Sample Analyses Taken in 2009. Units are in Bq/L. See Chapter 6 for Sampling Locations.

Location		Sample [RN][a]	Sample 2σTPU[b]	Sample MDC[c]	Duplicate [RN][a]	Duplicate 2σTPU[b]	Duplicate MDC[c]	RER[d]
IDN	$^{233/234}U$	4.44E-03	2.50E-03	1.19E-03	4.58E-03	1.92E-03	1.03E-03	0.377
(Dup labeled "Coy" as blind)	^{238}U	4.23E-03	2.41E-03	9.99E-04	1.69E-03	9.95E-04	8.41E-04	0.972
BRA	$^{233/234}U$	6.03E-02	6.19E-03	1.08E-03	7.26E-02	7.08E-03	1.10E-03	1.301
	^{235}U	1.23E-03	9.50E-04	5.61E-04	1.84E-03	1.20E-03	5.87E-04	0.401
	^{238}U	2.96E-02	4.22E-03	8.12E-04	3.66E-02	4.85E-03	8.34E-04	1.102

[a] Radionuclide concentration
[b] Total propagated uncertainty
[c] Minimum detectable concentration
[d] Relative error ratio

The laboratory used the blind field duplicate sample COY (location IDN) for the laboratory duplicate sample in this batch. The RERs were reported for all the target radionuclides, including those which were not "detects." All of the RERs were <1.0. The greater imprecision for the field samples appears to be related to the collected samples and possibly the presence of particulates with a nonhomogeneous distribution of radionuclides. Surface water sampling and preservation procedures could be a factor in the lack of precision, but an actual difference in the samples seems more likely.

4.5 Sediments

4.5.1 Sample Collection

Sediment samples were collected from 12 locations around the WIPP site, with duplicate samples collected from two sites. The sites included all the same sites as for surface water except for FWT, SWL, and the COW blank (see Figure 4.3; see Appendix C for location codes). The samples were collected in 1-L plastic containers from the top 15 cm (6 in.) of the sediments of the water bodies and transferred to WIPP Laboratories for determination of individual radionuclides.

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. A 2-gram (0.08 oz) aliquot of each of the dried and homogenized sediment samples was 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 acid 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 followed by 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.

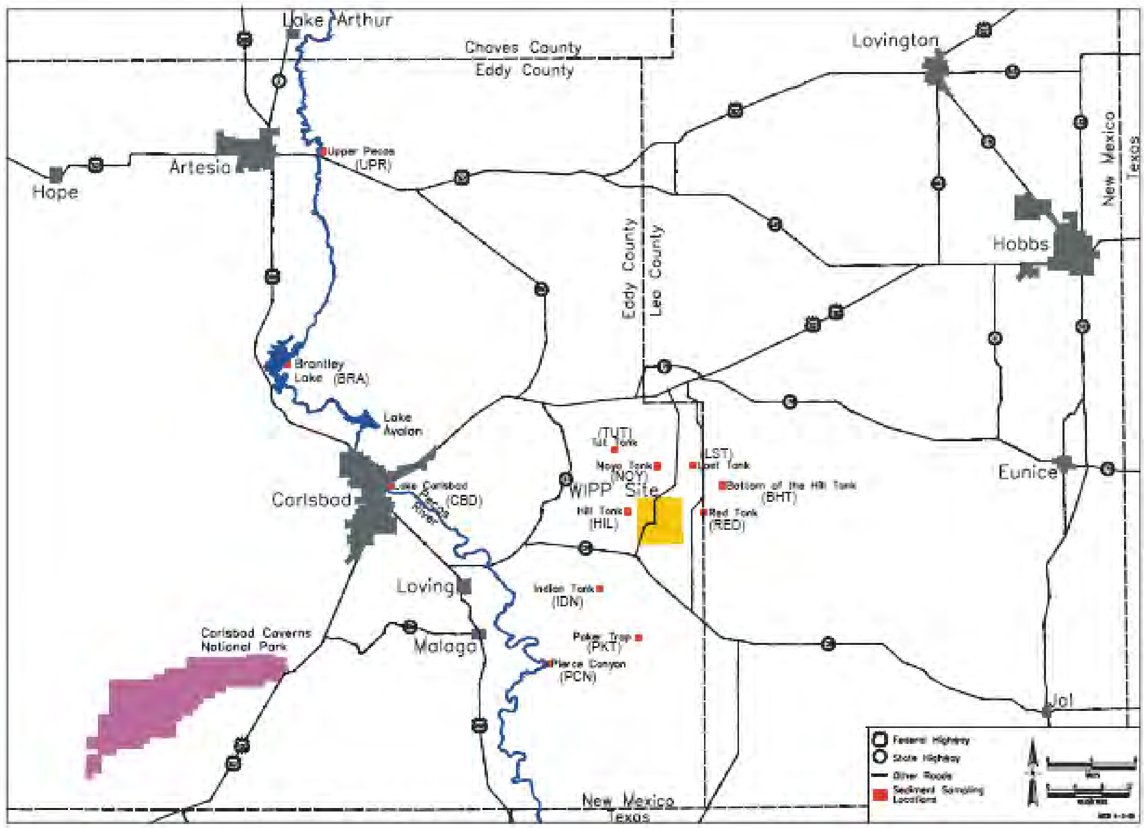

Figure 4.3 – Sediment Sampling Sites

4.5.4 Results and Discussion

Uranium-233/234, ^{235}U,and ^{238}U were detected in all the sediment samples with the exception of ^{235}U, which was not detected at the NOY and UPR locations (Table 4.11).

The concentrations of the uranium isotopes were compared between 2008 and 2009 and also among sampling locations using ANOVA. Average concentrations were used for BRA and IDN in 2009 and for CBD and TUT in 2008. There were 12 common locations with detections in both 2008 and 2009 for $^{233/234}$U and ^{238}U, and 10 common locations for ^{235}U.

The $^{233/234}$U calculations showed that the concentrations between 2008 and 2009 did not vary significantly (ANOVA, $^{233/234}$U p=0.412). The p value for difference in the concentrations of $^{233/234}$U between sampling locations was 0.0372, just below the 0.05 significance level. The value slightly favors significant difference in the $^{233/234}$U concentrations by location.

The ^{235}U ANOVA calculations showed that the concentrations between 2008 and 2009 did not vary significantly (ANOVA, ^{235}U $p=0.259$). The p value for the difference in the concentrations of ^{235}U between sampling locations was 0.020 indicating that the concentrations varied significantly more by location, which is commonly observed for sediments, likely due to the washing away of existing sediments and deposition of new sediments at some locations due to rainfall.

The ^{238}U calculations showed that the concentrations between 2008 and 2009 did not vary significantly (ANOVA, ^{235}U $p=0.748$). The concentrations did vary significantly by location (ANOVA, ^{235}U $p=0.0262$).

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).

Table 4.11 – 2009 Uranium Concentrations (Bq/g) in Sediment Samples Taken Near the WIPP Site. See Appendix C for sampling location codes.

Table 4.11 – 2009 Uranium Concentrations (Bq/g) in Sediment Samples Taken Near the WIPP Site. See Appendix C for sampling location codes.

Location	[RN][a]	2σTPU[b]	MDC[c]	[RN][a]	2σTPU[b]	MDC[c]	[RN][a]	2σTPU[b]	MDC[c]
	$^{233/234}U$			^{235}U			^{238}U		
RED	1.12E-02	1.25E-03	8.24E-04	5.92E-04	3.13E-04	1.86E-04	9.74E-03	1.16E-03	5.53E-04
NOY	7.07E-03	1.10E-03	8.49E-04	1.45E-04	1.81E-04	2.16E-04	7.38E-03	1.12E-03	5.77E-04
HIL	9.49E-03	1.16E-03	8.27E-04	5.36E-04	2.99E-04	1.89E-04	9.22E-03	1.14E-03	5.56E-04
TUT	8.96E-03	1.31E-03	8.61E-04	6.56E-04	3.98E-04	2.31E-04	1.07E-02	1.45E-03	5.89E-04
PKT	1.29E-02	1.71E-03	8.51E-04	9.01E-04	4.91E-04	2.59E-04	1.29E-02	1.70E-03	5.80E-04
IDN	1.23E-02	1.51E-03	8.54E-04	9.04E-04	4.45E-04	2.23E-04	1.22E-02	1.51E-03	5.83E-04
IDN Dup	1.21E-02	1.88E-03	8.92E-04	9.59E-04	5.90E-04	3.09E-04	1.17E-02	1.85E-03	6.20E-04
PCN	1.96E-02	1.63E-03	8.10E-04	5.67E-04	2.91E-04	1.70E-04	1.48E-02	1.39E-03	5.30E-04
CBD	6.15E-03	1.20E-03	8.62E-04	4.07E-04	3.46E-04	2.72E-04	5.28E-03	1.10E-03	5.90E-04
BRA	1.03E-02	1.34E-03	8.20E-04	6.96E-04	3.84E-04	2.20E-04	1.01E-02	1.33E-03	5.48E-04
BRA Dup	1.14E-02	1.34E-03	8.07E-04	6.73E-04	3.53E-04	2.05E-04	1.03E-02	1.26E-03	5.36E-04
UPR	6.15E-03	9.28E-04	7.99E-04	1.45E-04	1.72E-04	1.92E-04	5.79E-03	8.97E-04	5.28E-04
LST	1.04E-02	1.22E-03	8.27E-04	4.09E-04	2.63E-04	1.89E-04	1.06E-02	1.23E-03	5.56E-04
BHT	1.08E-02	1.25E-03	8.28E-04	7.14E-04	3.42E-04	1.90E-04	1.05E-02	1.23E-03	5.56E-04

[a] Radionuclide concentration
[b] Total propagated uncertainty
[c] Minimum detectable concentration

Sediment samples were also analyzed for ^{241}Am, ^{238}Pu, and $^{239/240}Pu$ by alpha spectroscopy, with the results reported in Table 4.12. There were four detects for $^{239/240}Pu$ - HIL, PKT, LST, and BHT. However, $^{239/240}Pu$ was not detected in any of the sediment samples in 2008. Since the radionuclide was not detected in 2008, no ANOVA calculations were performed.

The baseline concentration of $^{239/240}Pu$ in sediments is 1.90E-03 Bq/g, and thus, the concentrations detected in 2009 were all lower than the baseline concentration.

Table 4.12 - 2009 Americium and Plutonium Concentrations (Bq/g) in Sediment Samples Taken Near the WIPP Site. See Appendix C for sampling location codes.

Location	[RN][a]	2σTPU[b]	MDC[c]	[RN][a]	2σTPU[b]	MDC[c]	[RN][a]	2σTPU[b]	MDC[c]
		^{241}Am			^{238}Pu			$^{239/240}$Pu	
RED	6.89E-05	1.54E-04	3.03E-04	0.00E+00	8.30E-05	9.53E-05	4.17E-05	8.62E-05	1.27E-04
NOY	2.17E-04	1.77E-04	2.81E-04	-2.02E-05	9.72E-05	9.65E-05	1.42E-05	7.36E-05	1.34E-04
HIL	2.24E-04	2.21E-04	3.16E-04	-6.13E-05	1.84E-04	9.48E-05	2.13E-04	1.72E-04	1.32E-04
TUT	7.64E-05	1.56E-04	3.06E-04	-2.68E-05	5.45E-05	9.24E-05	2.06E-05	1.02E-04	1.30E-04
PKT	-2.20E-04	6.06E-04	4.46E-04	7.04E-06	1.12E-04	1.19E-04	6.41E-04	3.41E-04	1.61E-04
IDN	6.15E-05	1.80E-04	3.46E-04	-1.61E-05	9.45E-05	9.63E-05	8.98E-05	1.33E-04	1.34E-04
IDN Dup	2.05E-04	2.61E-04	3.29E-04	-4.08E-05	7.41E-05	9.95E-05	1.09E-04	1.51E-04	1.42E-04
PCN	4.20E-06	1.61E-04	3.45E-04	7.47E-06	1.50E-04	1.57E-04	5.61E-06	1.52E-04	1.99E-04
CBD	3.91E-05	1.81E-04	3.24E-04	4.03E-06	8.65E-05	9.21E-05	-2.22E-05	1.04E-04	1.35E-04
BRA	3.09E-05	1.66E-04	3.10E-04	-2.31E-05	5.73E-05	1.05E-04	-2.77E-05	6.28E-05	1.48E-04
BRA Dup	-3.50E-05	1.92E-04	3.50E-04	-2.08E-05	5.41E-05	1.04E-04	1.83E-05	8.79E-05	1.47E-04
UPR	-7.09E-06	1.23E-04	2.99E-04	6.47E-05	1.19E-04	8.83E-05	-2.11E-05	4.95E-05	1.29E-04
LST	1.86E-04	1.75E-04	2.93E-04	6.42E-05	1.34E-04	1.06E-04	2.05E-04	1.87E-04	1.44E-04
BHT	6.29E-05	1.42E-04	3.21E-04	-4.53E-06	7.83E-05	8.78E-05	1.75E-04	1.46E-04	1.26E-04

[a] Radionuclide concentration
[b] Total propagated uncertainty
[c] Minimum detectable concentration

Potassium-40 was detected in all sediment samples except for PKT and the BRA duplicate as shown in Table 4.13. The activities were greater than the 2σTPU and MDC for both samples, but the ID confidence was 0.00 for the BRA Dup, and the ID confidence was just under 0.90 for PKT.

The concentrations of ^{40}K were compared between 2008 and 2009 and also among sampling locations using ANOVA. Average concentrations were used for IDN in 2009 and for TUT and CBD in 2008. The single BRA detected concentration was used for 2009. Using the single BRA concentration, there were 12 common locations with detections in both 2008 and 2009.

When the ^{40}K analysis data from 2008 and 2009 were compared, there was no statistical difference in the concentration between the years (ANOVA, $p = 0.506$) or among locations (ANOVA, $p = 0.0741$) although the variability was greater among locations than between years.

All detected concentrations of ^{40}K observed in the sediment samples associated with the tanks and tank-like structures (these include BHT, HIL, RED, IDN, LST, NOY, and TUT) were within the 99 percent confidence interval range of baseline concentrations (baseline concentration: 1.20E+00 Bq/g).

None of the detected concentrations of ^{40}K at sediment locations associated with the Pecos River and associated bodies of water (these include PCN, CBD, BRA, and UPR) exceeded the baseline concentration for sediments (baseline concentration of 4.00E-01 Bq/g). Potassium is ubiquitous throughout the earth's crust and therefore would be expected to be present in the sediment samples.

Cesium-137 was detected in six of the twelve locations including the duplicate samples from IDN as shown by the data in Table 4.13. The radionuclide was not detected at locations NOY, TUT, PCN, BRA, BRA Dup, UPR, and CBD.

In comparing the 2009 data with the 2008 data, ^{137}Cs was detected in six common locations including RED, HIL, PKT, IDN, LST, and BHT, all which are tanks and tank-like structures.

There was no significant difference in the concentrations between 2008 and 2009 (ANOVA, $p = 0.504$). There was more of a difference in the concentrations by sampling location (ANOVA, $p = 0.209$), but the p value was higher than the 0.05 significance factor.

All the measured ^{137}Cs concentrations in the sediments associated with tanks and tank-like structures (the tank and tank-like structures include BHT, HIL, PKT, RED, FWT, IDN, LST, and NOYT) were within the 99 percent confidence interval range of the baseline concentration (3.50E-02 Bq/g). Cesium-137 is a fission product and is quite ubiquitous in sediment and soil because of global fallout from atmospheric nuclear weapons testing (Beck and Bennett, 2002; and UNSCEAR [United Nations Scientific Committee on the Effects of Atomic Radiation], 2000).

Strontium-90 and ^{60}Co were not detected in any of the sediment samples as shown in Table 4.13. Thus, no ANOVA among sampling locations or between years could be calculated.

Table 4.13 – 2009 Gamma Radionuclides and 90Sr Concentrations (Bq/g) in Sediment Samples Taken Near the WIPP Site. See Appendix C for sampling location codes.

Table 4.13 – 2009 Gamma Radionuclides and 90Sr Concentrations (Bq/g) in Sediment Samples Taken Near the WIPP Site. See Appendix C for sampling location codes.

Location	[RN][a]	2σTPU[b]	MDC[c]	[RN][a]	2σTPU[b]	MDC[c]
	^{40}K			^{60}Co		
RED	6.15E-01	8.09E-02	1.08E-02	-1.01E-03	1.30E-03	1.32E-03
NOY	1.36E-01	2.79E-02	4.73E-03	-3.49E-04	7.94E-04	8.28E-04
HIL	1.01E+00	1.42E-01	1.72E-02	2.21E-03	2.31E-03	2.76E-03
TUT	7.54E-01	1.13E-01	2.85E-02	1.89E-03	3.98E-03	4.58E-03
PKT	0.966[d]	1.37E-01	2.05E-02	-8.93E-04	2.55E-03	2.64E-03
IDN	6.51E-01	3.52E-02	8.55E-02	3.67E-04	2.31E-03	2.60E-03
IDN Dup	1.51E-01	3.14E-02	6.86E-03	-2.14E-04	1.04E-03	1.12E-03
PCN	3.48E-01	5.86E-02	2.41E-02	-1.92E-03	3.52E-03	3.60E-03
CBD	3.01E-01	3.98E-02	6.45E-03	5.44E-05	6.63E-04	7.42E-04
BRA	9.11E-02	1.91E-02	4.81E-03	7.44E-04	1.18E-03	1.36E-03
BRA Dup	0.429	6.42E-02	5.61E-02	-1.52E-04	1.58E-03	1.71E-03
UPR	3.20E-01	5.13E-02	1.90E-02	4.34E-04	2.46E-03	2.78E-03
LST	8.29E-01	1.08E-01	1.43E-02	2.86E-05	1.30E-03	1.45E-03
BHT	1.52E-01	3.15E-02	6.47E-03	-3.24E-05	1.02E-03	1.12E-03
	^{137}Cs			^{90}Sr		
RED	4.21E-03	9.04E-04	9.58E-04	-7.89E-03	7.56E-03	1.73E-03
NOY	5.57E-04	7.07E-04	7.95E-04	-7.93E-03	8.02E-03	1.75E-03
HIL	9.46E-03	1.97E-03	1.96E-03	-6.42E-03	7.87E-03	1.75E-03
TUT	5.26E-04	3.95E-03	4.32E-03	-5.71E-03	7.95E-03	1.74E-03

Table 4.13 – 2009 Gamma Radionuclides and 90Sr Concentrations (Bq/g) in Sediment Samples Taken Near the WIPP Site. See Appendix C for sampling location codes.

Location	[RN][a]	2σTPU[b]	MDC[c]	[RN][a]	2σTPU[b]	MDC[c]
PKT	1.28E-02	2.47E-03	2.32E-03	-5.16E-03	6.39E-03	1.69E-03
IDN	3.24E-03	1.26E-03	1.71E-03	-2.21E-03	7.64E-03	1.70E-03
IDN Dup	7.40E-04	3.98E-04	5.81E-04	-3.61E-03	6.20E-03	1.68E-03
PCN	2.75E-03	3.50E-03	3.97E-03	-5.08E-03	6.31E-03	1.70E-03
CBD	3.52E-04	3.37E-04	5.34E-04	-7.97E-03	6.32E-03	1.69E-03
BRA	3.22E-04	7.54E-04	8.37E-04	-5.34E-03	6.51E-03	1.73E-03
BRA Dup	-8.07E-04	1.32E-03	1.37E-03	-5.99E-03	6.64E-03	1.72E-03
UPR	9.05E-04	2.45E-03	2.73E-03	-2.46E-03	6.83E-03	1.75E-03
LST	5.48E-03	1.07E-03	1.04E-03	-1.76E-03	7.95E-03	1.74E-03
BHT	1.22E-03	4.57E-04	6.16E-04	-6.93E-03	7.47E-03	1.68E-03

[a] Radionuclide concentration
[b] Total propagated uncertainty
[c] Minimum detectable concentration
[d] Gamma spectroscopy samples with ID confidence <0.90 - not considered "detects."
Shaded values are not detected for ^{40}K and ^{137}Cs.

Duplicate analyses were performed for all the target radionuclides in sediment samples from sampling locations IDN and BRA as shown in Table 4.14. Relative error ratios are reported for the isotopes with measurable concentrations in both the primary and the duplicate samples.

The RERs were <1.0 for all the uranium isotopes detected in the primary and duplicate samples, indicating good precision for the reproducibility of the combined sampling and alpha spectroscopy analysis procedures. The RER was >1 but 1.96 for the ^{137}Cs detections in the IDN primary and duplicate samples. However, the RERs were much higher for the ^{40}K analyses in the two sets of duplicate samples. Since the laboratory duplicates readily met the precision objective, the reason for the poorer precision for the field duplicates likely reflects actual differences in the composition of the duplicate sediment samples taken in the field.

Table 4.14 - Results of 2009 Duplicate Sediment Sampling and Analysis. Units are in Bq/g. See Chapter 6 for Sampling Locations.

Location		Sample			Duplicate			
		[RN][a]	2σTPU[b]	MDC[c]	[RN][a]	2σTPU[b]	MDC[c]	RER[d]
IDN	$^{233/234}$U	1.23E-02	1.51E-03	8.54E-04	1.21E-02	1.88E-03	8.92E-04	0.064
	^{235}U	9.04E-04	4.45E-04	2.23E-04	9.59E-04	5.90E-04	3.09E-04	0.075
	^{238}U	1.22E-02	1.51E-03	5.83E-04	1.17E-02	1.85E-03	6.20E-04	0.209
	^{40}K	6.51E-01	3.52E-02	8.55E-02	1.51E-01	3.14E-02	6.86E-03	10.600
	^{137}Cs	3.24E-03	1.26E-03	1.71E-03	7.40E-04	3.98E-04	5.81E-04	1.892
BRA	$^{233/234}$U	1.03E-02	1.34E-03	8.20E-04	1.14E-02	1.34E-03	8.07E-04	0.615
	^{235}U	6.96E-04	3.84E-04	2.20E-04	6.73E-04	3.53E-04	2.05E-04	0.044
	^{238}U	1.01E-02	1.33E-03	5.48E-04	1.03E-02	1.26E-03	5.36E-04	0.114
	^{40}K	9.11E-02	1.91E-02	4.81E-03	1.21E-02	1.88E-03	8.92E-04	5.045

[a] Radionuclide concentration
[b] Total propagated uncertainty
[c] Minimum detectable concentration
[d] Relative error ratio

4.6 Soil Samples

4.6.1 Sample Collection

Soil samples were collected from near six of the locations where the low-volume air samplers are stationed around the WIPP site: MLR, SEC, SMR, WEE, WFF, and WSS (Figure 4.4). Samples were collected from each location in three incremental profiles: surface 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.

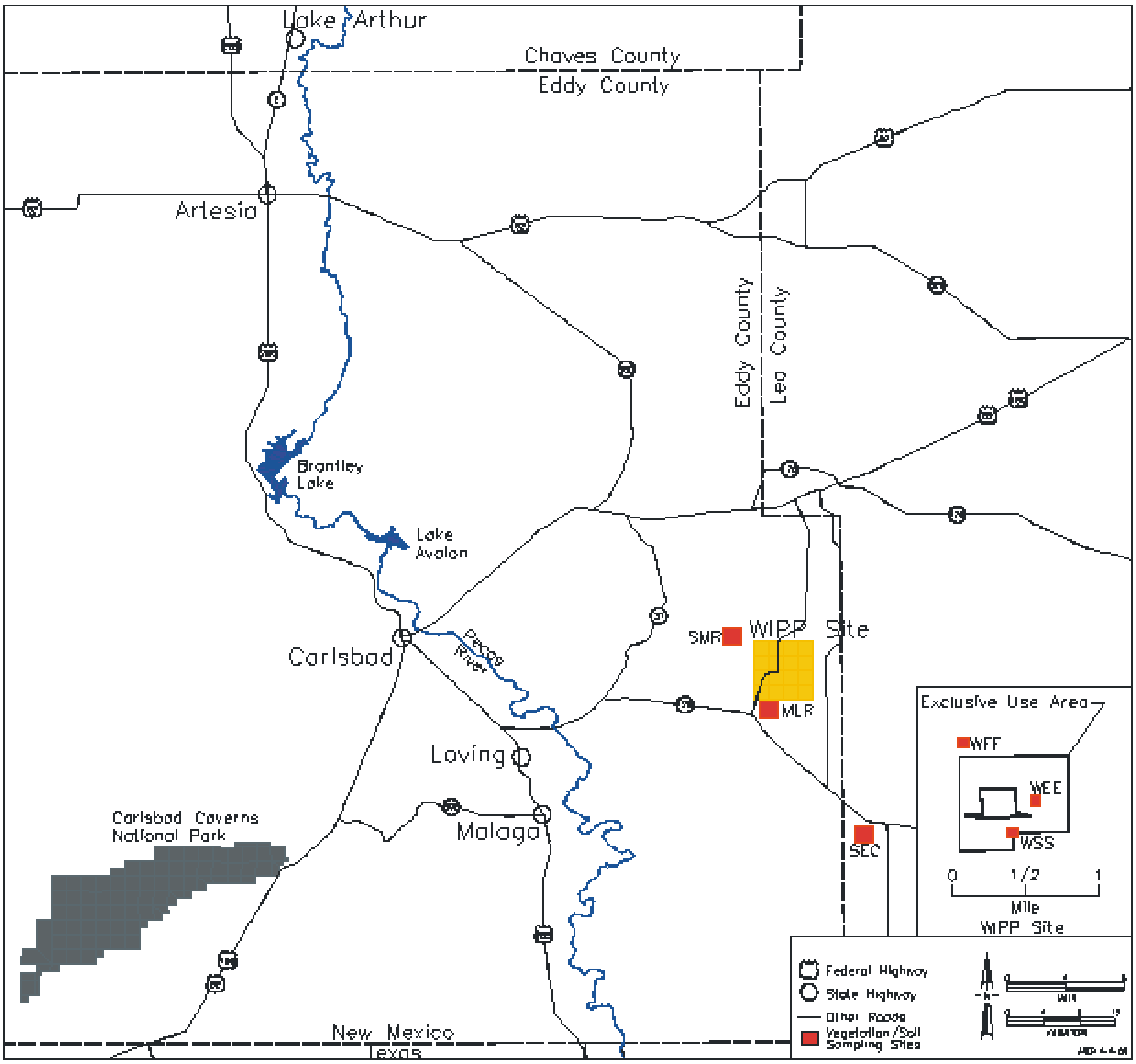

Figure 4.4 – Routine Soil and Vegetation Sampling Areas

4.6.2 Sample Preparation

Soil samples were dried at 110°C (230°F) for several hours and homogenized by grinding to small particle sizes. A 2-g aliquot of each of the dried and homogenized soil samples was 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 the measurement of 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 acid 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 followed by 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

The $^{233/234}$U and ^{238}U isotopes were detected in all soil samples, and ^{235}U was detected in a few of the samples. However, the concentrations of all the uranium isotopes in all the samples were flagged with "NJ," indicating estimated concentrations due to some interferences in the sample analyses.

Uranium-233/234 and ^{238}U were detected in all the soil samples, while ^{235}U was detected in the 0-2 cm and 5-10 cm sample of WEE; 0-2 cm and 5-10 cm samples of MLR; the first two levels of MRL duplicates; and the second two levels of SMR (five samples total).

In comparing 2008 and 2009, the primary sample was used for those sample locations where duplicate samples were taken. The general trend for these samples was that there was significant difference in concentrations between years evidenced by p values significantly <0.05 (ANOVA, $^{233/234}$U p=0.000796; ^{235}U p=0.00174; and ^{238}U p=0.00012), while the concentrations between locations was not significantly different based on p values >0.95 (ANOVA $^{233/234}$U p=0.999; ^{235}U p=997; and ^{238}U p=0.999). The significant difference between years appears to be due to generally lower uranium isotope concentrations in 2009.

The highest concentrations of $^{233/234}$U measured in 2009 (9.67E-03 Bq/g) fell within the 99 percent confidence interval range of baseline concentrations (baseline = 2.20E-02 Bq/g). The highest concentration of ^{235}U at 5.94E-04 Bq/g fell within the 99 percent confidence interval of 1.70E-03 Bq/g. The highest concentration of ^{238}U at 9.84E-03 Bq/g was lower than the ^{238}U baseline concentration of 1.30E-02 Bq/g (DOE/WIPP-92-037).

These detected concentrations are lower than the range of natural concentrations of uranium found in soils throughout the world. The average concentration of ^{238}U in the earth's soil (upper crust) is 3.60E-02 Bq/g (NCRP Report No. 94, 2009). The agreement of the measured uranium concentrations with natural uranium in soils throughout the world, and the fact that none of the transuranics that would be expected to be released along with uranium were detected in concentrations in excess of baseline quantities, suggests that these soil concentrations follow a pattern of natural variability consistent with the existence of natural uranium.

Table 4.15 - Uranium Concentrations (Bq/g) in Soil Samples Taken Near the WIPP Site. See Appendix C for sampling location codes.

Location	Depth (cm)	[RN][a]	2σTPU[b]	MDC[c]	[RN][a]	2σTPU[b]	MDC[c]	[RN][a]	2σTPU[b]	MDC[c]
		$^{233/234}U$			^{235}U			^{238}U		
WFF	0-2	2.68E-03	5.71E-04	8.44E-04	3.16E-05	1.27E-04	1.33E-04	2.37E-03	5.37E-04	6.06E-04
WFF	2-5	2.97E-03	6.60E-04	8.63E-04	1.64E-04	1.87E-04	1.56E-04	3.03E-03	6.67E-04	6.25E-04
WFF	5-10	2.51E-03	6.60E-04	8.80E-04	7.97E-05	1.65E-04	1.77E-04	3.02E-03	7.21E-04	6.42E-04
WEE	0-2	4.15E-03	7.29E-04	8.49E-04	2.67E-04	2.05E-04	1.39E-04	3.52E-03	6.66E-04	6.11E-04
WEE	2-5	3.21E-03	7.32E-04	8.77E-04	1.33E-04	1.88E-04	1.73E-04	3.71E-03	7.85E-04	6.39E-04
WEE	5-10	3.41E-03	7.15E-04	8.65E-04	3.05E-04	2.45E-04	1.58E-04	3.07E-03	6.74E-04	6.27E-04
WSS	0-2	6.54E-03	1.04E-03	8.66E-04	1.90E-04	2.39E-04	1.76E-04	5.48E-03	9.47E-04	6.33E-04
WSS	2-5	2.52E-03	6.79E-04	8.83E-04	-2.27E-05	7.05E-05	1.97E-04	2.78E-03	7.14E-04	6.50E-04
WSS	5-10	3.37E-03	7.64E-04	8.75E-04	7.97E-05	1.65E-04	1.87E-04	3.66E-03	7.94E-04	6.42E-04
MLR	0-2	4.45E-03	9.50E-04	8.94E-04	2.98E-04	2.75E-04	2.10E-04	5.05E-03	1.01E-03	6.61E-04
MLR	2-5	7.06E-03	1.24E-03	9.03E-04	2.34E-04	2.71E-04	2.21E-04	6.30E-03	1.16E-03	6.70E-04
MLR	5-10	7.43E-03	1.29E-03	9.06E-04	5.80E-04	4.04E-04	2.25E-04	5.35E-03	1.08E-03	6.73E-04
MLR Dup	0-2	7.07E-03	1.04E-03	8.77E-04	4.02E-04	2.97E-04	1.61E-04	7.25E-03	1.05E-03	6.20E-04
MLR Dup	2-5	6.58E-03	1.07E-03	8.93E-04	5.60E-04	3.50E-04	1.81E-04	6.46E-03	1.06E-03	6.37E-04
MLR Dup	5-10	6.53E-03	1.19E-03	9.19E-04	1.62E-04	2.38E-04	2.14E-04	6.56E-03	1.18E-03	6.63E-04
SEC	0-2	7.32E-03	1.65E-03	1.02E-03	3.12E-04	3.84E-04	3.36E-04	5.20E-03	1.37E-03	7.62E-04
SEC	2-5	4.73E-03	9.31E-04	9.01E-04	2.57E-04	2.57E-04	1.90E-04	5.08E-03	9.63E-04	6.44E-04
SEC	5-10	5.56E-03	1.39E-03	1.01E-03	3.82E-04	4.31E-04	3.23E-04	5.22E-03	1.34E-03	7.51E-04
SMR	0-2	9.67E-03	1.56E-03	9.42E-04	1.97E-04	2.69E-04	2.41E-04	9.84E-03	1.57E-03	6.85E-04
SMR	2-5	6.98E-03	9.81E-04	8.68E-04	5.94E-04	3.21E-04	1.50E-04	6.38E-03	9.35E-04	6.11E-04
SMR	5-10	7.00E-03	1.13E-03	8.98E-04	4.17E-04	3.14E-04	1.87E-04	6.44E-03	1.08E-03	6.42E-04

[a] Radionuclide concentration. Only radionuclides with activities greater than the 2σTPU and MDC are "detects."
[b] Total propagated uncertainty
[c] Minimum detectable concentration

Plutonium-238, $^{239/240}Pu$, and ^{241}Am were analyzed for in all the soil samples (Table 4.16). Americium-241 and ^{238}Pu were not detected in any of the soil samples.

Plutonium-239/240 was detected in seven samples, including the 2-5 cm depth of WFF; the 2-5 cm depth and 5-10 cm depth of WEE; the 0-2 cm and 2-5 cm depth of MLR duplicates; the 0-2 cm depth of SEC; and the 5-10 cm depth of SEC. The detected concentrations of $^{239/240}Pu$ were low and not much higher than the TPU.

There were five detections of $^{239/240}Pu$ in 2008. The only common locations between the two years were the 0-2 cm and 2-5 cm depths for MLR. The ANOVA calculation on this very limited data set showed that the concentrations varied significantly between years (ANOVA, $^{239/240}Pu$ $p=0.00154$), but did not vary significantly between locations (ANOVA, $^{239/240}Pu$ $p=0.970$).

The detected concentrations of $^{239/240}Pu$ fell within the 99 percent confidence interval range of the baseline concentration of 1.90E-03 Bq/g (DOE/WIPP-92-037).

Table 4.16 – Americium and Plutonium Concentrations (Bq/g) in Soil Samples Taken Near the WIPP Site. See Appendix C for sampling location codes.

Table 4.16 - Americium and Plutonium Concentrations (Bq/g) in Soil Samples Taken Near the WIPP Site. See Appendix C for sampling location codes.

Location	Depth (cm)	[RN][a]	2σTPU[b]	MDC[c]	[RN][a]	2σTPU[b]	MDC[c]	[RN][a]	2σTPU[b]	MDC[c]
		^{241}Am			^{238}Pu			$^{239/240}Pu$		
WFF	0-2	-2.23E-05	5.50E-05	3.65E-04	5.62E-05	9.39E-05	1.15E-04	-1.90E-05	4.26E-05	1.05E-04
WFF	2-5	1.71E-04	2.51E-04	4.25E-04	5.45E-05	9.47E-05	1.15E-04	1.49E-04	1.37E-04	1.05E-04
WFF	5-10	2.19E-05	1.05E-04	3.18E-04	-2.26E-05	5.24E-05	1.33E-04	-2.03E-05	4.97E-05	1.24E-04
WEE	0-2	9.65E-05	1.78E-04	3.94E-04	1.10E-05	6.25E-05	1.16E-04	3.99E-05	7.78E-05	1.07E-04
WEE	2-5	2.14E-04	2.16E-04	3.83E-04	4.22E-06	6.71E-05	1.16E-04	1.60E-04	1.37E-04	1.06E-04
WEE	5-10	1.26E-04	2.11E-04	3.97E-04	-1.81E-06	7.18E-05	1.16E-04	1.71E-04	1.35E-04	1.07E-04
WSS	0-2	1.73E-05	2.45E-04	3.65E-04	-1.72E-05	4.48E-05	1.25E-04	7.78E-05	1.10E-04	1.25E-04
WSS	2-5	2.33E-04	3.81E-04	4.09E-04	9.14E-05	1.62E-04	1.57E-04	1.40E-04	1.79E-04	1.57E-04
WSS	5-10	1.72E-04	2.61E-04	3.81E-04	-3.39E-05	6.42E-05	1.28E-04	8.58E-05	1.12E-04	1.28E-04
MLR	0-2	1.18E-04	1.61E-04	3.77E-04	-3.05E-05	6.43E-05	1.38E-04	3.17E-05	1.21E-04	1.38E-04
MLR	2-5	-3.70E-05	1.03E-04	4.57E-04	-2.92E-05	7.39E-05	1.75E-04	1.79E-05	1.22E-04	1.75E-04
MLR	5-10	6.16E-05	1.57E-04	4.56E-04	-2.51E-05	6.20E-05	1.50E-04	1.01E-04	1.45E-04	1.50E-04
MLR Dup	0-2	3.95E-04	3.03E-04	4.02E-04	3.50E-05	8.96E-05	1.37E-04	3.11E-04	1.94E-04	1.27E-04
MLR Dup	2-5	9.73E-05	1.80E-04	3.95E-04	1.21E-04	1.36E-04	1.39E-04	1.73E-04	1.59E-04	1.30E-04
MLR Dup	5-10	1.36E-04	2.28E-04	4.07E-04	1.26E-04	1.38E-04	1.42E-04	6.95E-05	1.10E-04	1.32E-04
SEC	0-2	1.25E-04	1.94E-04	3.88E-04	6.81E-05	1.04E-04	1.37E-04	2.40E-04	1.69E-04	1.28E-04
SEC	2-5	8.13E-06	1.07E-04	3.80E-04	6.57E-05	1.40E-04	1.33E-04	4.34E-05	1.15E-04	1.19E-04
SEC	5-10	1.34E-04	2.11E-04	4.68E-04	1.72E-04	2.11E-04	1.80E-04	2.93E-04	2.32E-04	1.70E-04
SMR	0-2	2.56E-04	4.18E-04	4.26E-04	3.68E-05	1.08E-04	1.50E-04	1.27E-04	1.57E-04	1.40E-04
SMR	2-5	9.77E-05	2.81E-04	3.93E-04	3.65E-05	8.24E-05	1.32E-04	1.14E-04	1.21E-04	1.23E-04
SMR	5-10	-7.14E-05	1.97E-04	4.20E-04	4.05E-05	9.43E-05	1.42E-04	1.34E-04	1.36E-04	1.32E-04

[a] Radionuclide concentration. Only radionuclides with activities greater than the 2σTPU and MDC are "detects."
[b] Total propagated uncertainty
[c] Minimum detectable concentration

The sample data in Table 4.17 show that ^{40}K was detected in all of the soil samples except the 5-10 cm depth of WFF and the 0-2 cm depth of WSS where the activity was greater than 2σTPU and the MDC, but the ID confidence was <0.90.

Potassium-40 is a naturally occurring gamma-emitting radionuclide that is ubiquitous in soils and would be expected to be present. There was no significant variation in the ^{40}K concentrations between 2008 and 2009 (ANOVA, $p = 0.361$). There also was no significant variation in the concentrations among locations, including the soil depths (ANOVA, $p=0.429$).

The highest ^{40}K concentration of 1.83E+01 Bq/g occurred at the 0-2 cm depth at location SMR. In 2008 the highest ^{40}K was at the 5-10 cm depth at SMR (6.92E-01 Bq/g). A total of eight ^{40}K concentrations in 2009 were higher than the 99 percent confidence interval range of baseline levels (3.40E-01 Bq/g) (DOE/WIPP-92-037). The other seven samples were the 0-2 cm depth of WFF (3.44 E-01 Bq/g); the 0-2 cm and 2-5 cm depth at MLR (3.79E-01 and 3.55E-01 Bq/g, respectively); all three levels in the MLR duplicate samples (3.67E-01, 3.88E-01, and 3.55E-01 Bq/g, respectively); and the 2-5 cm depth at SMR (5.28E-01 Bq/g). In 2008, the three samples from MLR were higher than the baseline concentration.

Cesium-137 was detected in all but three of the soil samples (0-2 cm and 5-10 cm depths of WSS [ID confidence <.90], and the 5-10 cm depth of MLR), while ^{60}Co and ^{90}Sr were not detected in any of the soil samples.

Statistical analyses of ^{137}Cs using the mean concentration for WSS samples show that there was no statistical difference between the concentrations in 2008 and 2009 (ANOVA, p = 0.388). In addition there was no significant difference in the concentrations among locations (ANOVA, ^{137}Cs p = 0.512).

Cesium-137 concentrations for 2009 fell within the 99 percent confidence interval range of the baseline concentration (4.00E-02 Bq/g), although the sample from 0-2 cm at SMR was close at 3.87E-02 Bq/g. Cesium-137 is a fission product and is ubiquitous in soils because of global fallout from atmospheric nuclear weapons testing (Beck and Bennett, 2002; and UNSCEAR, 2000).

Since ^{90}Sr and ^{60}Co were not detected at any sampling locations (Table 4.17), there are insufficient data to permit any kind of variance analysis between years or among sampling locations.

Table 4.17 - Selected Radionuclide Concentrations (Bq/g) in Soil Samples Taken Near the WIPP Site. See Appendix C for sampling location codes.

Location	Depth (cm)	[RN][a]	2σTPU[b]	MDC[c]	[RN][a]	2σTPU[b]	MDC[c]
		^{40}K			^{60}Co		
WFF	0-2	3.44E-01	5.25E-02	1.11E-02	5.13E-04	1.45E-03	1.68E-03
WFF	2-5	1.75E-01	2.79E-02	7.67E-03	-2.35E-04	1.03E-03	1.10E-03
WFF	5-10	0.165*[d]	2.81E-02	9.83E-03	-3.05E-04	1.27E-03	1.34E-03
WEE	0-2	2.22E-01	2.97E-02	5.79E-03	-1.67E-04	5.55E-04	6.08E-04
WEE	2-5	2.03E-01	3.17E-02	8.76E-03	4.06E-04	1.14E-03	1.32E-03
WEE	5-10	2.03E-01	3.31E-02	1.02E-02	5.01E-04	1.09E-03	1.33E-03
WSS	0-2	0.187*	2.99E-02	3.21E-02	-1.77E-04	8.06E-04	8.95E-04
WSS	2-5	1.96E-01	3.08E-02	8.53E-03	-2.23E-04	1.13E-03	1.19E-03
WSS	5-10	1.65E-01	2.94E-02	1.69E-02	-4.86E-04	1.36E-03	1.41E-03
MLR	0-2	3.79E-01	5.48E-02	1.21E-02	4.72E-04	9.59E-04	1.18E-03
MLR	2-5	3.55E-01	5.24E-02	1.07E-02	9.79E-05	1.38E-03	1.53E-03
MLR	5-10	3.02E-01	4.78E-02	1.84E-02	-4.82E-04	1.55E-03	1.61E-03
MLR Dup	0-2	3.67E-01	5.32E-02	1.08E-02	-5.70E-04	1.19E-03	1.26E-03
MLR Dup	2-5	3.88E-01	5.10E-02	7.28E-03	-6.14E-05	7.31E-04	8.18E-04
MLR Dup	5-10	3.55E-01	5.15E-02	9.72E-03	1.62E-04	1.14E-03	1.34E-03
SEC	0-2	2.15E-01	2.89E-02	5.95E-03	3.55E-04	5.36E-04	6.39E-04
SEC	2-5	2.21E-01	2.97E-02	6.60E-03	3.18E-04	5.69E-04	6.72E-04
SEC	5-10	2.26E-01	3.41E-02	9.32E-03	2.26E-04	9.61E-04	1.15E-03
SMR	0-2	1.83E+01	2.60E+00	3.77E-01	2.78E-02	4.26E-02	5.09E-02
SMR	2-5	5.28E-01	7.48E-02	1.27E-02	-6.56E-04	1.38E-03	1.47E-03
SMR	5-10	2.03E-01	2.77E-02	7.04E-03	-5.39E-04	6.74E-04	6.89E-04
Location	**Depth (cm)**	**[RN]a**	**2σTPUb**	**MDCc**	**[RN]a**	**2σTPUb**	**MDCc**
		^{137}Cs			^{90}Sr		
WFF	0-2	1.98E-03	8.42E-04	1.15E-03	-4.78E-03	6.82E-03	1.19E-03
WFF	2-5	1.86E-03	6.15E-04	7.50E-04	-9.71E-03	7.03E-03	1.21E-03
WFF	5-10	1.52E-03	6.39E-04	8.39E-04	-4.84E-03	6.75E-03	1.17E-03
WEE	0-2	2.23E-03	4.75E-04	4.98E-04	-7.00E-03	6.67E-03	1.16E-03
WEE	2-5	3.09E-03	8.17E-04	9.21E-04	-1.04E-03	7.26E-03	1.23E-03
WEE	5-10	2.35E-03	7.71E-04	9.30E-04	-1.08E-02	6.95E-03	1.21E-03
WSS	0-2	0.00164*	8.54E-04	1.13E-03	-2.81E-03	6.65E-03	1.22E-03

Table 4.17 - Selected Radionuclide Concentrations (Bq/g) in Soil Samples Taken Near the WIPP Site. See Appendix C for sampling location codes.

Location	Depth (cm)	[RN][a]	2σTPU[b]	MDC[c]	[RN][a]	2σTPU[b]	MDC[c]
		^{40}K			^{60}Co		
WSS	2-5	2.42E-03	6.80E-04	7.63E-04	-3.71E-03	7.06E-03	1.25E-03
WSS	5-10	0.00352*	1.27E-03	1.72E-03	-3.81E-03	7.03E-03	1.27E-03
MLR	0-2	6.58E-03	1.22E-03	9.49E-04	-6.89E-03	6.76E-03	1.23E-03
MLR	2-5	2.86E-03	8.69E-04	1.07E-03	-3.80E-03	6.72E-03	1.23E-03
MLR	5-10	1.23E-03	1.51E-03	1.83E-03	-7.37E-03	6.81E-03	1.23E-03
MLR Dup	0-2	7.52E-03	1.39E-03	1.15E-03	-5.66E-03	1.04E-02	1.35E-03
MLR Dup	2-5	3.59E-03	7.65E-04	8.57E-04	-9.90E-03	1.12E-02	1.42E-03
MLR Dup	5-10	2.92E-03	8.55E-04	1.03E-03	-9.96E-03	1.06E-02	1.39E-03
SEC	0-2	3.68E-03	6.29E-04	5.03E-04	-5.49E-03	1.20E-02	1.51E-03
SEC	2-5	3.80E-03	6.78E-04	6.04E-04	-3.93E-03	1.10E-02	1.42E-03
SEC	5-10	1.65E-03	6.38E-04	8.49E-04	-8.75E-03	1.09E-02	1.39E-03
SMR	0-2	3.87E-02	2.62E-02	4.01E-02	-1.07E-03	1.16E-02	1.46E-03
SMR	2-5	3.65E-03	1.23E-03	1.64E-03	-5.53E-03	1.13E-02	1.43E-03
SMR	5-10	1.27E-03	3.87E-04	4.90E-04	-6.20E-03	1.04E-02	1.35E-03

[a] Radionuclide concentration
[b] Total propagated uncertainty
[c] Minimum detectable concentration
[d] *Gamma spectroscopy samples with ID confidence less than 90 percent not considered detects.
Shaded values are not detected for ^{40}K and ^{137}Cs

Duplicate soil samples from all three depths were collected and analyzed separately from location MLR. The analysis results are shown in Table 4.18. The RERs were calculated for $^{233/234}$U, ^{235}U, and ^{238}U and for ^{40}K and ^{137}Cs in those samples with ID confidence >0.90.

All of the calculated RERs were 1.96, and all but two of the values were <1.0, demonstrating good reproducibility for the combined sampling and analysis procedures.

Table 4.18 – Results of 2009 Duplicate Soil Sampling and Analysis. Units are in Bq/g. See Chapter 6 for Sampling Locations.

Location	Depth (cm)		Sample			Duplicate			
			[RN][a]	2σTPU[b]	MDC[c]	[RN][a]	2σTPU[b]	MDC[c]	RER[d]
MLR	0-2	$^{233/234}$U	7.07E-03	1.04E-03	8.77E-04	7.32E-03	1.65E-03	1.02E-03	0.129
MLR	2-5	$^{233/234}$U	6.58E-03	1.07E-03	8.93E-04	4.73E-03	9.31E-04	9.01E-04	1.305
MLR	5-10	$^{233/234}$U	6.53E-03	1.19E-03	9.19E-04	5.56E-03	1.39E-03	1.01E-03	0.526
MLR	0-2	^{235}U	4.02E-04	2.97E-04	1.61E-04	3.12E-04	3.84E-04	3.36E-04	0.186
MLR	2-5	^{235}U	5.60E-04	3.50E-04	1.81E-04	2.57E-04	2.57E-04	1.90E-04	0.698
MLR	5-10	^{235}U	1.62E-04	2.38E-04	2.14E-04	3.82E-04	4.31E-04	3.23E-04	0.446
MLR	0-2	^{238}U	7.25E-03	1.05E-03	6.20E-04	5.20E-03	1.37E-03	7.62E-04	1.187
MLR	2-5	^{238}U	6.46E-03	1.06E-03	6.37E-04	5.08E-03	9.63E-04	6.44E-04	0.966
MLR	5-10	^{238}U	6.56E-03	1.18E-03	6.63E-04	5.22E-03	1.34E-03	7.51E-04	0.748
MLR	0-2	^{40}K	3.79E-01	5.48E-02	1.21E-02	3.67E-01	5.32E-02	1.08E-02	0.157
MLR	2-5	^{40}K	3.55E-01	5.24E-02	1.07E-02	3.88E-01	5.10E-02	7.28E-03	0.084
MLR	5-10	^{40}K	3.02E-01	4.78E-02	1.84E-02	3.55E-01	5.15E-02	9.72E-03	0.754
MLR	0-2	^{137}Cs	6.58E-03	1.22E-03	9.49E-04	7.52E-03	1.39E-03	1.15E-03	0.508
MLR	2-5	^{137}Cs	2.86E-03	8.69E-04	1.07E-03	3.59E-03	7.65E-04	8.57E-04	0.631

[a] Radionuclide concentration
[b] Total propagated uncertainty
[c] Minimum detectable concentration
[d] Relative error ratio

4.7 Biota

4.7.1 Sample Collection

Rangeland vegetation samples were collected from the same six locations from which the soil samples were collected (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

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 and carriers 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 separation of the individual radionuclides.

Fauna

The tissue samples were spiked with tracers and carriers 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 dissolved in nitric acid for the separation of the individual radionuclides.

4.7.3 Determination of Individual Radionuclides

The nitric acid digestates of the biota samples were split into two fractions. One acid 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 followed by 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

Vegetation

Table 4.19 shows that ^{238}U, $^{233/234}U$, and ^{235}U were not detected in any of the vegetation samples. There also were no uranium radionuclide detections in vegetation in 2008. Thus, no ANOVA comparisons could be performed. Americium-241, ^{238}Pu, and $^{239/240}Pu$ were not detected in any of the vegetation samples. Cesium-137, ^{60}Co, and ^{90}Sr were also not detected in any vegetation samples and no statistical comparisons between years or among locations could be performed on any of these undetected radionuclides.

Potassium-40 was detected in every vegetation sample analyzed (Table 4.19) as it was in 2008. There was no statistical difference in ^{40}K vegetation concentrations between 2008 and 2009 (ANOVA, $p = 0.480$). However, the detected concentrations varied significantly at the different locations where the vegetation was collected (ANOVA, $p = 0.00514$) due to the natural variability of this naturally occurring radionuclide in the soil. The concentrations of ^{40}K all fell within the 99 percent ID confidence range of the average baseline concentration of 3.2 Bq/g.

Table 4.19 – Radionuclide Concentrations (Bq/g Wet Mass) in Vegetation Samples Taken Near the WIPP Site. See Appendix C for sampling location codes.

Table 4.19 – Radionuclide Concentrations (Bq/g Wet Mass) in Vegetation Samples Taken Near the WIPP Site. See Appendix C for sampling location codes.

Location	[RN][a]	2σTPU[b]	MDC[c]	[RN][a]	2σTPU[b]	MDC[c]	[RN][a]	2σTPU[b]	MDC[c]
	$^{233/234}U$			^{235}U			^{238}U		
WFF	1.55E-04	1.64E-04	7.87E-04	9.14E-06	7.81E-05	1.73E-04	1.38E-04	1.47E-04	5.69E-04
WEE	1.32E-04	9.53E-05	7.55E-04	4.74E-06	4.04E-05	1.33E-04	1.36E-04	9.45E-05	5.37E-04
WEE Dup	1.39E-04	9.04E-05	7.51E-04	-3.25E-06	4.08E-05	1.28E-04	1.43E-04	8.95E-05	5.33E-04
WSS	1.77E-04	1.51E-04	7.73E-04	-4.02E-06	6.95E-05	1.55E-04	1.24E-04	1.20E-04	5.55E-04
MLR	5.31E-04	3.03E-04	7.69E-04	-1.64E-05	3.82E-05	1.51E-04	4.45E-04	2.63E-04	5.51E-04
SEC	3.10E-04	1.63E-04	7.56E-04	-1.20E-05	2.77E-05	1.34E-04	2.45E-04	1.39E-04	5.38E-04
SMR	2.03E-04	1.29E-04	7.58E-04	5.19E-06	4.42E-05	1.37E-04	2.17E-04	1.34E-04	5.40E-04
	^{241}Am			^{238}Pu			$^{239/240}Pu$		
WFF	-1.74E-06	3.75E-05	2.48E-04	-2.62E-05	4.83E-05	7.70E-05	2.31E-06	6.25E-05	7.22E-05
WEE	7.43E-07	3.02E-05	2.43E-04	1.03E-05	4.33E-05	4.78E-05	-6.61E-06	1.77E-05	4.31E-05
WEE Dup	4.62E-05	5.37E-05	2.43E-04	-5.82E-06	3.84E-05	4.80E-05	3.65E-05	5.50E-05	4.32E-05
WSS	0.00E+00	4.85E-05	2.60E-04	-1.85E-05	3.19E-05	5.28E-05	-6.11E-07	3.98E-05	4.80E-05
MLR	4.76E-05	5.92E-05	2.51E-04	-2.00E-05	3.38E-05	5.44E-05	-8.38E-06	2.19E-05	4.97E-05
SEC	1.03E-04	7.09E-05	2.43E-04	4.17E-05	5.92E-05	4.63E-05	4.94E-05	5.61E-05	4.16E-05
SMR	3.41E-05	4.71E-05	2.42E-04	-1.66E-05	2.83E-05	4.81E-05	1.25E-05	4.24E-05	4.33E-05
	^{40}K			^{60}Co			^{137}Cs		
WFF	2.96E-01	7.79E-02	6.24E-02	1.32E-03	5.99E-03	7.56E-03	-1.21E-03	6.23E-03	6.88E-03
WEE	5.15E-01	1.42E-01	9.12E-02	-2.28E-03	9.70E-03	1.03E-02	-1.86E-03	9.50E-03	1.05E-02
WEE Dup	5.10E-01	1.12E-01	7.72E-02	3.70E-03	7.70E-03	1.00E-02	1.98E-03	6.40E-03	7.66E-03
WSS	3.43E-01	1.11E-01	9.31E-02	-1.23E-03	1.02E-02	1.11E-02	-6.98E-03	1.03E-02	1.04E-02
MLR	4.26E-01	8.94E-02	6.01E-02	3.97E-03	5.22E-03	7.07E-03	-2.49E-05	5.13E-03	5.86E-03
SEC	6.57E-01	1.78E-01	1.03E-01	3.94E-03	1.15E-02	1.37E-02	-7.41E-03	1.26E-02	1.29E-02
SMR	1.34E+00	2.21E-01	7.78E-02	-1.30E-02	1.15E-02	9.42E-03	3.71E-03	7.56E-03	9.17E-03

Table 4.19 – Radionuclide Concentrations (Bq/g Wet Mass) in Vegetation Samples Taken Near the WIPP Site. See Appendix C for sampling location codes.

Location	[RN][a]	2σTPU[b]	MDC[c]	[RN][a]	2σTPU[b]	MDC[c]	[RN][a]	2σTPU[b]	MDC[c]
	^{90}Sr								
WFF	2.61E-04	2.47E-03	1.33E-03						
WEE	-3.48E-04	2.50E-03	1.34E-03						
WEE Dup	-1.66E-03	2.41E-03	1.33E-03						
WSS	-7.51E-04	2.48E-03	1.34E-03						
MLR	-1.48E-03	2.46E-03	1.34E-03						
SEC	-1.96E-03	2.36E-03	1.33E-03						
SMR	-2.11E-03	2.49E-03	1.35E-03						

[a] Radionuclide concentration.
[b] Total propagated uncertainty
[c] Minimum detectable concentration

A duplicate analysis of the vegetation sample from sampling location WEE was performed for all the radionuclides of interest. An RER was calculated for ^{40}K. The RER was less than 1, indicating good precision for the duplicate analysis.

Table 4.20 – Results of Duplicate Vegetation Sample Analysis. Units are Bq/g. See Appendix C for sampling location codes

Table 4.20 – Results of Duplicate Vegetation Sample Analysis. Units are Bq/g. See Appendix C for sampling location codes.

Location		Sample			Duplicate			
		[RN][a]	2σTPU[b]	MDC[c]	[RN]	2σTPU	MDC	RER[d]
WEE	^{40}K	5.15E-01	1.42E-01	9.12E-02	5.10E-01	1.12E-01	7.72E-02	0.024

[a] Radionuclide concentration
[b] Total propagated uncertainty
[c] Minimum detectable concentration
[d] Relative error ratio

<u>Fauna</u>

Table 4.21 shows that the only radionuclide to be detected in any of the animal samples was ^{40}K, and that it was detected in all the samples. Uranium-233/234, ^{235}U, ^{238}U, ^{241}Am, ^{238}Pu, $^{239/240}Pu$, ^{137}Cs, ^{60}Co, and ^{90}Sr, were not detected in any of the animal samples. No statistical comparisons between locations or years could be performed for any of these undetected radionuclides.

The fauna samples with the ^{40}K detections included a quail, three fish, a cottontail rabbit, and a deer sample. However, there were too few samples to allow statistical comparison between years. The detected ^{40}K concentrations were within the baseline analysis results, including 0.39 Bq/g for rabbit (dry); 0.41 Bq/g for quail (dry); 0.61 Bq/g for fish (dry); and 0.34 Bq/g for beef muscle (dry) (DOE/WIPP-92-037).

These results can only be used as a gross indication of uptake by the animals, since the sample sizes are too small to provide a thorough analysis. Within this limitation, the data suggest that there has not been any animal uptake of the radionuclides at the WIPP facility.

Precision data for animal samples were limited to laboratory duplicates from the same sample since duplicate animal samples were not collected. The precision is measurable in samples where the radionuclides were not detected, and the laboratory duplicate RERs were all <1 for all the radionuclides measured in three different fish samples.

Table 4.21 – Radionuclide Concentrations (Bq/g Wet Mass) in Quail, Fish, Rabbit, and Deer Samples Taken Near the WIPP Site. See Appendix C for sampling location codes.

Biota (Location)	[RN][a]	2σTPU[b]	MDC[c]	[RN][a]	2σTPU[b]	MDC[c]	[RN][a]	2σTPU[b]	MDC[c]
	$^{233-234}U$			^{235}U			^{238}U		
Quail (WEE)	1.32E-05	4.41E-06	7.07E-04	8.24E-07	1.33E-06	6.29E-05	1.87E-05	5.23E-06	5.32E-04
Fish (PCN)	1.30E-04	7.30E-05	8.36E-04	6.21E-06	5.33E-06	1.16E-04	7.17E-05	4.11E-05	5.51E-04
Fish (BRA)	9.86E-05	2.88E-05	7.31E-04	3.74E-06	2.71E-06	1.01E-04	5.74E-05	1.77E-05	5.65E-04
Fish (CBD)	1.75E-05	7.88E-06	7.31E-04	-2.60E-07	7.27E-07	1.20E-04	1.15E-05	5.81E-06	5.37E-04
Rabbit (SOO)	1.33E-05	4.35E-06	7.08E-04	7.89E-07	1.24E-06	6.75E-05	1.13E-05	3.96E-06	4.09E-04
Deer (SOO)	2.34E-07	1.99E-06	7.47E-04	-3.85E-07	1.19E-06	7.85E-05	2.07E-06	2.99E-06	4.53E-04
	^{241}Am			^{238}Pu			$^{239/240}Pu$		
Quail (WEE)	1.58E-06	2.34E-06	3.05E-04	9.10E-07	1.50E-06	6.25E-05	2.33E-06	1.96E-06	1.99E-05
Fish (PCN)	3.64E-07	1.76E-06	2.19E-04	6.63E-07	1.48E-06	5.79E-05	-7.36E-08	3.23E-07	8.16E-05
Fish (BRA)	2.75E-08	1.21E-06	2.67E-04	5.40E-07	3.75E-06	3.12E-05	-1.40E-06	2.36E-06	3.60E-05
Fish (CBD)	1.57E-06	1.98E-06	2.62E-04	-2.07E-07	5.56E-07	5.32E-05	2.46E-07	8.89E-07	5.79E-06
Rabbit (SOO)	1.89E-06	2.43E-06	2.39E-04	-2.87E-07	5.93E-07	1.51E-05	9.55E-08	8.14E-07	4.36E-05
Deer (SOO)	1.85E-06	3.49E-06	1.92E-04	6.33E-08	1.27E-06	6.03E-06	-4.44E-07	9.01E-07	5.82E-05
	^{40}K			^{60}Co			^{137}Cs		
Quail (WEE)	6.05E-02	2.16E-02	2.90E-02	-4.44E-04	3.24E-03	3.65E-03	-3.35E-03	4.12E-03	4.48E-03
Fish (PCN)	3.47E-02	1.35E-02	1.72E-02	1.73E-03	2.11E-03	2.66E-03	7.15E-04	2.30E-03	2.64E-03
Fish (BRA)	1.04E-01	2.62E-02	2.51E-02	9.87E-04	2.75E-03	3.33E-03	-2.12E-03	3.38E-03	3.52E-03
Fish (CBD)	6.69E-02	1.92E-02	1.88E-02	-9.64E-04	2.55E-03	2.74E-03	1.01E-03	2.80E-03	3.21E-03
Rabbit (SOO)	2.78E-02	1.80E-02	2.75E-02	2.62E-03	2.79E-03	3.37E-03	-3.54E-03	3.62E-03	3.79E-03
Deer (SOO)	5.00E-01	5.92E-02	6.22E-02	3.91E-03	6.18E-03	7.14E-03	-1.10E-02	7.57E-03	8.02E-03
	^{90}Sr								
Quail (WEE)	-7.13E-05	1.07E-04	2.77E-04						
Fish (PCN)	-2.03E-05	5.81E-05	7.34E-04						
Fish (BRA)	-7.80E-05	8.28E-05	1.18E-03						
Fish (CBD)	-1.44E-05	8.55E-05	1.13E-03						
Rabbit (SOO)	-7.53E-05	7.48E-05	1.06E-04						
Deer (SOO)	-2.55E-05	7.94E-05	1.38E-03						

[a] Radionuclide concentration
[b] Total propagated uncertainty
[c] Minimum detectable concentration

4.8 Potential Dose From WIPP Operations

4.8.1 Dose Limits

Compliance with the regulatory standards is determined by comparing annual radiation doses to the regulatory standards. The regulatory standards can be found in 40 CFR Part 191, Subpart A. The referenced standard 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 mrem to the whole body and 75 mrem to any critical organ. In addition, in a 1995 MOU between the EPA and the DOE, the DOE agreed that the WIPP facility would comply with the applicable NESHAP for radionuclides. The NESHAP standard states that the emissions of radionuclides to the ambient air from DOE facilities shall not exceed those amounts that would cause any member of the public to receive in any year an EDE of 10 mrem per year. 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 that total is the EDE. In this manner, the risk from different sources of radiation can be controlled by a single standard.

Compliance with applicable regulatory requirements is determined by monitoring, extracting, and calculating 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 predicts air concentrations, 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 is 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 >0.04 mSv (4 mrem). It is important to note that all of these dose equivalent limits are set for radionuclides released to the environment from DOE operations. They do not include, but 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, thorium, and their decay products. Potassium-40 is another source of terrestrial radiation. While not a major radiation source, ^{40}K in the southeastern New Mexico environment may be due to the deposition of tailings from local potash mining. Radon gas, a decay product of uranium, is a widely known naturally occurring terrestrial radionuclide. In addition to natural radioactivity, small amounts of radioactivity from aboveground nuclear weapons tests that occurred from 1945 through 1980, and the 1986 Chernobyl nuclear accident are also present in the environment. Together, these sources of radiation are called "background" radiation.

Naturally occurring radiation in our environment can deliver both internal and external doses. Internal dose is received as a result of the intake of radionuclides. The routes of intake of radionuclides for members of the public are ingestion and inhalation. Ingestion includes eating and drinking food or drink containing radionuclides. Inhalation includes the intake of radionuclides through 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) (Table 4.22).

Table 4.22 - Annual Estimated Average Radiation Dose Received by a Member of the Population of the United States From Naturally Occurring Radiation Sources (adapted from NCRP, 2009)

Source	Average Annual EDE (mSv)	Average Annual EDE (mrem)
Internal Radionuclides, inhalation (radon and thoron)	2.28	228
External, Space	0.33	33
Internal, Ingestion	0.29	29
External, Terrestrial	0.21	21
Rounded Total from Natural Sources	3	311

NCRP,2009: National Council on Radiation Protection and Measurements (NCRP) Report No. 160. March 3, 2009. National Council on Radiation Protection and Measurements; 7910 Woodmont Avenue, Suite 400. Bethesda, MD 20814-3095.

4.8.3 Dose From Air Emissions

The 40 CFR Part 191, Subpart A, standard limits radiation doses to members of the public in the general environment. The DOE has identified air emissions as the major pathway of concern for the WIPP facility.

Compliance with Subpart A (40 CFR §191.03[b]) and the NESHAP standard (40 CFR §61.92) is determined by comparing annual radiation doses to the MEI to the regulatory standards. As recommended by the EPA, the DOE uses computer modeling to calculate radiation doses for compliance with the Subpart A and NESHAP standards. Compliance procedures for DOE facilities (40 CFR §61.93[a]) require the use of CAP88-PC or AIRDOS-PC computer models, or equivalent, to calculate dose to members of the public. Source term input for CAP88-PC was determined by radiochemical analyses of filter air samples taken from 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 CH and RH waste. A combination of measured concentration or activity results, the 2σTPU and MDC, were used as input nuclide data in the CAP88-PC computer model 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

The radiation dose equivalent received by members of the public as a result of the management and storage of TRU radioactive wastes at any disposal facility operated by the DOE is regulated under 40 CFR Part 191, Subpart A. Specific standards 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 other critical organ. Section 4.8.4.3 discusses the potential dose equivalent received from radionuclides released to the air from WIPP. 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 2009.

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 not expected to be affected by WIPP facility contaminants based on current radionuclide transport scenarios summarized in the *Waste Isolation Pilot Plant Documented Safety Analysis* (DOE/WIPP-08-3372). The only credible pathway for contaminants from the WIPP facility to accessible groundwater is through the Culebra Member of the Rustler Formation (Culebra) as stated in *Title 40 CFR Part 191 Compliance Certification Application for the Waste Isolation Pilot Plant 2004* (DOE/CAO-96-2194). Water from the Culebra is naturally not potable due to high levels of total dissolved solids (TDS). Water from the Dewey Lake Redbeds Formation is suitable for livestock consumption, having TDS values below 10,000 milligrams per liter (mg/L). Groundwater samples collected around the WIPP facility during 2009 did not contain radionuclide concentrations discernable from those in samples collected prior to the WIPP facility receiving waste.

4.8.4.2 Potential Dose From Wild Game Ingestion

Game animals sampled during 2009 were mule deer, rabbit, fish, and quail. The only radionuclides detected were not different from baseline levels measured prior to commencement of waste shipments to the WIPP facility. Therefore, no dose from WIPP facility-related radionuclides could have been received by any individual from this pathway during 2009.

4.8.4.3 Total Potential Dose From All Pathways

The only credible pathway from the WIPP facility to humans is through air emissions and, therefore, this is the only pathway for which a dose is calculated. The total radiological dose and atmospheric release at WIPP in 2009 is summarized in Table 4.23 for the regulations 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 fence line in the northwest sector. For 2009, the dose to this receptor was estimated to be <1.71E-05 mSv (1.71E-03 mrem) per year for the whole body and <2.10E-05 mSv (2.106E-03 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 2009 assumed to be residing 7.5 km (4.66 mi) west-northwest of WIPP is calculated to be <7.80E-07 mSv (7.80E-05 mrem) per year for the whole body. This value is in compliance with 40 CFR §61.92 requirements.

As required by DOE Order 5400.5, Chapter II, Section 6.b, the collective dose to the public within 80 km (50 mi) of the WIPP facility has been evaluated, and is 2.57E-06 Sv (2.75E-04 rem) in 2009. The collective dose to the public is a factor considered in developing the field program for the ALARA process, as required by DOE Order 5400.5, Chapter II, Section 2.a(2).

Table 4.23 – WIPP Radiological Dose and Release Summary

Table 4.23 - WIPP Radiological Dose and Release Summary

WIPP Radiological Atmospheric Releases [a] During 2009

^{238}Pu	$^{239/240}$Pu	^{241}Am	^{90}Sr
1.5E-07 Ci	2.3E-07 Ci	2.1E-07 Ci	2.8E-06 Ci
5,550 Bq	8,510 Bq	7,770 Bq	103,600 Bq
$^{233/234}$U	**^{238}U**	**^{137}Cs**	
4.8E-07 Ci	4.4E-07 Ci	2.9E-04 Ci	
17,760 Bq	16,280 Bq	10,730,000 Bq	

WIPP Radiological Dose Reporting Table in 2009

Pathway	EDE to the MEI at 7,500 Meters WNW		Percent of EPA 10-mrem/ Year Limit to Member of the Public	Estimated Population Dose Within 50 Miles		Estimated Population Dose Within 50 Miles[b]	Estimated Natural Radiation Population Dose[c]
	(mrem/year)	*(mSy/year)*		*(person-rem/year)*	*(person-Sv/year)*		*(person-rem)*
Air	7.80E-05	7.80E-07	7.80E-04	2.57E-04	2.57E-06	101,017	30,305
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 in 2009

Pathway	Dose equivalent to the whole body of the receptor who resides year-round at WIPP fence line 350 meters NW		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 350 meters NW		Percent of EPA 75-mrem/Year Critical Organ Limit
	(mrem/year)	*(mSy/year)*		*(mrem/year)*	*(mSv/year)*	
Air	1.71E-03	1.71E-05	6.84E-03	2.10E-03	2.10E-05	2.80E-03
Water	N/A	N/A	N/A	N/A	N/A	N/A
Other Pathways	N/A	N/A	N/A	N/A	N/A	N/A

a Total releases from the combination of Stations A, B, and C. Values are calculated from detected activities or either the 2σTPU or MDC, whichever are greater (where activities were less than the 2σTPU and MDC) and multiplied by the ratio of flow to stack flow volumes.

b Source: 2000 Census Data

c Estimated natural radiation populations dose = (estimated population within 50 mi) x (300 mrem/year)

d Not applicable at WIPP

4.8.5 Dose to Nonhuman Biota

Dose limits for populations of aquatic and terrestrial organisms are discussed in NCRP Report No. 109, Effects of Ionizing Radiation on Aquatic Organisms (NCRP, 1991), and the International Atomic Energy Agency (IAEA) 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 mGy/d (1 rad/d)
- Terrestrial plants - 10 mGy/d (1 rad/d)
- Terrestrial animals - 1 mGy/d (0.1 rad/d)

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 was 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 (BCGs) 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 BCGs and the results are summed for each organism. If the sum of these fractions is <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 2009 using the maximum radionuclide concentrations listed in Table 4.24, and the sum of fractions was <1.0 for all media. The element ^{40}K is not included in Table 4.24 since it is a natural component of the earth's crust and is not part of TRU-waste-related radionuclides.

Table 4.24 – 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 in 2008

Table 4.24 – 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 in 2008

Medium	Radionuclide	Maximum Detected Concentration	BCG[a]	Concentration/BCG
		Aquatic System Evaluation		
Sediment (Bq/g)	^{60}Co	ND[c]	5.00E+01	N/A[d]
	^{90}Sr	ND	2.00E+01	N/A
	^{137}Cs	1.28E-02	1.00E+02	1.28E-04
	$^{233/234}U$	1.96E-02	2.00E+02	9.80E-05
	^{235}U	9.59E-04	1.00E+02	5.59E-06
	^{238}U	1.48E-02	9.00E+01	1.64E-04
	^{238}Pu	ND	2.00E+02	N/A
	$^{239/240}Pu$	ND	2.00E+02	N/A
	^{241}Am	ND	2.00E+02	N/A
Water[b] (Bq/L)	^{60}Co	ND	1.00E+02	N/A
	^{90}Sr	ND	1.00E+01	N/A
	^{137}Cs	ND	2.00E+00	N/A
	$^{233/234}U$	9.49E-02	7.00E+00	1.36E-02
	^{235}U	2.17E-03	8.00E+00	2.71E-04
	^{238}U	3.66E-02	8.00E+00	4.58E-03
	^{238}Pu	ND	7.00E+00	N/A
	$^{239/240}Pu$	ND	7.00E+00	N/A
	^{241}Am	ND	2.00E+01	N/A
			SUM OF FRACTIONS	1.88E-02

Table 4.24 – 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 in 2008

Medium	Radionuclide	Maximum Detected Concentration	BCG[a]	Concentration/BCG
		Terrestrial System Evaluation		
Soil (Bq/g)	^{60}Co	ND	3.00E+01	N/A
	^{90}Sr	ND	8.00E-01	N/A
	^{137}Cs	3.87E-02	8.00E-01	4.84E-02
	$^{233/234}$U	9.67E-03	2.00E+02	4.84E-05
	^{235}U	5.94E-04	1.00E+02	5.94E-06
	^{238}U	9.84E-03	6.00E+01	1.64E-04
	^{238}Pu	ND	2.00E+02	N/A
	$^{239/240}$Pu	3.11E-04	2.00E+02	1.56E-06
	^{241}Am	ND	1.00E+02	N/A
Water (Bq/L)	^{60}Co	ND	4.00E+04	N/A
	^{90}Sr	ND	2.00E+04	N/A
	^{137}Cs	ND	2.00E+04	N/A
	$^{233/234}$U	9.49E-02	1.00E+04	9.49E-06
	^{235}U	2.17E-03	2.00E+04	1.09E-07
	^{238}U	3.66E-02	2.00E+04	1.83E-06
	^{238}Pu	ND	7.00E+03	N/A
	$^{239/240}$Pu	ND	7.00E+03	N/A
	^{241}Am	ND	7.00E+03	N/A
			SUM OF FRACTIONS	4.86E-02

[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 water sample were assumed to be co-located
[c] Not detected in all sampling locations for a given medium
[d] Not available for calculation

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

4.8.6 Release of Property Containing Residual Radioactive Material

There was no release of radiologically contaminated materials or property from the WIPP facility in 2009. The criteria used for release of potentially radioactive materials are specified in DOE Order 5400.5, *Radiation Protection of the Public and the Environment,* Figure IV-1, Allowable Total Residual Surface Contamination. The primary isotopes of concern for unrestricted release of potentially contaminated materials are transuranic. The values for transuranic isotopes are very low and close to minimum detectable activity for instruments used for the assessments of removable and total contamination levels on items being released. The values in Order 5400.5 for transuranics are <20 percent of the values in ANSI/HPS [Health Physics Society] N13.12-1999, *Surface and Volume Radioactivity Standards for Clearance*.

4.9 Radiological Program Conclusions

Effluent Monitoring

For 2009, the EDE to the receptor (hypothetical MEI) who resides year-round at the fence line is <1.71E-05 mSv (1.71E-03 mrem) per year for the whole body, and is

<2.10E-05 mSv (2.10E-03 mrem) per year for the critical organ. For the WIPP effluent monitoring program, Figure 4. 5 and Table 4.25 show the dose to the whole body for the hypothetical MEI for CY 1999 to CY 2009. In addition, Figure 4.6 and Table 4.26 show the dose to the critical organ for the hypothetical MEI for CY 1999 to CY 2009. These dose equivalent values are below the 25 mrem to the whole body and 75 mrem to any critical organ, in accordance with the provisions of 40 CFR §191.03(b).

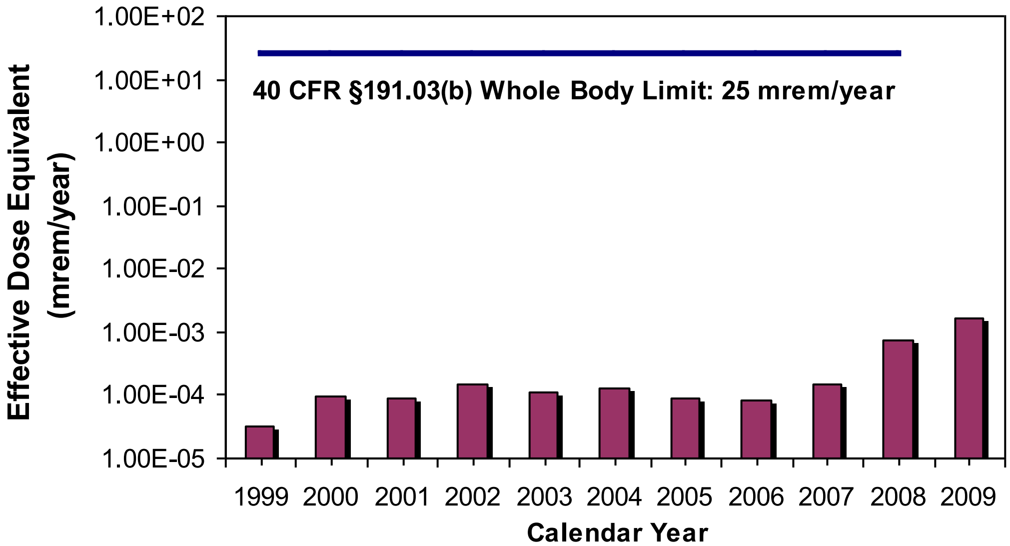

Figure 4. 5 – Dose To the Whole Body for the Hypothetical MEI at the WIPP Fence Line (In the 2008 ASER, the 2005 whole body limit was illustrated incorrectly.)

Table 4.25 – Comparison of Dose to the Whole Body to EPA Limit of 25 mrem/Year per 40 CFR §191.03(b)

Year	Annual Dose (mrem/yr)	Percent of EPA Limit
1999	3.10E-05	0.00012
2000	9.35E-05	0.00037
2001	8.99E-05	0.00036
2002	1.51E-04	0.0006
2003	1.15E-04	0.00046
2004	1.27E-04	0.00051
2005	8.86E-05	0.00035
2006	8.16E-05	0.00033
2007	1.52E-04	0.00061
2008	7.14E-04	0.0029
2009	1.71E-03	0.0068
40 CFR §191.03(b) Whole Body Limit	25	

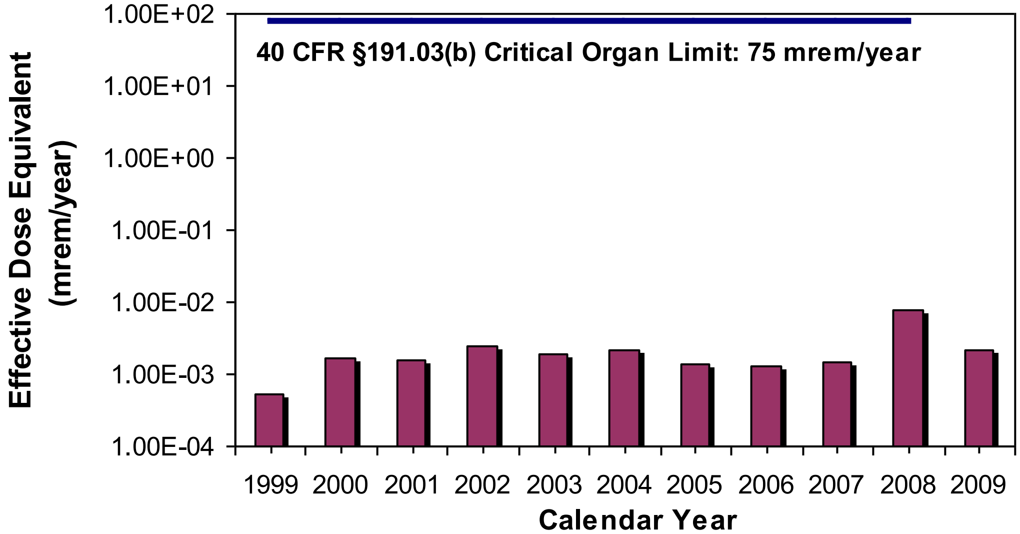

Figure 4.6 – Dose to the Critical Organ for Hypothetical MEI at the WIPP Fence Line

Table 4.26 – Comparison of Dose to the Critical Organ to EPA Limit of 75 mrem/Year per 40 CFR §191.03(b)

Year	Annual Dose (mrem/yr)	Percent of EPA Limit
1999	5.30E-04	0.00071
2000	1.63E-03	0.0022
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	0.0014
2009	2.10E-03	0.0028
40 CFR §191.03(b) Critical Organ Limit	75	

In addition, for 2008, the EDE to the MEI from normal operations conducted at the WIPP facility is <7.81E-03 mSv (7.81E-05 mrem) - no new numbers given in markup per year. For the WIPP effluent monitoring program, Figure 4.7 and Table 4.27 show the EDE to the MEI for CY 1999 to CY 2009. These EDE values are more than six orders of magnitude below the EPA NESHAP standard of 10 mrem per year, as specified in 40 CFR §61.92.

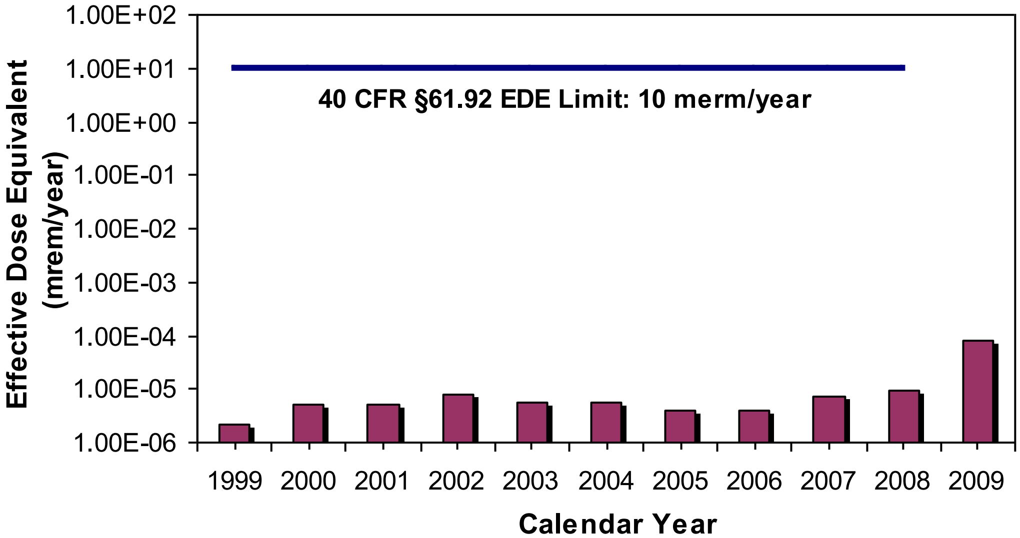

Figure 4.7 – WIPP EDE to the Off-Site MEI

Table 4.27 - Comparison of EDEs to EPA Limit of 10 mrem/Year per 40 CFR

Year	Annual Dose (mrem/yr)	Percent of EPA Limit
1999	2.23E-06	0.000022
2000	5.18E-06	0.000051
2001	4.96E-06	0.000050
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

Environmental Monitoring

Radionuclide concentrations observed in environmental monitoring were extremely small and comparable to radiological baseline levels. Appendix H contains graphs comparing detected radionuclide concentrations to their respective baseline values. In cases where the radionuclide concentrations slightly exceeded baseline levels (uranium isotopes and ^{40}K in some samples), these differences are most likely due to natural spatial variability, and they are so far below the regulatory limit as to be nonimpactive.

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CHAPTER 5 — ENVIRONMENTAL NONRADIOLOGICAL PROGRAM INFORMATION

Nonradiological programs at the WIPP facility include land management, meteorological monitoring, VOC monitoring, hydrogen and methane monitoring, seismic monitoring, certain aspects of liquid effluent, and groundwater monitoring. The monitoring is performed to comply with the provisions of the WIPP HWFP. Surface water monitoring is performed in accordance with the discharge permit (DP-831). Radiological and nonradiological groundwater monitoring is discussed in Chapters 4 and 6, respectively.

5.1 Principal Functions of Nonradiological Sampling

The principal functions of the nonradiological environmental surveillance program are to:

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

5.2 Land Management Programs

On October 30, 1992, the WIPP LWA was approved by Congress. This act transferred the responsibility for the management of the WIPP Land Withdrawal Area from the Secretary of the Interior to the Secretary of Energy. In accordance with Sections 3(a)(1) and (3) of the Act, these lands:

> . . . are withdrawn from all forms of entry, appropriation, and disposal under the public land laws . . . are reserved for the use of the Secretary . . . for the construction, experimentation, operation, repair and maintenance, disposal, shutdown, monitoring, decommissioning, and other authorized activities associated with the purposes of WIPP as set forth in Section 213 of the Department of Energy National Security and Military Application of the Nuclear Energy Authorization Act of 1980 (Pub. L. 96-164; 93 Stat. 1259, 1265), and this Act.

The DOE developed the LMP as required by Section 4 of the WIPP LWA. The LMP identifies resource values, promotes multiple-use management, and identifies long-term goals for the management of WIPP lands until the culmination of the decommissioning phase. The LMP was developed in consultation and cooperation with the BLM and the state of New Mexico.

The LMP sets forth cooperative arrangements and protocols for addressing WIPP-related land management actions. Commitments contained in current permits, agreements, or concurrent Memoranda of Understanding with other agencies will be respected when addressing and evaluating land use management activities and future amendments that affect the management of WIPP lands.

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 may be submitted to the Land Use Coordinator by any organization wishing to complete any construction, right-of-way, pipeline easement, or similar action within the WIPP Land Withdrawal Area or on lands used in the operation of the WIPP facility, under the jurisdiction of the DOE. In 2009, thirteen land use requests were submitted to, and approved by, the Land Use Coordinator.

5.2.2 Wildlife Population Monitoring

In 1995, the USFWS provided an updated list of threatened and endangered species for Eddy and Lea Counties, New Mexico. Included were 18 species that may be present on DOE lands. A comprehensive evaluation in support of the SEIS-II (*Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement*, DOE/EIS-0026-S-2) was conducted in 1996 to determine the presence or absence of threatened or endangered species in the vicinity of the WIPP site and the effect of WIPP facility operations on these species. Results indicated that activities associated with the operation of the WIPP facility had no impact on any threatened or endangered 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 MOU, the Joint Powers Agreement with the state of New Mexico, and 50 CFR Part 17, "Endangered and Threatened Plants and Wildlife." An example of this is protection is the Lesser Prairie Chicken (a candidate for listing under the Endangered Species Act) and its habitat in accordance with BLM guidance. Favorable habitat for the Lesser Prairie Chicken has been observed within the WIPP Land Withdrawal Area and areas affected by WIPP operational activities.

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 which are conducive to soil stabilization, wildlife, and livestock needs. Additionally, special seed mixes identified by the BLM are used where necessary to preserve the habitat of the Lesser Prairie Chicken.

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:

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

During 2009, WIPP surveillance teams conducted weekly surveillances and field inspections.

Proposed new well locations, staked within one mile of the WIPP site, are field-verified. This ensures that the proposed location is of sufficient distance from the WIPP boundary to protect the WIPP site from potential trespass. Ten new wells were drilled and completed in 2009. If a well is within 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. Deviation calculations showed that there were no trespass conditions.

5.3 Meteorological Monitoring

The WIPP facility meteorological station is located 600 m (1,970 ft) northeast of the Waste Handling Building. The main function of the station is to provide data for atmospheric dispersion modeling. The station measures and records wind speed, wind direction, and temperature at elevations of 2, 10, and 50 m (6.5, 33, and 165 ft). Measurements taken at 10 m (33 ft) are provided in this report. The station also records ground-level measurements of barometric pressure, relative humidity, precipitation, and solar radiation.

5.3.1 Climatic Data

The precipitation at the WIPP site for 2009 was 268.98 mm (10.6 in.). Figure 5. 1 displays the monthly precipitation at the WIPP site. Snow at the WIPP site was minimal in 2009.

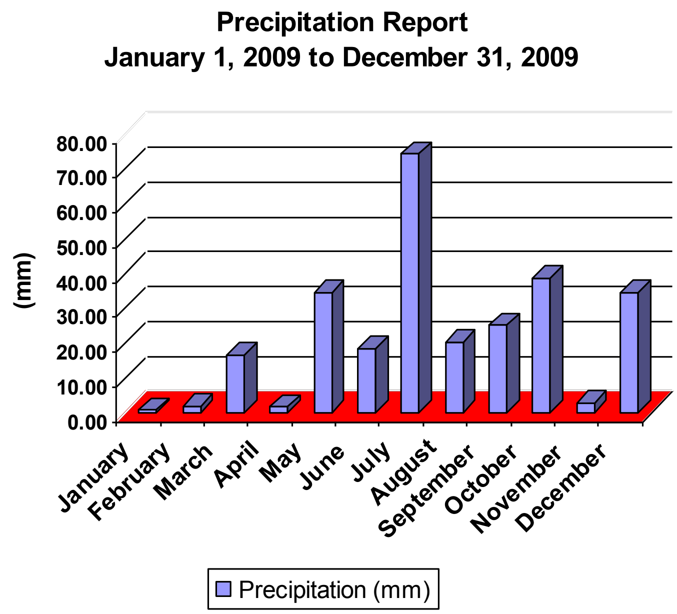

Figure 5. 1 – WIPP Precipitation Report for 2009

The maximum recorded temperature at the WIPP site in 2009 was 38.11°C (100.6°F) in July (Figure 5.2). Monthly temperatures are illustrated in Figure 5.2, Figure 5.3, and Figure 5.4. The mean temperature at the WIPP site in 2009 was 16.67°C (62.01°F). The mean monthly temperatures for the WIPP area ranged from 27.43°C (81.35°F) during June to 4.79°C (40.62°F) in December (Figure 5.3). The lowest recorded temperature was -6.08°C (21.06°F) in January (Figure 5.4).

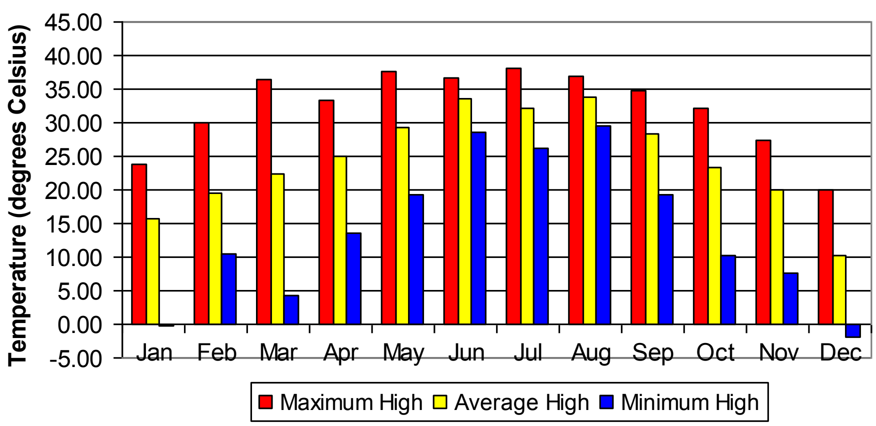

Figure 5.2 – WIPP High Temperatures for 2009

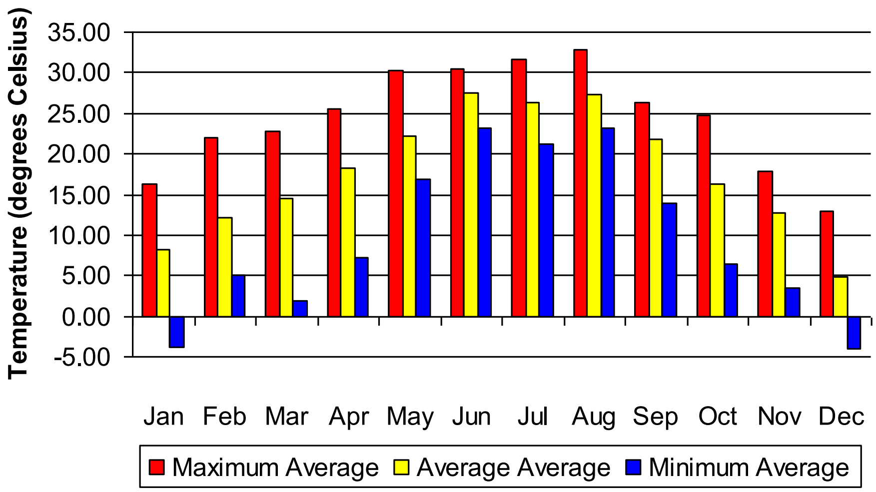

Figure 5.3 – WIPP Average Temperatures for 2009

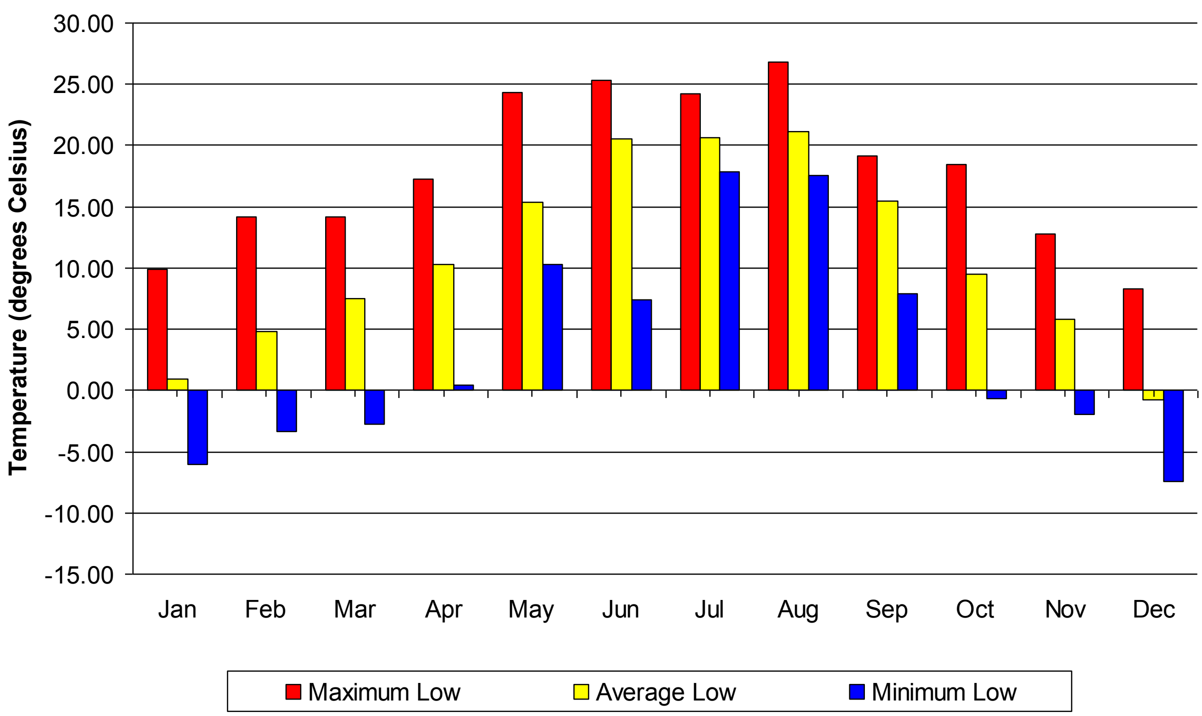

Figure 5.4 – WIPP Average Low Temperatures for 2009

5.3.2 Wind Direction and Wind Speed

Winds in the WIPP area are predominantly from the southeast. In 2009, wind speed measured at the 10-m (33-ft) level was calm (less than 0.5 meters per second [m/s]) (1.1 miles per hour [mph]) approximately 1.12 percent of the time. Winds of 3.71 to 6.30 m/s (8.30 to 14.09 mph) were the most prevalent over 2009, occurring approximately 34.7 percent of the time. There were no tornadoes at the WIPP site in

2009; the strongest wind recorded at WIPP was 25.26 m/s (56.5 mph). Figure 5.5 displays the annual wind data at WIPP for 2009.

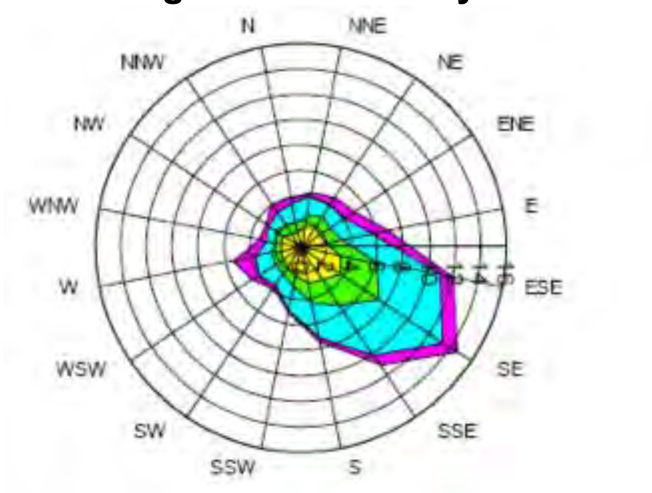

Figure 5.5 – Wind Speed Report for 2009

Table 5.1 – Wind Speed Report (Meters/Second)
January 1, 2009 to December 31, 2009 – Elevation 10.0 Meters

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
E	0.06	0.58	1.40	1.22	2.58	1.08	6.91
ENE	0.05	0.40	1.34	1.01	1.29	1.00	5.09
NE	0.06	0.44	1.51	0.99	1.04	0.72	4.75
NNE	0.06	0.41	1.24	0.86	1.52	0.27	4.37
N	0.04	0.28	0.95	0.74	1.49	0.51	4.02
NNW	0.04	0.37	0.86	0.80	1.23	0.65	3.95
NW	0.09	0.42	1.26	0.68	0.58	0.27	3.31
WNW	0.05	0.38	1.13	0.51	0.74	0.53	3.33
W	0.21	0.32	1.05	0.65	1.30	1.74	5.28
WSW	0.05	0.33	1.31	0.71	1.49	0.67	4.56
SW	0.08	0.39	1.40	0.56	1.07	0.36	3.86
SSW	0.07	0.48	1.68	0.95	1.82	0.21	5.21
S	0.05	0.57	2.17	1.64	2.67	0.33	7.43
SSE	0.07	0.57	2.44	2.31	4.86	0.87	11.12
SE	0.04	0.68	3.07	3.51	6.06	1.35	14.70
ESE	0.08	0.66	2.48	2.84	4.98	1.08	12.13
	1.12%	7.29%	25.27%	19.98%	34.70%	11.63%	100.00%

5.4 Volatile Organic Compound Monitoring

VOC monitoring was implemented on April 21, 1997, in accordance with WP 12-VC.01, Confirmatory Volatile Organic Compound Monitoring Program. This program is a requirement of the HWFP. VOC monitoring is performed to verify that VOCs emitted by the waste are within the concentration limits specified by the HWFP.

Nine target compounds, which contribute approximately 99 percent of the calculated human health risks from RCRA constituents, were chosen for monitoring. These target compounds are shown in Table 5.1.

On November 16, 2006, additional HWFP conditions were implemented, requiring the addition of disposal room VOC monitoring to the program. This new requirement included the addition of sampling locations within active hazardous waste facility units. Within each active unit, two sampling locations are required for each filled 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. The sampling frequency for disposal room sampling is once every two weeks. Typical disposal room VOC sampling locations are shown in Figure 5.6.

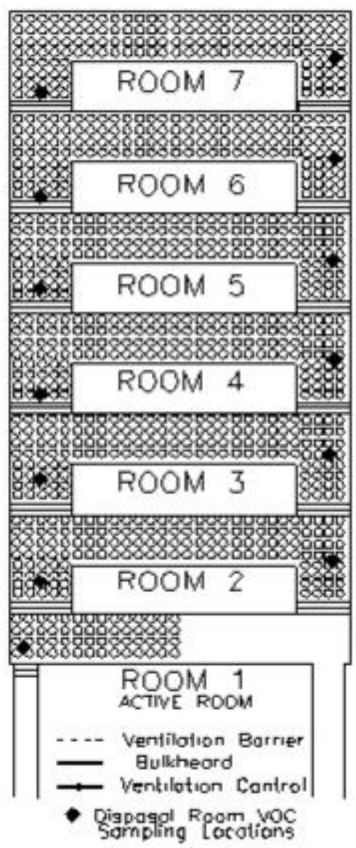

Figure 5.6 – Typical Disposal Room VOC Sampling Locations

For panel 4, sampling locations included two locations in rooms 7 through 2 and one location at the exhaust side of room 1. Sampling in panel 5 included two locations in rooms 7 and 6, and one location at the exhaust side of rooms 5.

On March 25, 2008, new permit conditions were added, requiring ongoing disposal room VOC monitoring in "filled" panels (panels in which waste emplacement is complete). Ongoing disposal room VOC monitoring included the continued monitoring of VOCs in room 1 of the filled panel. The sampling frequency for ongoing disposal room monitoring is once per month. For 2009, ongoing disposal room monitoring was conducted in panels 3 and 4.

Repository VOC sampling for target compounds is performed semiweekly at two ambient air monitoring stations. The stations are identified as VOC-A, located downstream from hazardous waste disposal unit panel 1 in Drift E300, and VOC-B, located upstream from the active panel. As waste is placed in new panels, VOC-B will be relocated to ensure that it samples underground air before it passes the waste panels. The location of VOC-A is not anticipated to change.

Target compounds found in VOC-B are not attributable to open or closed panels. The VOC concentrations measured at this location are VOCs entering the mine through the air intake shaft and VOCs contributed by facility operations upstream of the waste panels. Differences measured between the two stations represent any VOC contributions from the waste panels. Any positive concentration differences in the annual averages between the two stations must be less than the concentrations of concern listed in the HWFP (Table 5.1).

Table 5.2 – Concentrations of Concern for Volatile Organic Compounds, From Module IV of the HWFP (No. NM4890139088-TSDF)

Compound	Concentration of Concern ppbv[a]	Room Based Limits ppmv[b]
1,1,1-Trichloroethane	590	33,700
1,1,2,2-Tetrachloroethane	50	2,960
1,1-Dichloroethylene	100	5,490
1,2-Dichloroethane	45	2,400
Carbon tetrachloride	165	9,625
Chlorobenzene	220	13,000
Chloroform	180	9,930
Methylene chloride	1,930	100,000
Toluene	190	11,000

[a] Parts per billion by volume
[b] Parts per million by volume

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

For repository VOC sampling, the routine method reporting limits (MRLs) and maximum concentrations detected (MCDs) are shown in Table 5. 2. It should be noted that the MRLs are between 20 times and 386 times lower than the respective concentrations of concern for the nine target compounds.

The results of 2009 repository VOC monitoring, compared to 2008 (found in the *Semiannual VOC Data Summary* [DOE/WIPP-09-3443]), indicated an increase in the maximum and mean concentration of each detected target compound in air downstream of panel 1. Although the sample results for 2009 showed an overall increase in the concentration of detections and 28 individual sample sets (VOC-A and VOC-B) exceeded the concentration of concern for carbon tetrachloride, the annual average for repository VOC sample results remained below the concentrations of concern listed in Table 5.1.

Table 5.3 – Repository Air VOC MRLs and MCDs

Compound	MRL (ppbv)*	Annual Average (ppbv)	MCD (ppbv)*
1,1,1-Trichloroethane	5	15.8	75.88
1,1,2,2-Tetrachloroethane	2	<MRL	<MRL
1,1-Dichloroethylene	5	<MRL	<MRL
1,2-Dichloroethane	2	<MRL	<MRL
Carbon Tetrachloride	2	107.8	393.65
Chlorobenzene	2	<MRL	<MRL
Chloroform	2	10.8	46.04
Methylene chloride	5	<MRL	20.39
Toluene	5	<MRL	<MRL

* ppbv = parts per billion by volume

For disposal room VOC monitoring, 235 samples were collected during 2009 (including field duplicates). The routine MRLs and MCDs are shown in Table 5. 3. Four of the nine target compounds were detected above the MRL. The sample results indicated an increase in maximum concentrations detected in disposal rooms for chloroform at 22.2 ppmv (less than 0.3 percent of room-based limits [RBL]), and methylene chloride at 7.6 ppmv (less than 0.01 percent of RBL) 1,1,1-trichloroethane at 28.4 ppmv (0.09 percent of RBLs shown in Table 5.1), and carbon tetrachloride at 518.2 ppmv (5.38 percent of RBL).

Table 5.4 – Disposal Room VOC MRLs and MCDs

Compound	MRL (ppmv)*	MCD (ppmv)*
1,1,1-Trichloroethane	0.5	28.4
1,1,2,2-Tetrachloroethane	0.5	<MRL
1,1-Dichloroethylene	0.5	<MRL
1,2-Dichloroethane	0.5	<MRL
Carbon Tetrachloride	0.5	518.2
Chlorobenzene	0.5	<MRL
Chloroform	0.5	22.2
Methylene chloride	0.5	7.6
Toluene	0.5	<MRL

* ppmv = parts per million by volume

Ongoing disposal room VOC monitoring was conducted in panels 3 and 4 during 2009. A total of 12 samples and 12 field duplicates were collected in panel 3 and 8 samples and 8 field duplicates were collected from panel 4. Ongoing disposal room VOC monitoring results are listed in Table 5.4.

Table 5.5 – Ongoing Disposal Room VOC MRLs and MCDs

Compound	MRL (ppmv)*	MCD (ppmv)*
1,1,1-Trichloroethane	0.5	104.5
1,1,2,2-Tetrachloroethane	0.5	<MRL
1,1-Dichloroethylene	0.5	<MRL
1,2-Dichloroethane	0.5	<MRL
Carbon Tetrachloride	0.5	511.3
Chlorobenzene	0.5	<MRL
Chloroform	0.5	46.9
Methylene chloride	0.5	27.8
Toluene	0.5	<MRL

* ppmv = parts per million by volume

5.5 Hydrogen and Methane Monitoring

Hydrogen and methane monitoring in "filled" panels 3 through 7 was included as a new permit condition on March 25, 2008. Hydrogen and methane are required to be monitored at two locations in each room and at four additional bulkhead locations in the panel area upon the completion of waste emplacement in each panel. Monitoring is required for each location on a monthly basis. In April 2008, this permit condition was implemented. For 2009, hydrogen and methane monitoring was conducted in panels 3 and 4.

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.

A total of 336 samples were collected between January 1, 2009, and December 31, 2009. The maximum detected value for hydrogen, 732.4 ppmv, was considerably lower than the action levels (less than 19 percent of Action Level 1 and less than 9.2 percent of Action Level 2 shown in Table 5.5). None of the samples contained methane.

Table 5.6 – Hydrogen and Methane MRLs Action Levels and MCDs

Compound	MRL (ppmv)*	Action Level 1	Action Level 2	MCD (ppmv)
Hydrogen	0.5	4,000	8,000	732.4
Methane	0.5	5,000	10,000	N/A

* ppmv = parts per million by volume

5.6 Seismic Activity

Currently, seismicity within 300 km (186 mi) of the WIPP site is being monitored by the New Mexico Institute of Mining and Technology (NMIMT) using data from a nine-station network approximately centered on the site (Figure 5.7). Station signals are transmitted to the NMIMT Seismological Observatory in Socorro. When appropriate, readings from the WIPP network stations are combined with readings from an additional NMIMT 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 stations in West Texas.

The mean operational efficiency of the WIPP seismic monitoring stations during 2009 was approximately 78 percent. From January 1 through December 31, 2009, locations for 120 seismic events were recorded within 300 km (186 mi) of WIPP. These data included origin times, epicenter coordinates, and magnitudes. The strongest recorded event (magnitude 3.1) occurred on September 23, 2009, and was located approximately 83 km (52 mi) northwest of the site. The closest event to the site was located approximately 25 km (16 mi) northwest and had a magnitude of 1.4. These events had no effect on WIPP structures.

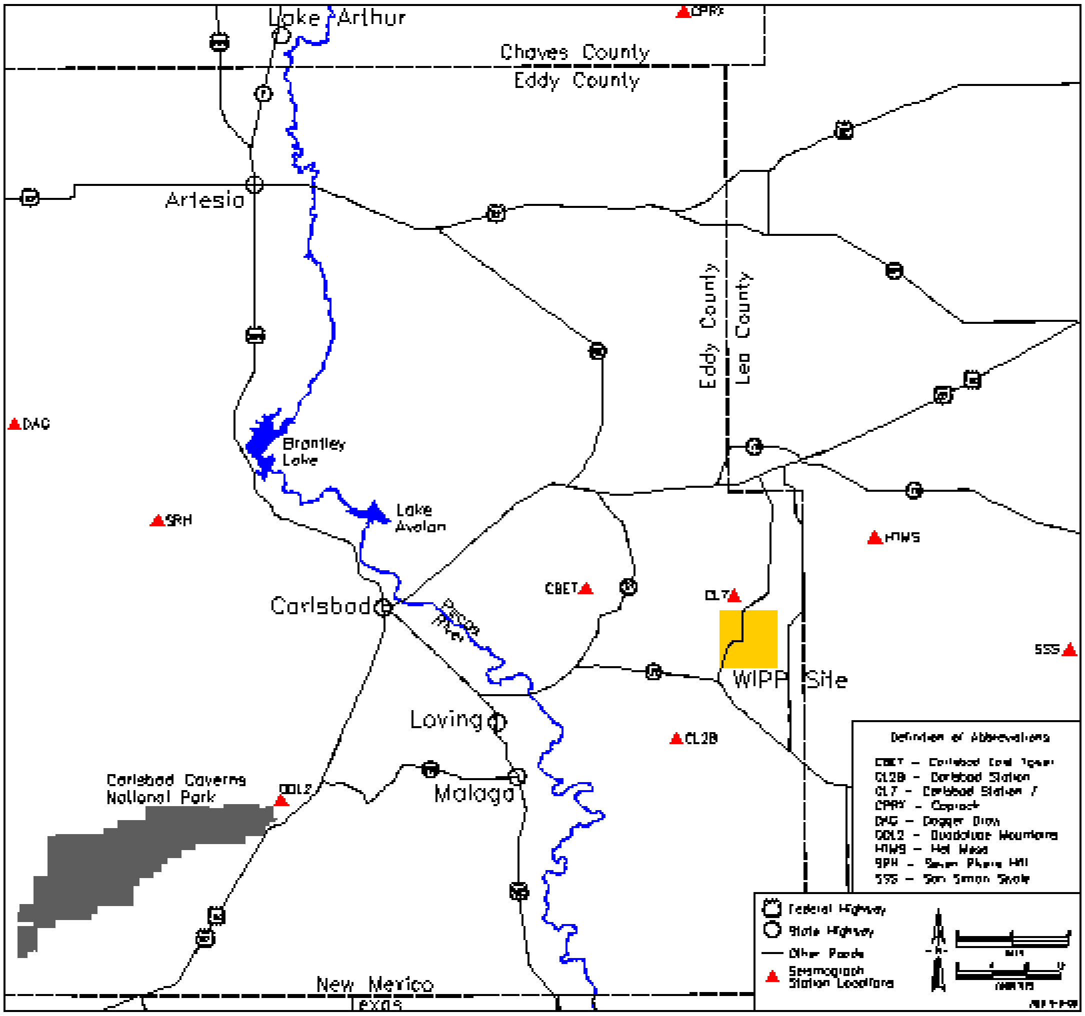

Figure 5.7 – Seismograph Station Locations in the Vicinity of the WIPP Site

5.7 Liquid Effluent Monitoring

The NMED Ground and Surface Water Protection regulations set forth in 20.6.2 NMAC regulate discharges that could impact surface water or groundwater. DOE compliance with the Ground and Surface Water Protection Regulations is discussed in Chapter 2, Section 2.6. The discharge permit was renewed on September 9, 2008. A modification to the discharge permit was submitted on November 15, 2009, to incorporate a new pond (the SSEB-II) into the permit that was built to provide additional holding and evaporation capacity for runoff from the active Salt Storage Area. Analytical data from the discharge monitoring reports are summarized in Table 5.67 and Table 5.78, respectively.

Table 5.7 – Sewage Lagoon and H-19 Analytical Results for January Through June 2009

Analyte	Influent Pond 2A		Evaporation Pond B		Evaporation Pond C		H-19 Evaporation Pond	
Nitrate (mg/L)	ND[a]		N/A		N/A[b]		N/A	
TKN[c] (mg/L)	100		N/A		N/A		N/A	
TDS[d] (mg/L)	603		341,000		334,000		NS[e]	
Sulfate (mg/l)	65.8		13,400		13,400		NS	
Chloride (mg/l)	84.8		221,000		15,200		NS	

[a] ND - not detected, analyte below detection limit
[b] N/A - The analytical parameter not required
[c] Total Kjeldahl Nitrogen (as N)
[d] Total dissolved solids
[e] NS - Not sampled

Table 5.8 – Sewage Lagoon, H-19, and Infiltration Control Pond Analytical Results for July Through December 2009

Location	Nitrate (mg/l)	TKN[a] (mg/l)	TDS[b] (mg/l)	Sulfate (mg/l)	Chloride (mg/l)
Influent Pond 2A	ND[c]	63	474	57	80
Evaporation Pond B	NS[d]	NS	NS	NS	NS
Evaporation Pond C	NS	NS	NS	NS	NS
H-19 Evaporation Pond	N/A[e]	N/A	348,000	600	280,000
Salt Pile Evaporation Pond	N/A	N/A	202,000	1,200	180,000
Salt Storage Extension Evaporation Basin	N/A	N/A	348,000	35,000	220,000
Pond 1	N/A	N/A	651	41	270
Pond 2	N/A	N/A	804	62	470
Pond A	N/A	N/A	793	34	420

[a] Total Kjeldahl Nitrogen (as N)
[b] Total dissolved solids
[c] ND - not detected, analyte below detection limit
[d] NS - not sampled, either the pond was dry and/or liner replacement was being conducted in the pond
[e] N/A - The analytical parameter not required

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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 parameter 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, Rev. 4, 2008).

6.1 Site Hydrology

The hydrology at and surrounding the WIPP site has been studied extensively over the last 30 years. A summary of the hydrology in this area is contained in the following sections. Figure 6.1presents the WIPP stratigraphy.

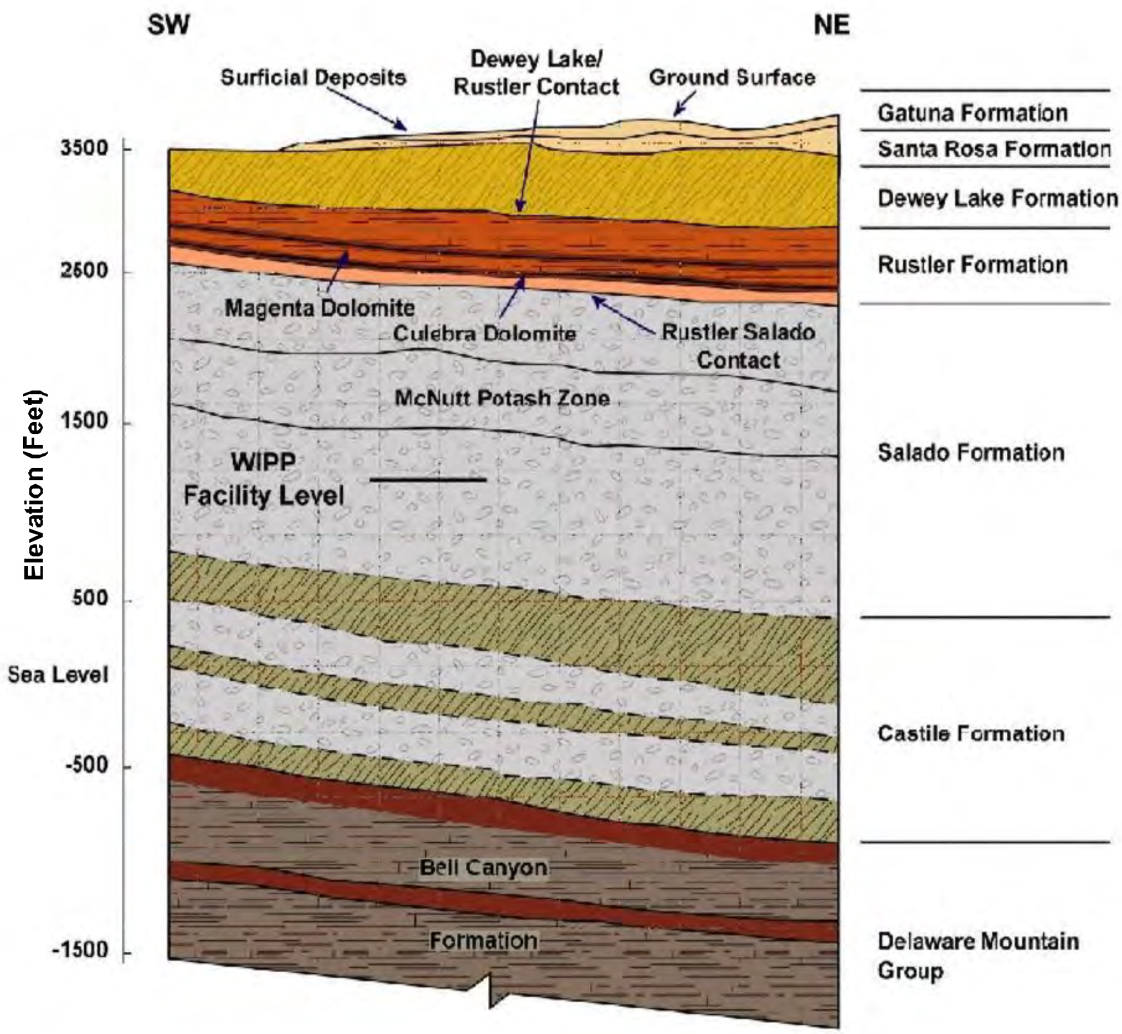

Figure 6.1 – WIPP Stratigraphy

6.1.1 Surface Hydrology

Surface water is absent at 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 Land Withdrawal Area. Two water-bearing units, the Culebra Dolomite Member (Culebra) and Magenta Dolomite Member (Magenta), occur in the Rustler Formation (Rustler) and produce brackish to saline water at and in the vicinity of the site. Another very low transmissivity, saline water-bearing zone is the Rustler-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 Formation (Salado) from the underlying water-bearing sandstones of the Bell Canyon Formation. 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 appears to be present 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 have been made by boreholes drilled for the WIPP facility: (1) ERDA-6, located northeast of the current WIPP site, encountered a pressurized brine reservoir in 1975; and (2) borehole WIPP-12, located one mile 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 not connected with each other (Popielak, et al., 1983).

6.1.2.2 Hydrology of the Salado Formation

The massive halite beds within the Salado host the WIPP facility 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, are generally consistent with a hydraulic conductivity of the undisturbed salt mass of less than 6.5E-09 m per day (m/d) (2.1E-08 ft/d), with the more pure (less argillaceous) halites having even lower permeability. Anhydrite interbeds typically have hydraulic conductivities ranging from 6.5E-09 m/d to 6.5E-07 m/d (2.1E-08 to 2.1E-06 ft/d) (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 also 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 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 (m2/d) to approximately 112 m^2/d (1.29E-07 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) (Beauheim, 1987; 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, though not the water-bearing zone of interest for monitoring of a facility release, 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 m2/d (2.1E-03 to 3.8E-01 ft2/d) (Beauheim et al., 1991;

Beauheim and Ruskauff, 1998; Sandia National Laboratories [SNL], 2003; 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 (see 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 Shallow Subsurface Water [SSW]). Well C-2811 is located approximately one mile (1.61 km) to the northeast of WQSP-6A on the C-2737 well pad (see Figure 6.2). Approximately one mile 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 (255 ft) thick in exploratory potash holes drilled for WIPP, east of the site boundary. The Santa Rosa is thicker to the east. The geologic data from design studies have been incorporated with data from drilling to investigate SSW in the Santa Rosa to provide structure and thickness maps of the Santa Rosa in the vicinity of the WIPP surface structures area. These results are consistent with the broader regional distribution of the Santa Rosa (CRA, DOE/WIPP-04-3231).

Water in the Santa Rosa has been found in the center part of the WIPP site since 1995 and because no water was found in this zone during the mapping of the shafts in 1980s, this water is deemed to be anthropogenic (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 6.16 of this report. During October 2007, three additional piezometers 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. This formation ranges in thickness from approximately 6 to 9 m (19 to 31 ft) at the

WIPP site and consists of silt, sand, and clay, with deposits formed in localized depressions during the Pleistocene period.

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 any 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; and
- 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 by the WIPP groundwater monitoring program support two major programs: (1) the RCRA DMP supporting the Permit in compliance with 20.4.1.500 NMAC (incorporating 40 CFR Part 264, Subparts F, "Releases From Solid Waste Management Units"; and X, "Miscellaneous Units"), and (2) performance assessment supporting the *Compliance Certification Application* (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 semiannually.

6.2.2 Summary of 2009 Activities

Routine groundwater monitoring activities include groundwater quality sampling, groundwater level monitoring, and the pressure density survey, as described in this section. These annual programs are required by the Permit. Supporting activities during 2009 included hydraulic testing and non-Permit groundwater quality sampling (Section 6.4), and well maintenance (Section 6.5). Table 6.1 presents a summary of WIPP groundwater monitoring activities at the end of 2009. 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.8, lists active groundwater monitoring wells used by the DOE for the WIPP facility at the end of 2009.

Radiological data for 2009 from the groundwater monitoring program are summarized in Chapter 4. The remainder of the results from the groundwater monitoring program are contained in this chapter.

Table 6.1 - Summary of 2009 DOE WIPP Region Groundwater Monitoring Program

	Environmental Surveillance
Number of Active Wells	83
Number of Samples Taken	28*
Number of Water Level Measurements	777
Number of Analyses Performed	1,708

* Primary and duplicate samples taken from seven wells, twice per year. Sixty-one constituents analyzed per sample.

** All VOCs, SVOCs (semivolatile organic compounds), and the majority of the target trace metals were nondetect. Most detections were for the routine major water chemistry parameters.

Regular monthly groundwater level data were gathered from 59 wells across the WIPP region (Figure 6.2), three of which were equipped with production-injection packers (PIPs) 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 nineteen shallow water wells, and H-3D, which was dry (for "SR/DL" [Santa Rosa/Dewey Lake Contact] listed in Appendix F, Table F.8), were measured quarterly. Table F.9 shows the water level data. Water levels were not taken where access was poor, or in certain wells when testing equipment was present.

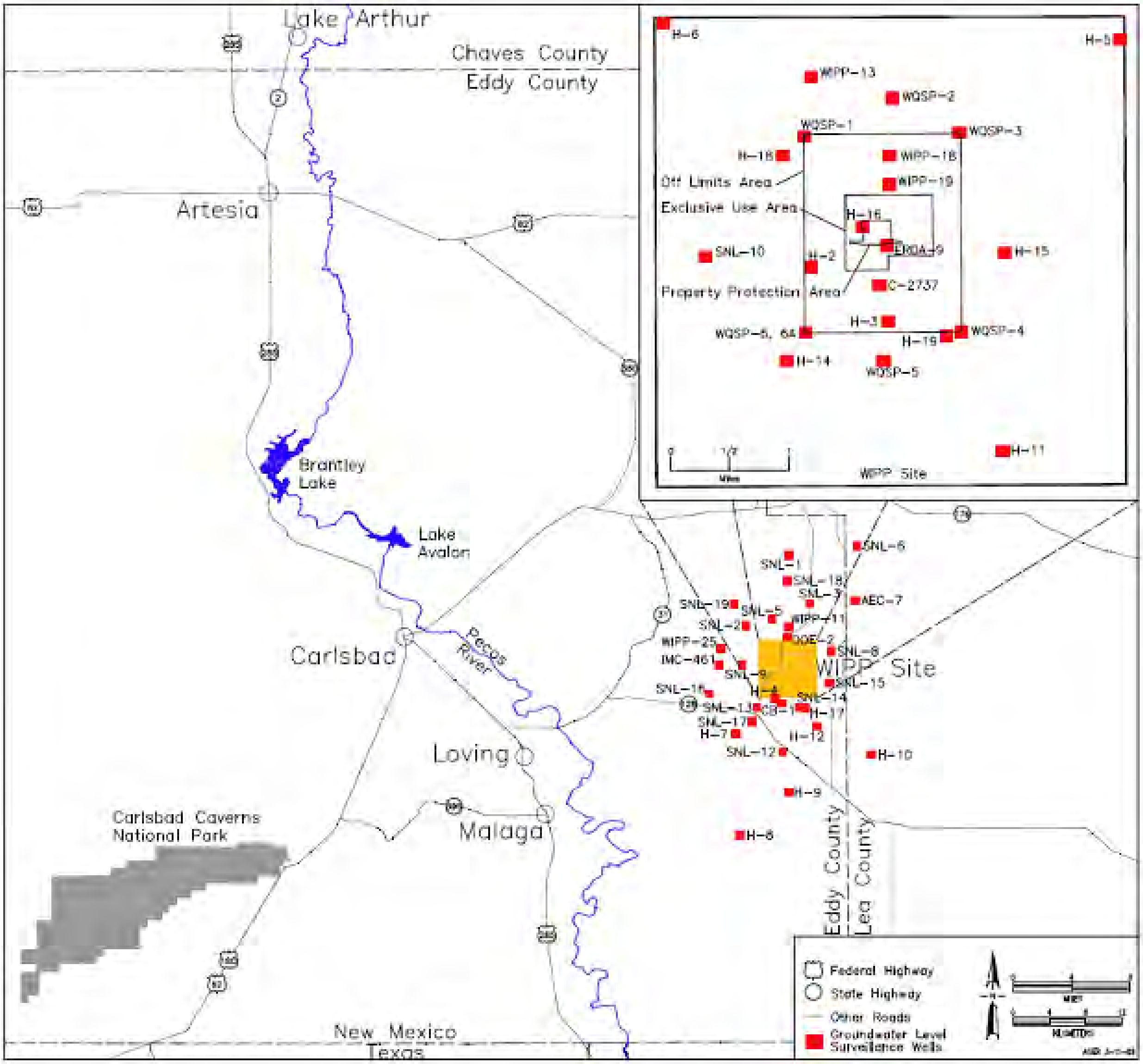

Figure 6.2 – Groundwater Level Surveillance Wells (insert represents the groundwater surveillance wells in the WIPP Land Withdrawal Area)

6.2.3 Groundwater Quality Sampling

The Permit Module V requires groundwater quality sampling twice a year, from March through May (Round 28 for 2009), and again from September through November (Round 29 for 2009). Sampling for groundwater quality was performed at seven well sites (Figure 6.3). Field analyses for oxygen-reduction potential, pH, specific gravity, specific conductance, temperature, acidity or alkalinity, chloride, divalent cations, and total iron were performed periodically during the sampling.

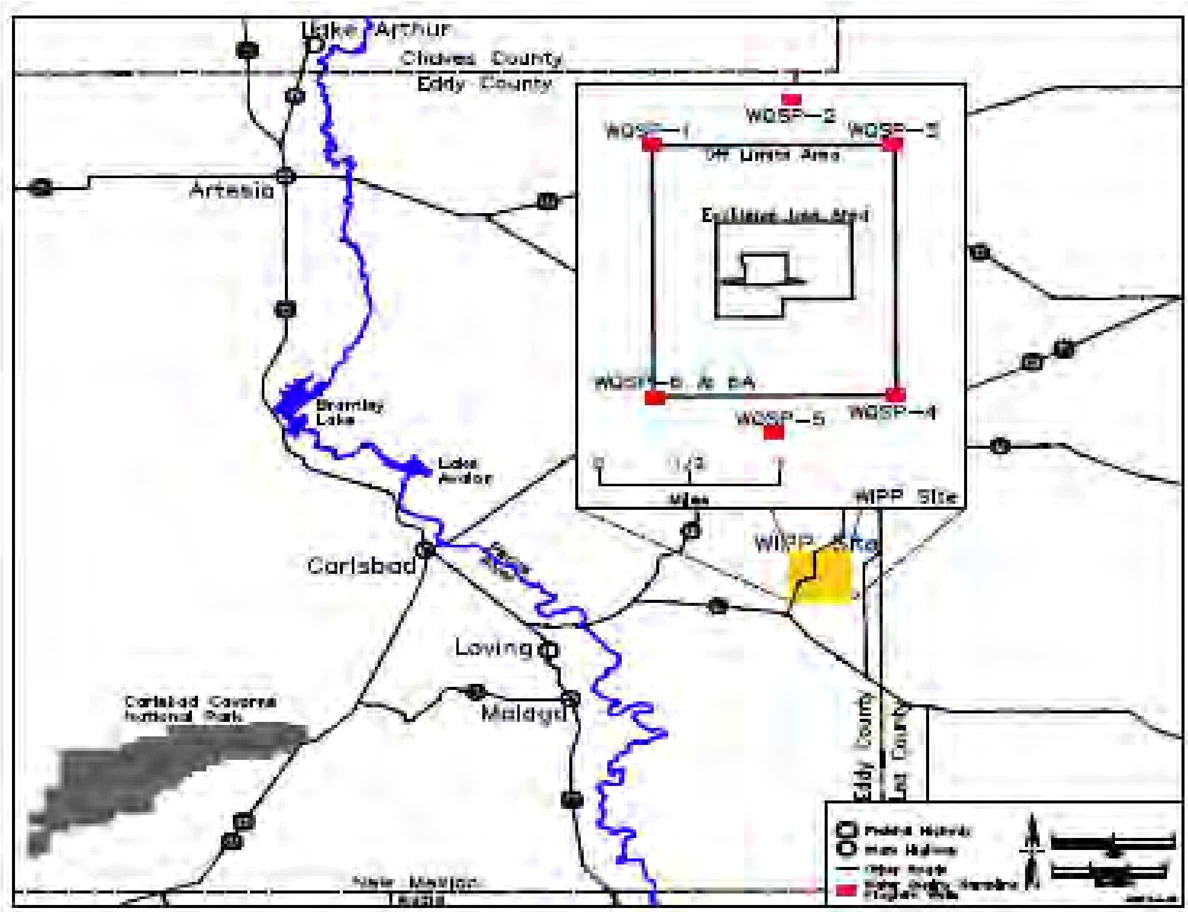

Figure 6.3 – Water Quality Sampling Program Wells

Primary and duplicate samples for groundwater quality were taken from each of the seven wells: six wells completed in the Culebra (WQSP-1 through WQSP-6) and one well completed in the Dewey Lake (WQSP-6A), for a total of 14 samples analyzed per sampling round.

Wells WQSP-1, WQSP-2, and WQSP-3 are located upgradient of the WIPP shaft area. The locations of the three upgradient wells were selected to be representative of the groundwater moving downgradient onto the WIPP site. Wells WQSP-4, WQSP-5, and WQSP-6 are located downgradient of the WIPP shaft area. WQSP-4 was also specifically located to monitor a zone of higher transmissivity. WQSP-6A was installed in the Dewey Lake at the WQSP-6 well pad to assess shallower groundwater conditions at this location.

The difference between the depth of the WIPP repository and the depth of the WQSP wells completed in the Culebra varies from 387 m to 587 m (1,271 ft to 1,925 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 a pathway upon closure of the facility, WIPP-related contamination of the groundwater is highly unlikely.

Table 6.2 lists the analytical parameters included in the 2009 groundwater sampling program.

Table 6.2 – Analytical Parameters for Which Groundwater Was Analyzed

Table 6.2 – Analytical Parameters for Which Groundwater Was Analyzed

CAS No.[a]	Parameter	EPA Method Number	CAS No.	Parameter	Method Number[b]
71-55-6	1,1,1-Trichloroethane	8260B	7782-50-5	Chloride	300.0
79-34-5	1,1,2,2-Tetrachloroethane	8260B		Densityb	SM2710F
79-00-5	1,1,2-Trichloroethane	8260B	7727-37-9	Nitrate (as N)	300.0
75-34-3	1,1-Dichloroethane	8260B		pH	SM 4500-H^+B
75-35-4	1,1-Dichloroethylene	8260B		Specific conductance	120.1
107-06-2	1,2-Dichloroethane	8260B		Sulfate	300.0
56-23-5	Carbon tetrachloride	8260B		Total dissolved solids	SM2540C
108-90-7	Chlorobenzene	8260B		Total organic carbon	S<5310B
67-66-3	Chloroform	8260B		Total organic halogen	9020B
540-59-0	*cis*-1,2-Dichloroethylene	8260B		Total suspended solids	SM2540D
540-59-0	*trans*-1, 2-Dichloroethylene	8260B			
78-93-3	Methyl ethyl ketone (2-butanone)	8260B			
75-09-2	Methylene chloride	8260B			
127-18-4	Tetrachloroethylene	8260B	7440-36-0	Alkalinity	SM2320B
108-88-3	Toluene	8260B	7440-38-2	Antimony	6010B
79-01-6	Trichloroethylene	8260B	7440-39-3	Arsenic	6010B
75-69-4	Trichlorofluoromethane	8260B	7440-41-7	Barium	6010B
75-01-4	Vinyl chloride	8260B	7440-43-9	Beryllium	6010B
1330-20-7	Xylene	8260B	7440-70-2	Cadmium	6010B
95-50-1	1,2-Dichlorobenzene	8270C	7440-47-3	Calcium	6010B
106-46-7	1,4-Dichlorobenzene	8270C	7439-89-6	Chromium	6010B
51-28-5	2,4-Dinitrophenol	8270C	7439-92-1	Iron	6010B
121-14-2	2,4-Dinitrotoluene	8270C	7439-95-4	Lead	6010B
95-48-7	2-Methylphenol	8270C	7439-97-6	Magnesium	6010B
108-39-4/ 106-44-5	3-Methylphenol/ 4-Methylphenol	8270C	7439-97-6	Mercury	7470A
			7440-02-0	Nickel	6010B
118-74-1	Hexachlorobenzene	8270C	7782-49-2	Potassium	6010B
67-72-1	Hexachloroethane	8270C	7440-22-4	Selenium	6010B
98-95-3	Nitrobenzene	8270C	7440-23-5	Silver	6010B
87-86-5	Pentachlorophenol	8270C	7440-28-0	Sodium	6010B
110-86-1	Pyridine	8270C	7440-62-2	Thallium	6010B
78-83-1	Isobutanol (isobutyl alcohol)	8260B	7440-66-6	Vanadium	6010B

[a] Chemical Abstract Service Registry Number
[b] Methods are EPA methods except those designated SM which are from Standard Methods.

6.2.4 Evaluation of Groundwater Quality

The quality of the Culebra water 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 2009, average TDS concentrations in the Culebra (as measured in WQSP wells) varied from a low of 16,200 mg/L (WQSP-6) to a high of 226,000 mg/L (WQSP-3). The groundwater of the Culebra is considered to be Class III water (non-potable) by EPA guidelines.

Water quality measurements performed in the Dewey Lake indicate that the water is considerably better quality than that from the Culebra. In 2009, the TDS concentrations in water from the well WQSP-6A, obtained from the Dewey Lake, averaged 3,480 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 2009 analytical results showing the concentrations of detectable constituents are displayed as Time Trend Plots compared to the baseline concentrations (Appendix E, Figures E.1 through E.49). The analysis results for each parameter or constituent for the two sampling sessions in 2009 (Rounds 28 and 29) are summarized in Appendix F, Tables F.1 through F.7.

The tables 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 beneath 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). 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 method reporting limit for the contract laboratory. These values were recomputed after the baseline sampling was completed in 2000, and were applied to sampling Rounds 28 and 29 to evaluate potential contamination of the local groundwater. None of the constituents of interest (organics and trace metals) exceeded the baseline concentrations.

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 (SR/DL Contact)
- Dewey Lake
- Magenta
- Culebra

- Bell Canyon

The two zones of most interest are the Culebra and Magenta (see Figure 6.1). Throughout 2009, water levels in up to 50 Culebra wells were measured (including the Culebra zone of dual completion wells) and 14 wells in the Magenta (including the Magenta zone of dual completion wells). One Dewey Lake well and two Bell Canyon wells were monitored. Nineteen wells in the shallow zone of the SR/DL Contact were monitored. 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) at each well site were measured on a quarterly basis (Appendix F, Table F.9). Water levels at SSW wells and piezometers were measured on a quarterly basis.

A breakdown of the groundwater zone(s) intercepted by each well measured at least once in 2009 is given in Appendix F, Table F.8. Note that three existing wells (Culebra/Magenta, C-2737; Culebra/Magenta, WIPP-25 [plugged and abandoned in June 2009], Culebra/Magenta, H-9c) are completed at multiple depths. By using PIPs, these wells monitor more than one formation.

Water elevation trend analysis was performed for 42 of 50 wells completed or isolated in the Culebra. The subset of wells analyzed were those which had a sufficient period of record to analyze through CY 2009, did not display anomalous levels or trends, and were representative of more than one well at a given well pad (Appendix F, Table F.8). Excluded from trend analysis were SNL-6 and SNL-15 because they both were in long-term water level recovery.

The dominant trend through 2009 was a spatially uniform, decreasing freshwater equivalent level in the Culebra. By "dominant," it is meant that (1) water levels were neutral or fell in 33 of 42 wells from January through December (or shorter periods in wells that still had a discernable trend), (2) the average water level decrease was 0.94 feet (0.28 m), and (3) the general water level fall is best indicated by twenty measured water levels falling in the zero (neutral) to 1.0 foot range, and all but one decline being less than 2.0 feet.

Water levels in the Culebra, and to a lesser extent in the Magenta, have generally been rising since the completion of site characterization activities in 1989. The rise was not recognized as having a regional extent for many years because well drilling and testing, shaft sinking, and other human activities disturbed water levels. Since these activities were completed, a rise in water levels over the monitored area has become evident. However, 2009 and 2008 trends indicate a decrease in water levels regionally.

The water-level rise is not monotonic, but shows variations related to factors both known and hypothesized. Water levels in the Culebra in Nash Draw, west of the WIPP site, respond to major rainfall events within a few days (Hillesheim et al., 2007). It is hypothesized that the change in head in Nash Draw then propagates under Livingston Ridge to the WIPP site in the succeeding weeks or months. It is also hypothesized that the Culebra may be receiving leakage through poorly plugged and abandoned drillholes, or through fractures in Nash Draw, from higher hydrologic units and/or potash tailings piles north of the WIPP site. For example, the observed long-term rise in water levels might be caused by the leakage into the Culebra of approximately 74 acre-ft/yr of brine discharged onto the Intrepid East tailings pile north of the WIPP site, and/or by the leakage of a similar volume through 26 potash exploration holes north, west, and south of the WIPP site that may not have been properly plugged through the Culebra (Lowry and Beauheim, 2004; 2005). Likewise, a number of plugged and abandoned oil or gas wells have been identified, mostly to the east and south of the WIPP site, that may not be plugged through the Culebra with cement and could, hypothetically, be sources of leakage that affects the head in the Culebra (Powers, 2004).

Because of the wide areal distribution of the rise, it does not result in significant changes in the hydraulic gradient in the Culebra, which controls the rate and direction of groundwater flow. The DOE uses updated heads in calculating potential radionuclide releases through the Culebra in the 10,000-year performance assessments that are part of each Compliance Recertification Application that is submitted to the EPA every five years.

Figure 6.4 through Figure 6.10 provide hydrographs of wells WQSP-1 to WQSP-6A for CY 2009. The six Culebra wells (Figure 6.4 through Figure 6.10; WQSP-6A is Dewey Lake) are typical of the hydrographs of the 42 wells analyzed for Culebra water level trends. Temporary declines from spring and fall water quality sampling are evident in some wells, such as WQSP-3, WQSP-5, and WQSP-6. The Permit requires that the NMED be notified if a cumulative groundwater surface elevation change of more than 2 feet is detected in wells WQSP-1 to WQSP-6A over the course of one year that is not attributable to site tests or natural stabilization of the site hydrologic system. There was no abnormal or unexplained rise in the DMP wells outside the regional trend. Wells WQSP-1, -2, and -3 had cumulative decreases in water level in excess of 1 foot during the course of the year from January to December.

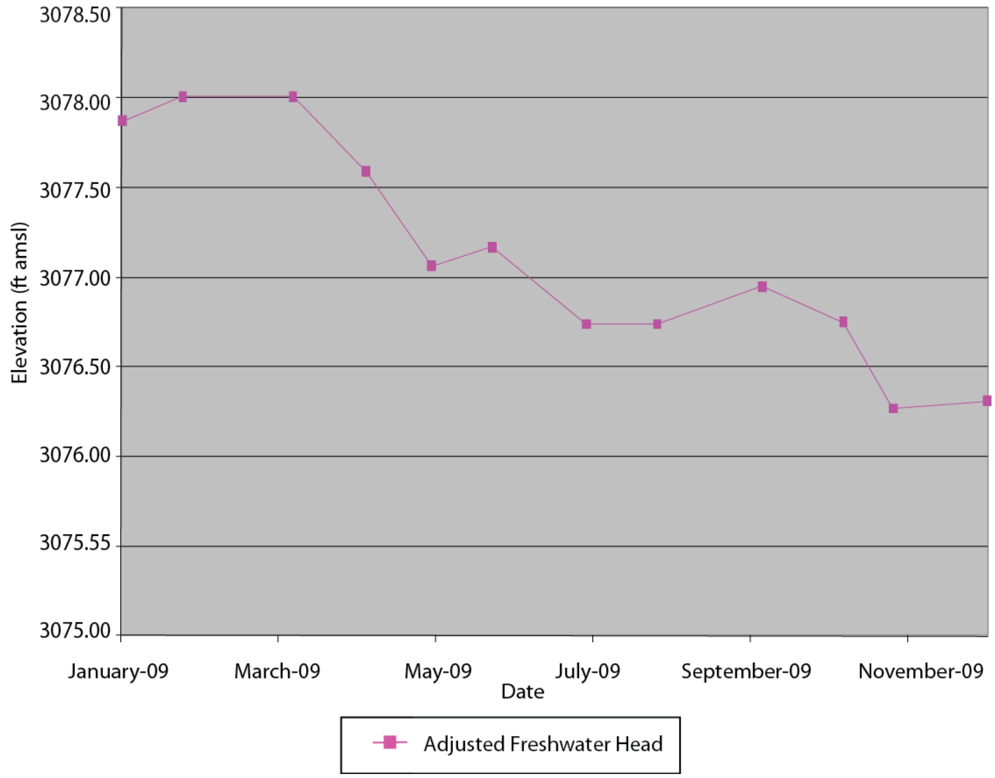

Figure 6.4 – Hydrograph of WQSP-1

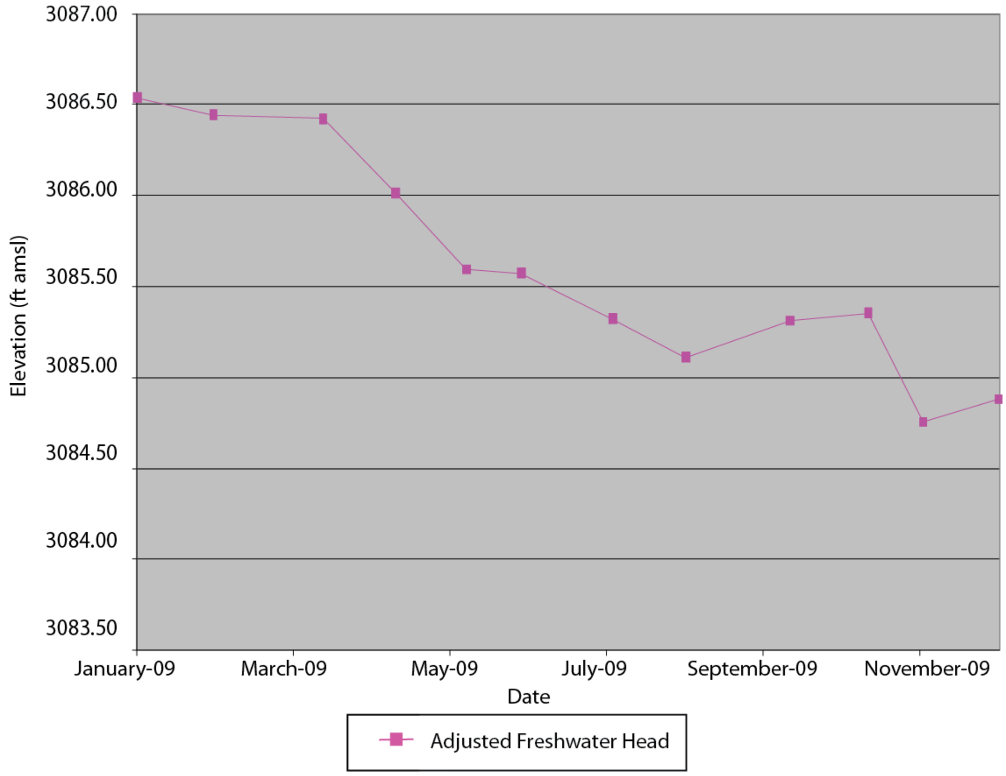

Figure 6.5 – Hydrograph of WQSP-2

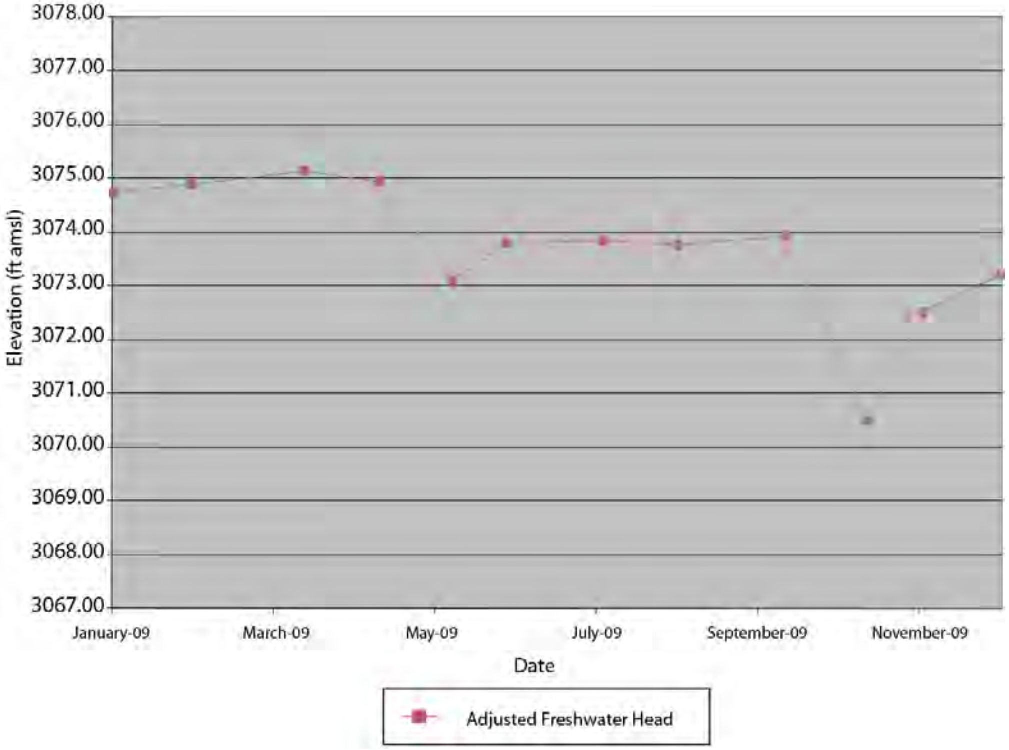

Figure 6.6 – Hydrograph of WQSP-3

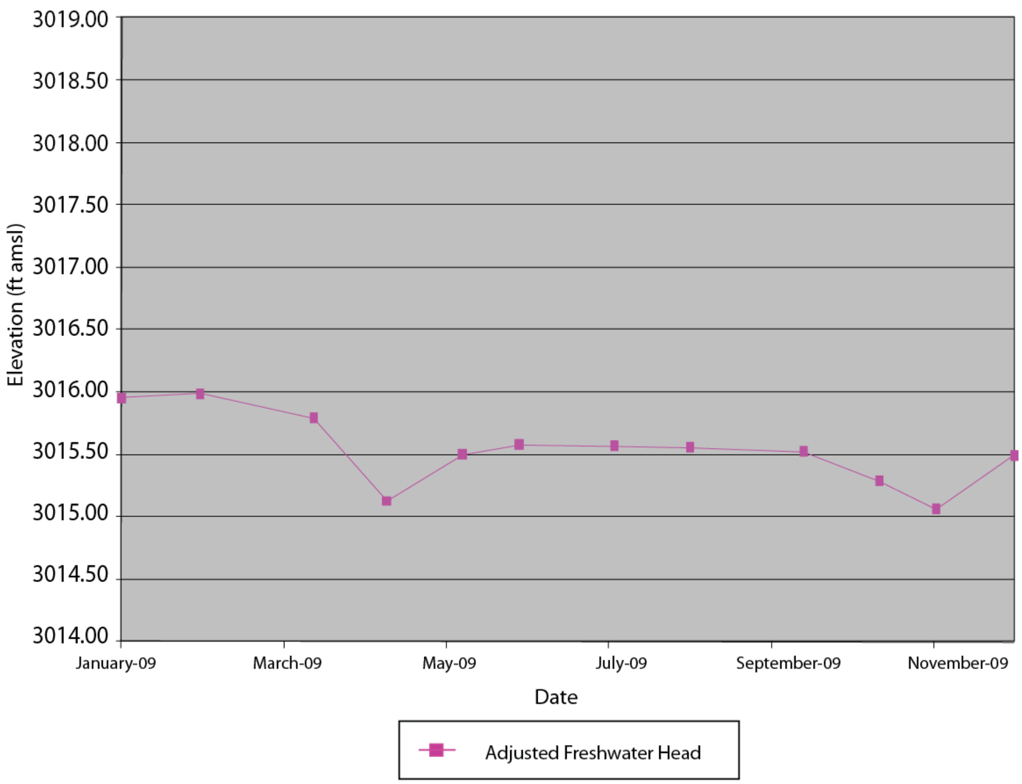

Figure 6.7 – Hydrograph of WQSP-4

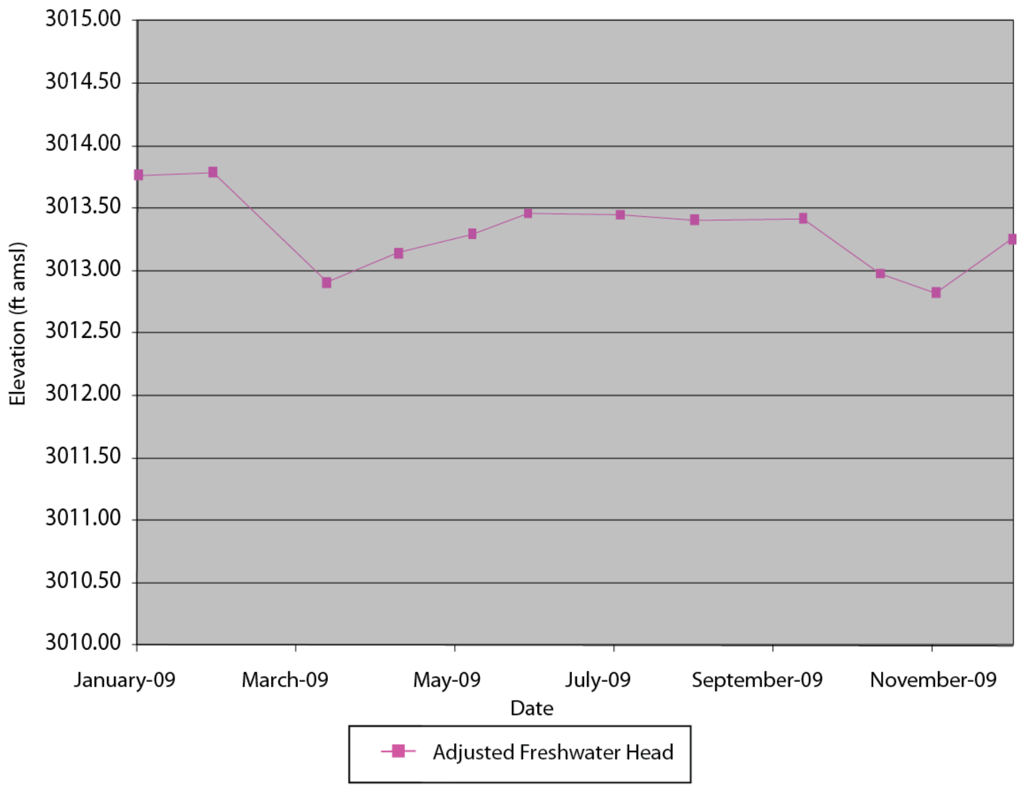

Figure 6.8– Hydrograph of WQSP-5

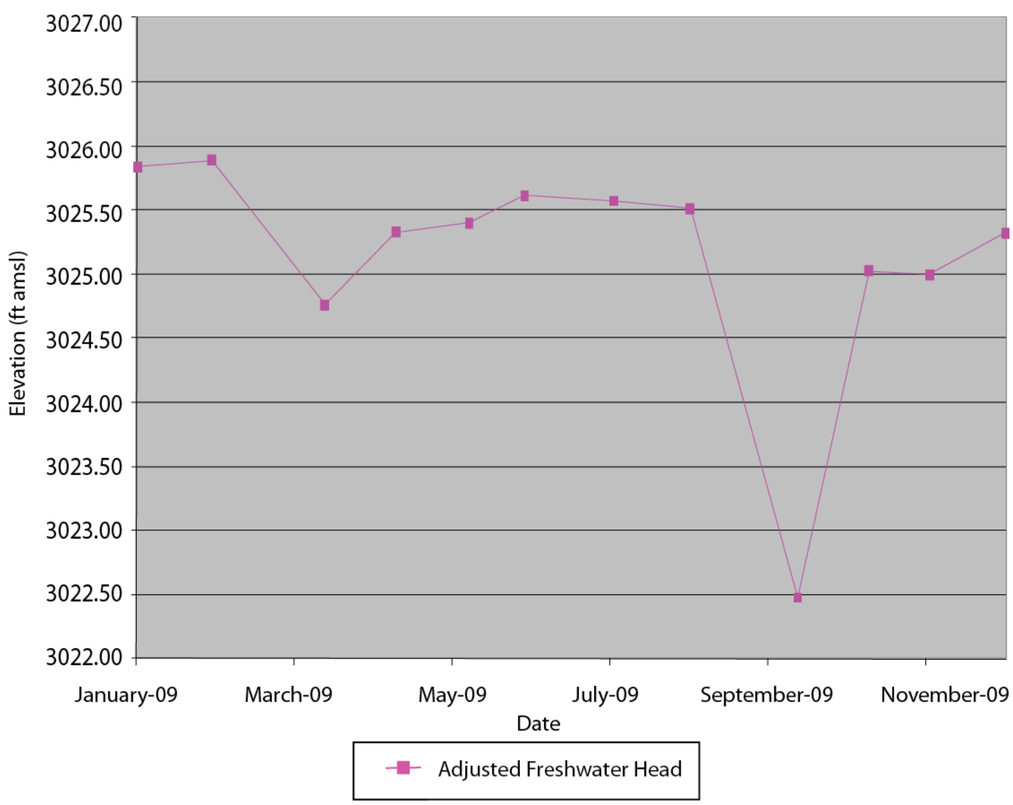

Figure 6.9 – Hydrograph of WQSP-6

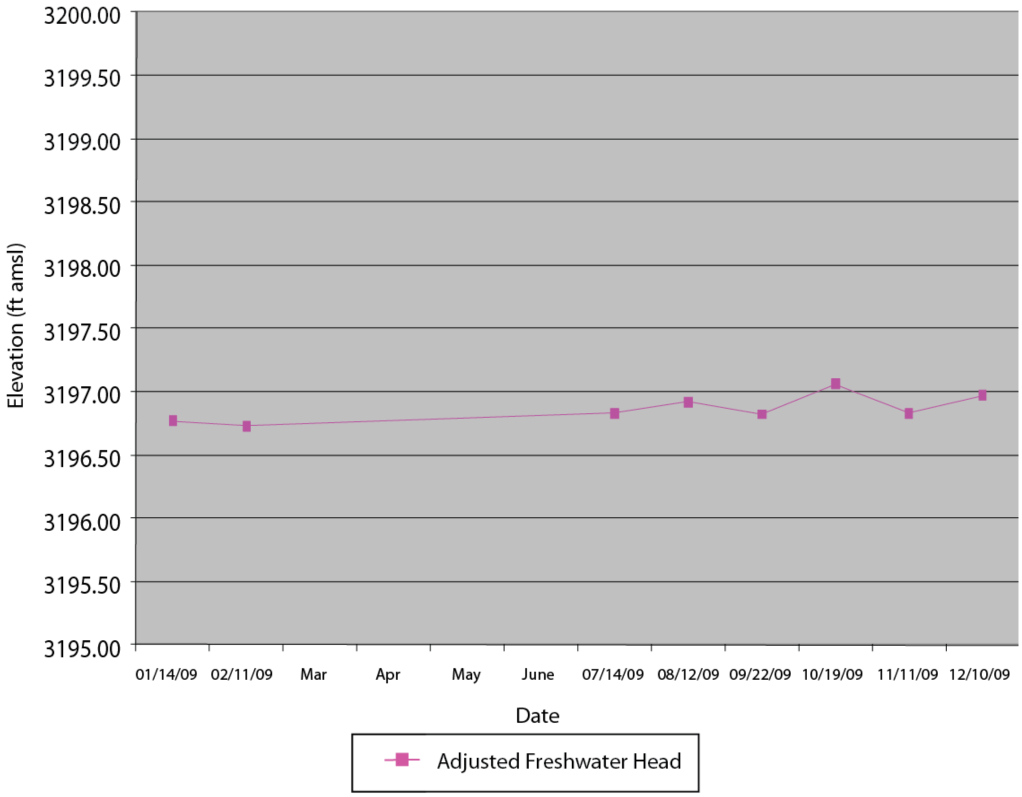

Figure 6.10– Hydrograph of WQSP-6A

Groundwater level data were transmitted on a monthly basis to the NMED and the CBFO. A copy of the data was placed in the operating record for inspection.

For the Culebra wells in the vicinity of the WIPP site, equivalent freshwater heads for June 2009 were used to calibrate a groundwater flow model, which was used by SNL to compute a potentiometric surface using SNL procedure SP 9-9. This month was judged to have a large 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. Adjusted freshwater heads are typically accurate to ± 1.5 feet 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 June 2009 Potentiometric Surface Calibration, Culebra Hydraulic Unit

Well I.D.	Date of Measurement	Adjusted Freshwater Head (feet, msl)	Density Used (grams/cc)	Notes
AEC-7	06/09/09	3064.59	1.078	
C-2737 (PIP)	06/11/09	3023.32	1.029	
ERDA-9	06/11/09	3033.59	1.067	
H-02b2	06/10/09	3043.09	1.000	
H-03b2	06/11/09	3013.69	1.038	
H-04b	06/09/09	3005.97	1.013	
H-05b	06/09/09	3081.40	1.093	
H-06bR	06/08/09	3070.79	1.033	
H-07b1	06/08/09	2998.35	1.000	

Table 6.3 – Water Level Elevations for the June 2009 Potentiometric Surface Calibration, Culebra Hydraulic Unit				
Well I.D.	**Date of Measurement**	**Adjusted Freshwater Head (feet, msl)**	**Density Used (grams/cc)**	**Notes**
H-09c (PIP)	06/09/09	2996.27	1.003	
H-10c	06/09/09	3024.23	1.001	Pre-bailing density
H-11b4	06/09/09	3006.94	1.062	
H-12	06/09/09	3007.34	1.096	
H-15R	06/10/09	3022.22	1.130	
H-16	06/11/09	3050.00	1.039	
H-17	06/09/09	3003.56	1.120	
H-19b0	06/11/09	3017.73	1.075	
I-461	06/08/09	3047.07	1.019	
SNL-01	06/08/09	3084.61	1.032	
SNL-02	06/08/09	3074.36	1.015	
SNL-03	06/08/09	3082.29	1.029	
SNL-05	06/08/09	3077.12	1.012	
SNL-06	06/10/09	2971.33	1.253	Exclude from mapping; long-term water level recovery
SNL-08	06/09/09	3055.63	1.104	
SNL-09	06/08/09	3057.38	1.026	
SNL-10	06/08/09	3056.29	1.013	
SNL-12	06/09/09	3004.22	1.011	
SNL-13	06/08/09	3012.75	1.028	
SNL-14	06/09/09	3005.56	1.048	
SNL-15	06/09/09	2937.74	1.232	Exclude from mapping; long-term water level recovery
SNL-16	06/08/09	3010.83	1.023	
SNL-17	06/09/09	3006.87	1.007	
SNL-18	06/08/09	3077.16	1.011	
SNL-19	06/08/09	3073.30	1.008	
WIPP-11	06/10/09	3082.30	1.035	
WIPP-13	06/10/09	3081.40	1.055	
WIPP-19	06/09/09	3063.24	1.046	
WIPP-25 (PIP)	06/11/09	3068.52	1.010	
WQSP-1	06/10/09	3077.17	1.048	
WQSP-2	06/10/09	3085.57	1.048	
WQSP-3	06/09/09	3073.79	1.144	
WQSP-4	06/10/09	3015.58	1.074	
WQSP-5	06/10/09	3013.46	1.025	
WQSP-6	06/10/09	3025.61	1.015	

Modeled freshwater head contours for June 2009 for the model domain are shown in Figure 6.11. These contours were generated using MODFLOW 2K (Harbaugh et al., 2000) results for the Culebra using ensemble average distributed aquifer parameters from the SNL Culebra flow model, calibrated as part of the performance assessment baseline calculation for the 2009 Compliance Recertification Application (DOE, 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 June 2009 Culebra freshwater heads presented in this report. The portion of the flow domain of interest to the site is extracted on Figure 6.12. The freshwater head values for June 2009 were estimated using densities computed from 2008.

The base transmissivity fields and the 100 calibrated model realizations derived from them for the performance assessment baseline calculation (PABC) essentially embody the hydrologic and geologic understanding of the Culebra behavior in the vicinity surrounding the WIPP site (Kuhlman, 2010). 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 Culebra flow model is a single-layer groundwater flow model. The boundary conditions of the flow model are of two types. First are the geologic or hydrologic-type boundary conditions, which include the specified head along the eastern boundary, and the no-flow boundary along the northwestern boundary of the domain. The second type of boundary condition is specified head. The northern and southern boundaries are of this type, along with the southern portion of the west boundary. The no-flow constant head boundary defined in Figure 6.12 is due to the low transmissivity for this area defined by such wells as SNL-15 and SNL-8 (Figure 6.2).

The second type of boundary conditions were determined using a calculational code called PEST (Doherty, 2002) as part of this modeling effort. PEST is used to systematically adjust the boundary conditions to maximize the fit between modeled and observed heads at wells.

The illustrated particle in Figure 6.12 (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 land withdrawal boundary (LWB) (a computed path length of 4.089 km). Assuming a thickness of 4 m for the transmissive portion of the Culebra and a constant porosity of 16 percent, the travel time to the WIPP LWB is 5,900 years (output from DTRKMF is adjusted from a 7.75-m Culebra thickness), for an average velocity of 0.69 m/yr. 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.

The scatter plot in Figure 6.13 shows measured and modeled freshwater heads at the observation locations used in the PEST calibration. The observations are divided into three groups, based on proximity to the WIPP site. Wells within the LWB are represented by red crosses, wells outside but within 3 km of the LWB are represented with green "×"s, and other wells within the MODFLOW model domain but distant from the WIPP site are given by a blue asterisk. These groupings were utilized in the PEST calibration; higher weights (2.5) were given to wells inside the LWB, and lower weights (0.4) were given to wells distant to the WIPP site, while wells in the middle received an intermediate weight (1.0). 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. This allowed PEST to improve the fit of the model to observed heads inside the area contoured in Figure 6.12, at the expense of fitting wells closer to the boundary conditions (i.e., wells shown in Figure 6.11).

The central diagonal line in Figure 6.13 represents a perfect model fit (1:1 or 45-degree slope); the two lines on either side of this represent a 1-m misfit above or below the perfect fit. Wells more than 1.5 m from the 1:1 line are labeled. AEC-7 has a large misfit (12.5 m) for two reasons. First, this well has historically had an anomalously low freshwater head elevation, lower than wells around it in all directions. Secondly, it did not have a May 2007 observation (due to ongoing well reconfiguration activities) and therefore was not included as a calibration target in the SNL Performance Assessment MODFLOW model calibration. The ensemble-average transmissivity, anisotropy, and recharge fields used here were not calibrated to accommodate this observation. This well is situated in a low-transmissivity region, and near the constant-head boundary associated with the halite margin, therefore PEST will not be able to improve this fit solely through adjustment of the second type boundary conditions along the edges of the domain (Figure 6.11).

Figure 6.14 and Figure 6.15 show the distribution of errors resulting from the PEST-adjusted fit to observed data. The distribution in Figure 6. is roughly symmetric about 0, indicating there is not a strong bias. Aside from AEC-7, and to a lesser degree some other distant wells whose modeled values do not greatly impact the contours shown in Figure 6.12, the model fit to the June 2009 observations is very good. The ensemble-average model captures the average Culebra behavior, while the PEST calibration improved the model fit to the specific June 2009 observations.

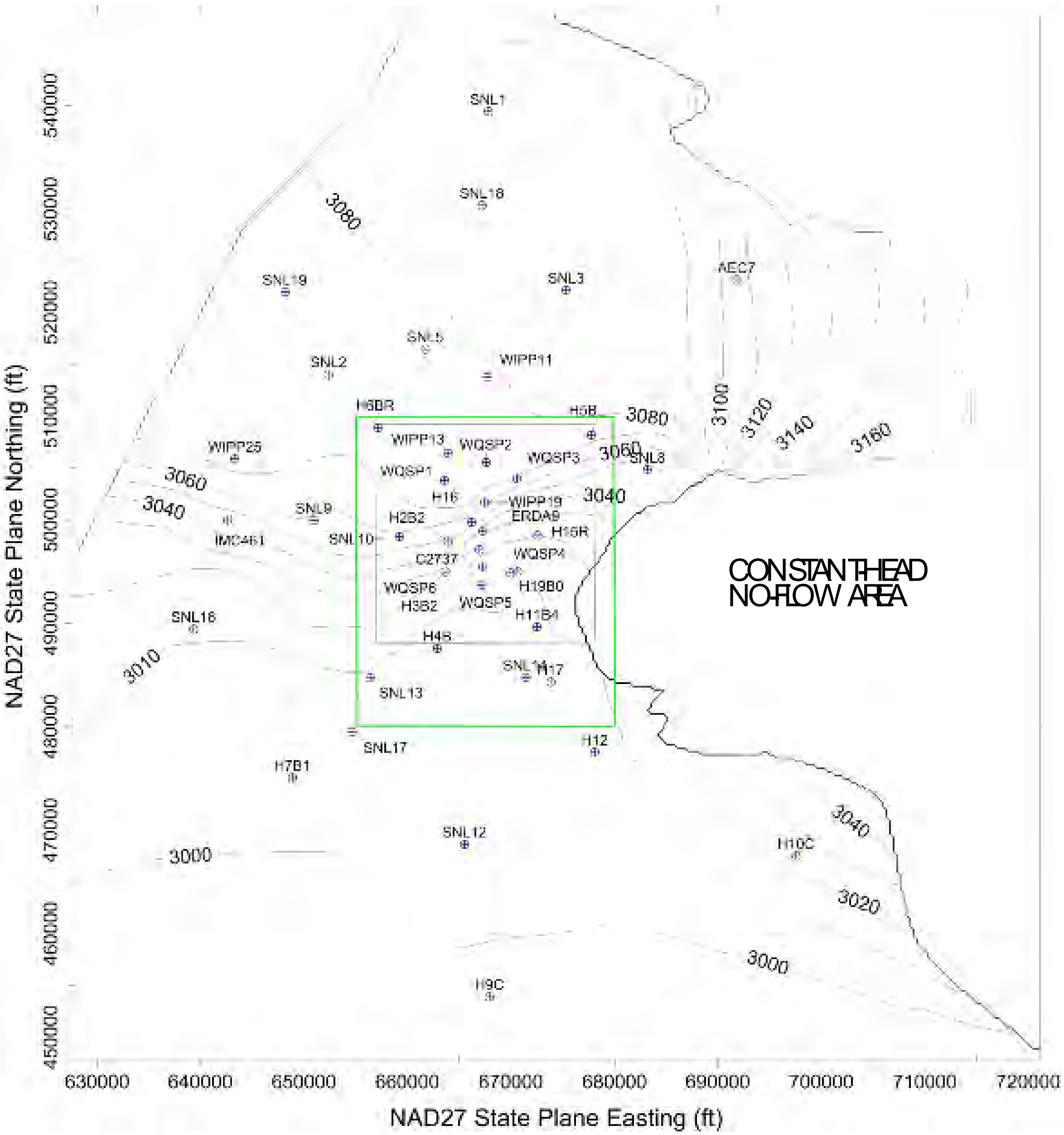

Figure 6.11 – Model Generated June 2009 Freshwater Head Contours in the Model Domain

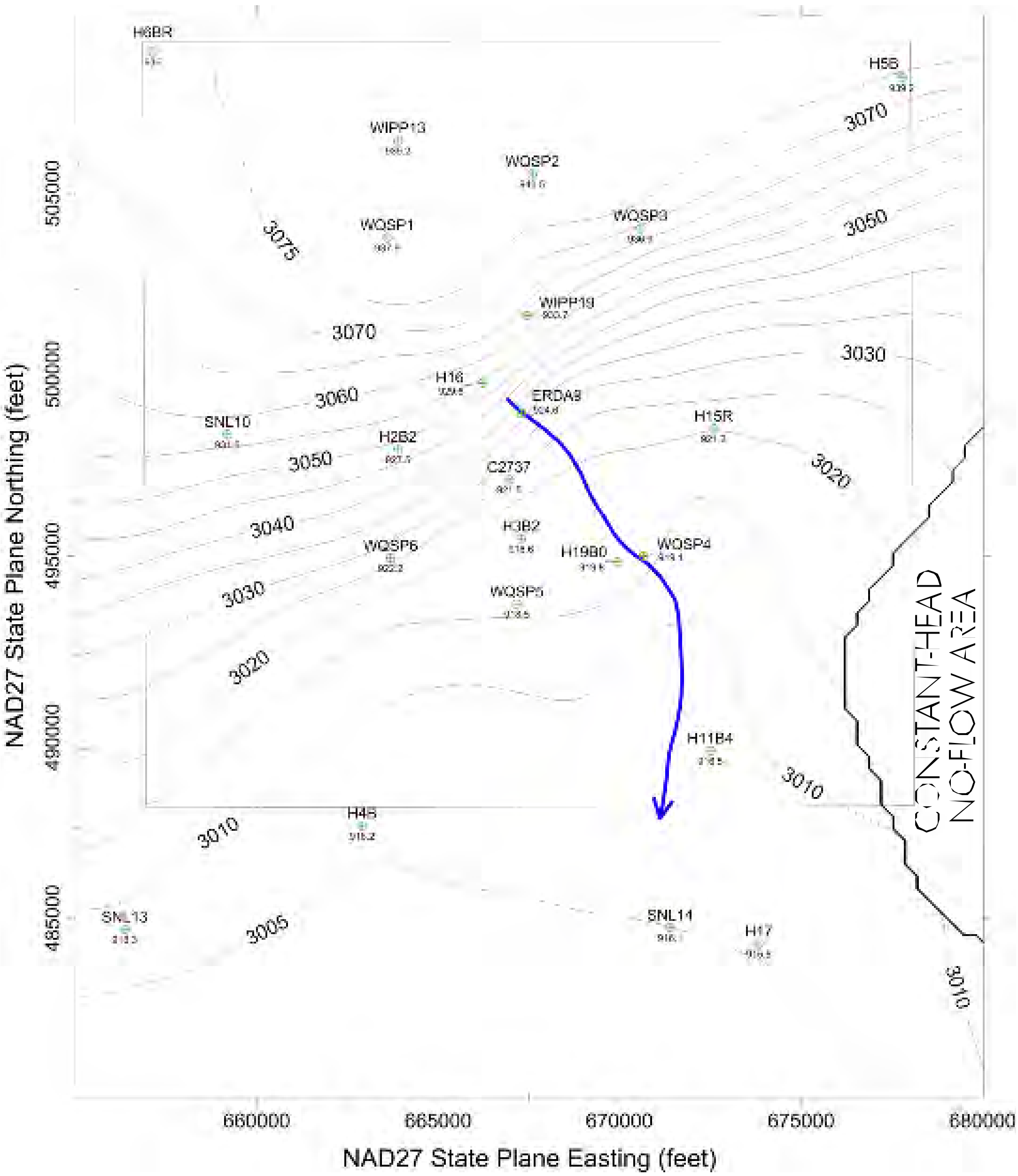

Figure 6. 12– Model-Generated June 2009 Freshwater Head Contours (5-Foot Contour Interval) in the WIPP Vicinity with Blue Water Particle Track From Waste Handling Shaft to WIPP LWB

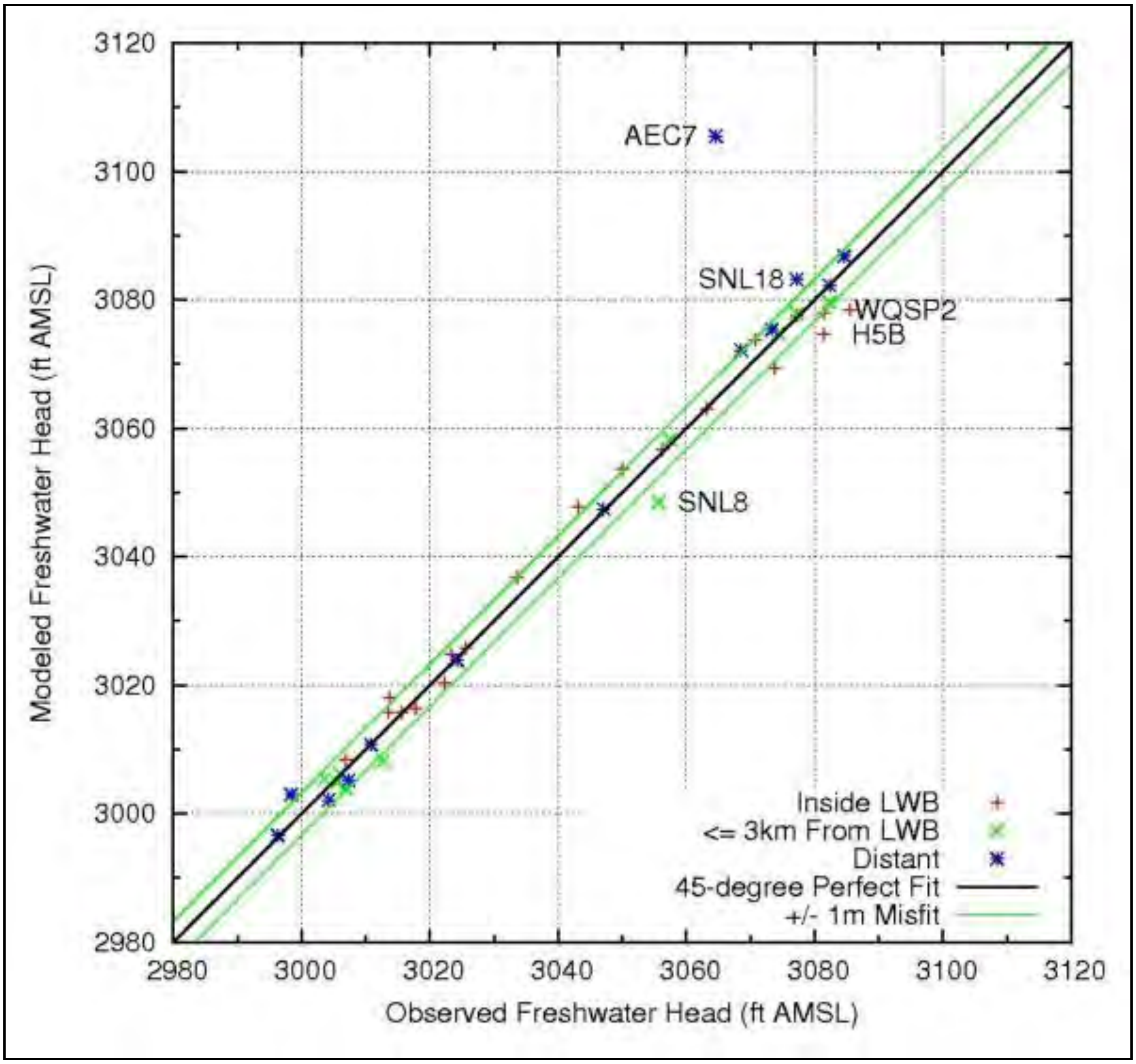

Figure 6.13 - Measured Versus Modeled Scatter Plot for PEST-Calibrated MODFLOW-2000 Generated Heads and June 2009 Observed Freshwater Heads

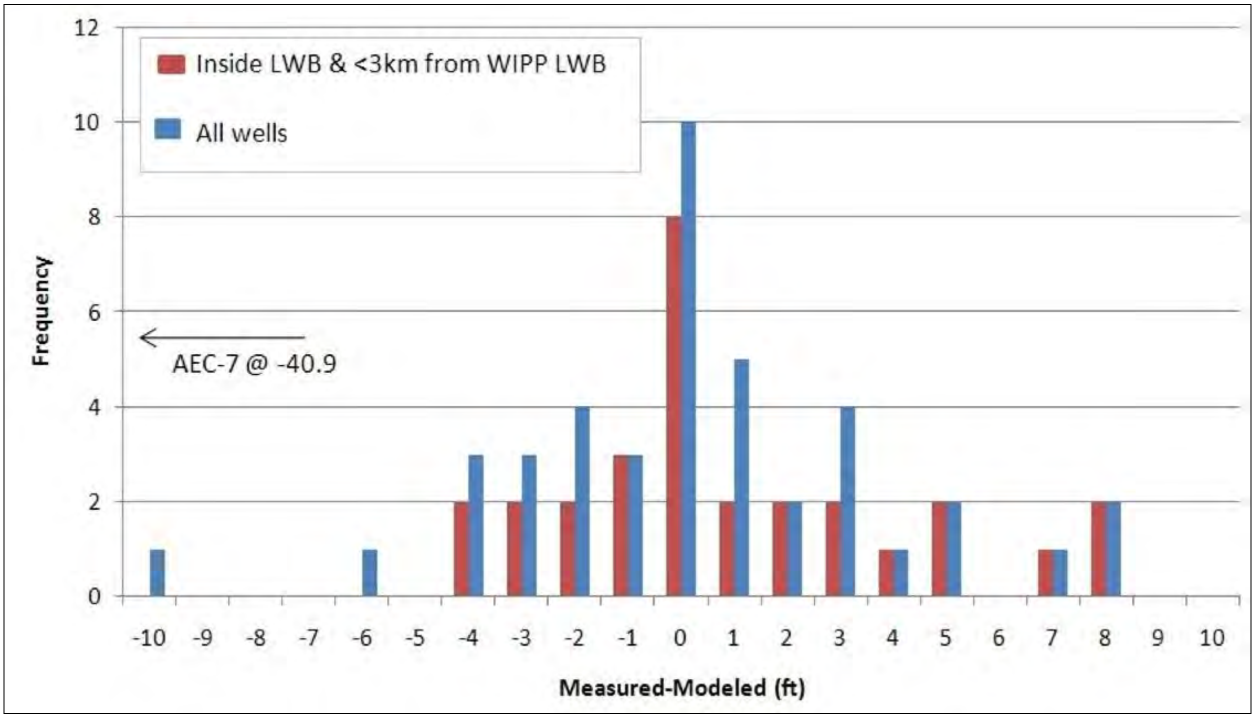

Figure 6. 14 – Frequency of Modeled Freshwater Head Residuals

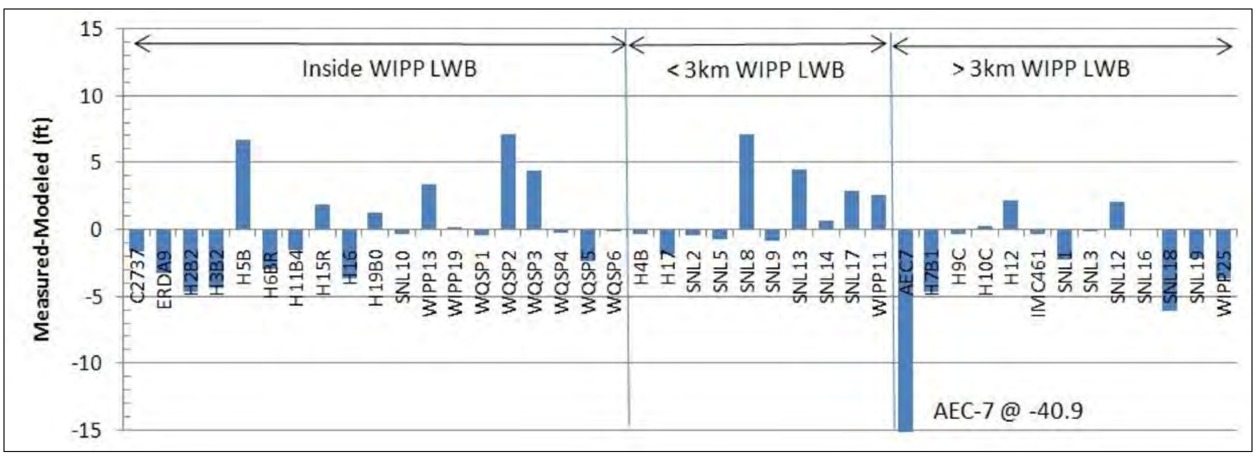

Figure 6. 15 – Modeled Residual Freshwater Head at Each Well

6.2.6 Pressure Density Surveys

At the WIPP site, variable TDS concentrations result in variability in groundwater density (WP 02-1). WIPP measures 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. Pressure density surveys have been performed by two different methods during past years. In 2006 (and prior years), pressure density was obtained by a mobile trailer-mounted system that obtained data at each well. In 2007, SNL installed a dedicated pressure transducer in each well.
In 2009, density measurements were derived from 44 wells, as shown in Table 6.4, from Mini-Trolls installed by SNL. This approach employed several calibrated pressure-measuring transducers dedicated to given wells at varying times during the year. For

the WQSP wells, field hydrometer measurements are always used. For comparison, 2007 and 2008 density data are shown. All year-to-year density differences are within the error as described in WP 02-1.

Table 6.4 – Pressure Density Survey for 2009

Well I.D.	2007 Pressure Density Survey Result	2008 Pressure Density Survey Result	2009 Pressure Density Survey Result	2009 Conversion to Specific Gravity at 70° F	Notes for 2009 Pressure Density Survey
	Density (grams/cc)	Density (grams/cc)	Density (grams/cc)	Density (grams/cc)	
AEC-7	1.211	1.078	1.078	1.080	
C-2737	1.010	1.029	1.025	1.027	
ERDA-9	1.047	1.067	1.068	1.070	
H-02b2	1.014	1.000*	1.009	1.011	* Rounded up in 2008
H-03b2	1.042	1.038	1.040	1.042	
H-04b	1.015	1.013			Plugged in July 2009
H-04bR			1.016	1.018	Replacement for well H-04b drilled in July 2009
H-05b	1.091	1.093	1.094	1.096	
H-06bR	N/A	1.033	1.035	1.037	Replacement well for H-6b drilled in 2008
H-07b1	1.002	1.000*	1.004	1.006	*Rounded up in 2008
H-09c	1.001	1.003	1.004	1.006	
H-10c	1.008	1.001	1.005	1.007	Use up to July 2009, Bailed in July to restore fluid density
H-10c	N/A	N/A	1.089	1.091	Use for July 2009 forward
H-11b4	1.070	1.062	1.058	1.060	
H-12	1.097	1.096	1.095	1.097	
H-15	1.053				Converted to Magenta Well in 2008
H-15R	N/A	1.130	1.118	1.120	H-15 Culebra replacement well drilled in 2008
H-16	N/A	1.039	1.037	1.039	New in 2008; formerly multi-packer transducer well
H-17	1.133	1.120	1.133	1.135	
H-19b0	1.068	1.075	1.065	1.067	
I-461	1.005	1.019	1.005	1.007	
SNL-01	1.033	1.032	1.028	1.030	
SNL-02	1.012	1.015	1.006	1.008	
SNL-03	1.023	1.029	1.030	1.032	
SNL-05	1.010	1.012	1.007	1.009	
SNL-06	1.246	1.253	1.230	1.232	
SNL-08	1.103	1.104	1.091	1.093	
SNL-09	1.024	1.026	1.016	1.018	
SNL-10	1.011	1.013	1.007	1.009	
SNL-12	1.005	1.011	1.002	1.004	
SNL-13	1.027	1.028	1.023	1.025	
SNL-14	1.048	1.048	1.044	1.046	
SNL-15	1.228	1.232	1.223	1.225	
SNL-16	1.010	1.023	1.013	1.015	
SNL-17	1.006	1.007	1.003	1.005	
SNL-18	1.028	1.011	1.003	1.005	
SNL-19	1.003	1.008	1.005	1.007	
WIPP-11	1.038	1.035	1.035	1.037	
WIPP-13	1.053	1.055	1.043	1.045	
WIPP-19	1.044	1.046	1.049	1.051	
WIPP-25	1.011	1.010	1.000*	1.000*	*March-May, not reliable, Plugged in 2009
WQSP-1	1.048	1.048	1.046	1.046	Average Rounds 28 and 29, field hydrometer
WQSP-2	1.048	1.048	1.045	1.045	Average Rounds 28 and 29, field hydrometer

Table 6.4 – Pressure Density Survey for 2009

Well I.D.	2007 Pressure Density Survey Result	2008 Pressure Density Survey Result	2009 Pressure Density Survey Result	2009 Conversion to Specific Gravity at 70° F	Notes for 2009 Pressure Density Survey
	Density (grams/cc)	Density (grams/cc)	Density (grams/cc)	Density (grams/cc)	
WQSP-3	1.146	1.144	1.144	1.144	Average Rounds 28 and 29, field hydrometer
WQSP-4	1.075	1.074	1.074	1.074	Average Rounds 28 and 29, field hydrometer
WQSP-5	1.025	1.025	1.025	1.025	Average Rounds 28 and 29, field hydrometer
WQSP-6	1.014	1.015	1.014	1.014	Average Rounds 28 and 29, field hydrometer

6.3 Drilling Activities

Well H-4bR was drilled as a replacement for well H-4b, which was plugged and abandoned in July 2009. The new well was drilled to a total depth of 518 feet, with the top of the screened interval at 490 feet below the ground surface.

6.4 Hydraulic Testing and Other Water Quality Sampling

In addition to the chemical testing in the seven WQSP wells required by the HWFP, the WIPP personnel also conducted basic water chemistry tests in some other wells as shown in Table 6.5 below.

Table 6.5 – 2009 Well and Water Quality Sampling Testing Activities

Table 6.5 – 2009 Well and Water Quality Sampling Testing Activities

Well Location	Dates	Activity[1]
H-15R, Culebra	January 2009	Water Chemistry
H-2b2, Magenta	January - February 2009	Water Chemistry
H-14, Magenta	February 2009	Water Chemistry
H-18	February - April 2009	Water Chemistry
H-3b1	April - July 2009	Water Chemistry
WIPP -18	June-September, December 2009	Water Chemistry
H-4bR	August 2009	Water Chemistry
H-6c	October, December 2009	Water Chemistry

[1] Water chemistry obtained by SNL. General chemical parameters (Anions/Cations).

6.5 Well Maintenance

Well maintenance for 2009 included plugging and abandonment of two wells, developing one well, repairing the surface access port on one WQSP well, and surveying one new well.

WIPP-25 was plugged and abandoned in late June 2009 and removed from the monitoring network. This well was a dual-completion well used to monitor Culebra and Magenta water levels. There was an unknown obstruction in the well below the PIP, which was assumed to be a bent casing. Well H-4b was a Culebra monitoring well plugged and abandoned in June; well H-4bR was drilled as a replacement (DOE/WIPP-10-3326).

Well H-10c was bailed in July to restore the fluid density due to freshwater remaining in borehole pond geophysical studies. WQSP-6A had an obstruction in the surface access tubing used for water level monitoring that was repaired in June. H-4bR was surveyed for its Top of Casing elevation and location in August. Table 6.6 shows the survey results.

Table 6.6 – 2009 Survey Data

Well	Northing NAD27(ft)	Easting NAD27(ft)	Top of Casing (TOC)(ft)	Ground Elevation(ft)
H-4bR	487,562	662,685	3,334.64	3,331.76
Note: Coordinates are New Mexico State Plane (feet)				

6.6 Shallow Subsurface Water Monitoring Program

Shallow subsurface water occurs beneath the WIPP site at a depth of less than 100 feet below ground level at the contact between the Santa Rosa and the Dewey Lake (Figure 6.1). Water yields are generally less than one gallon per minute in monitoring wells and piezometers and the water contains varying concentrations of TDS (1,730 mg/L to 255,000 mg/L) and chloride (350 mg/L to 170,000 mg/L). To the south, yields are greater and TDS lower. The origin of the high TDS in this water is believed to be primarily from anthropogenic sources, with some contribution from natural sources. The SSW occurs not only under the WIPP site surface facilities but also to the south as indicated by shallow water in drill hole C-2811, about one-half mile south of the WIPP facility. Additionally, 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 6.16). Natural shallow groundwater occurs in the middle part of the Dewey Lake at the southern portion of the WIPP site (WQSP-6A) (Figure 6.3) and to the south of the WIPP site (J. C. Mills Ranch). To date, there is no indication that the anthropogenic SSW has affected the naturally occurring groundwater in the Dewey Lake.

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) have been drilled as part of a monitoring program to measure spatial and temporal changes in SSW levels and water quality. Monitoring activities during 2009 included SSW level surveillance at these 19 locations (Figure 6.16).

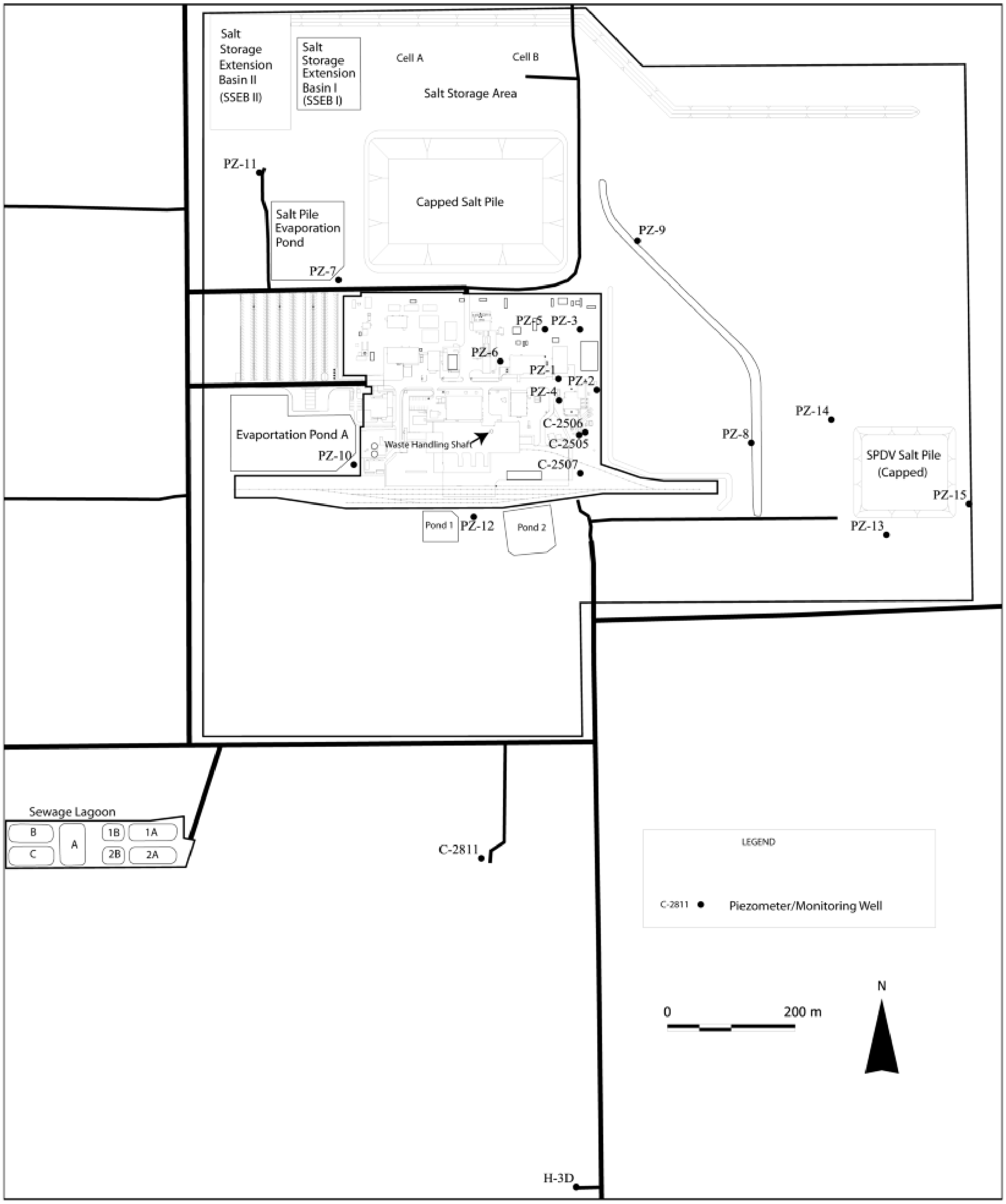

Figure 6. 16 – Location of SSW Wells (Piezometers PZ-1 through 15, C-2811, C-2505, C-2506, C-2507

6.6.1 Shallow Subsurface Water Quality Sampling

The discharge permit (DP-831), as modified, requires 11 SSW wells to be sampled on a semiannual basis. Wells PZ-1, PZ-5, PZ-6, PZ-7, PZ-9, PZ-10, PZ-11, PZ-12, PZ-13, C-2811, and C-2507 are sampled for this program. These wells were sampled in May and October 2009 and the parameters presented in Table 6.7 were analyzed.

Table 6.7 – 2009 Shallow Subsurface Water Quality Sampling Results

Table 6.7 – 2009 Shallow Subsurface Water Quality Sampling Results

	General Chemistry Parameters			
Monitoring Site	**Sample Date**	**Sulfate (mg/L)**	**Chloride (mg/L)**	**TDS (mg/L)**
PZ-1	5/19/2009	2,200	54,000	96,000
PZ-1	10/19/2009	2,300	66,000	101,000
PZ-5	5/19/2009	1,500	13,000	24,000
PZ-5	10/19/2009	1,600	14,000	20,200
PZ-6	5/19/2009	2,700	61,000	89,000
PZ-6	10/19/2009	2,300	50,000	83,600
PZ-7	5/18/2009	3,700	76,000	120,000
PZ-7	10/20/2009	4,200	67,000	106,000
PZ-9	5/19/2009	3,600	94,000	130,000
PZ-9	10/19/2009	4,000	77,000	139,000
PZ-10	5/18/2009	530	460	1,800
PZ-10	10/20/2009	500	440	1,730
PZ-11	5/18/2009	2,500	72,000	110,000
PZ-11	10/20/2009	3,200	64,000	112,000
PZ-12	5/18/2009	870	4,600	8,300
PZ-12	10/20/2009	980	6,500	10,100
PZ-13	5/18/2009	3,300	180,000	240,000
PZ-13	10/20/2009	3,300	170,000	255,000
C-2811	5/18/2009	360	1,200	2,300
C-2811	10/20/2009	320	1,000	2,120
C-2507	5/19/2009	950	2,600	5,200
C-2507	10/19/2009	930	3,400	5,710

6.6.2 Shallow Subsurface Water Level Surveillance

Nineteen wells were used to perform surveillance of the SSW-bearing horizon in the Santa Rosa and the upper portion of the Dewey Lake. Water levels were measured quarterly at all the piezometers and wells shown in Figure 6.16.

The potentiometric surface for the SSW using December 2009 data is presented in Figure 6.17 The contours were generated using SURFER version 8.06.39 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 6.17). 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. and PZ-15 and Shallow Subsurface Water*). PZ-13 and PZ-14 were completed at the contact of the Santa Rosa and Dewey Lake. PZ-15 was completed much shallower 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, stormwater evaporation ponds were lined with high-density polyethylene in accordance with the discharge permit requirements. Since the installation of the liners, there has been a decrease in SSW elevations, which indicates that the liners have minimized the potential for groundwater to be impacted.

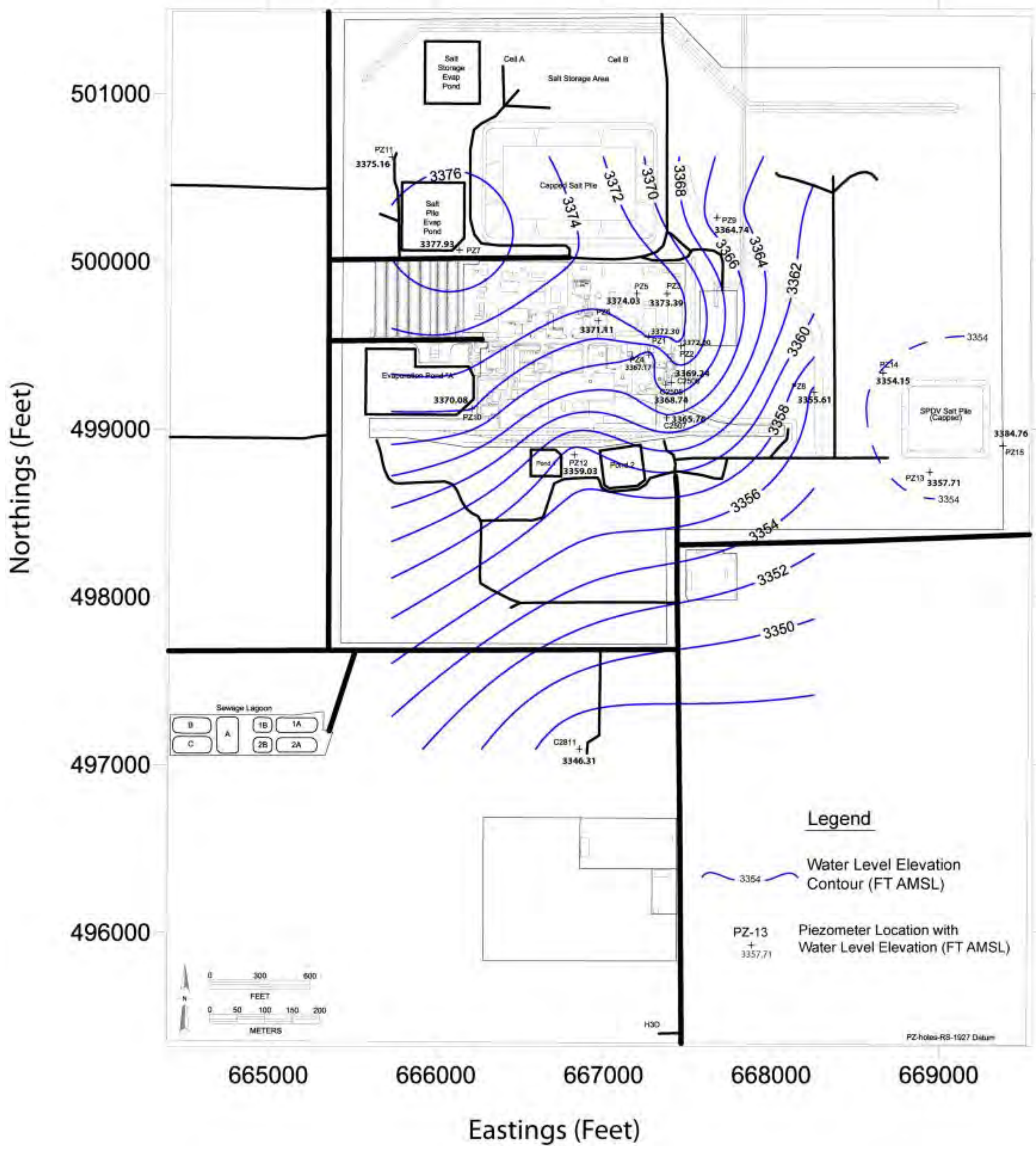

Figure 6. 17 – SSW Potentiometric Surface

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 miles south-southwest of the WIPP surface facilities, and about 1.75 miles south of WQSP-6A (see Figure 6.3 for location of WQSP-6A). Total dissolved solids concentrations 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 (CCA, DOE/CAO-96-2184).

A water budget analysis in 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 is expected to spread.

The potential extent for long-term SSW migration was examined by expanding the saturated flow model domain to include the 16-square-mile WIPP Land Withdrawal Area. The long-term migration model simulations indicated that the engineered seepage controls that are now in place will substantially reduce the extent of migration.

CHAPTER 7 – QUALITY ASSURANCE

The fundamental objective of the environmental QA program is to obtain accurate and precise analytical data that are technically and legally defensible. This is accomplished through a series of management activities that plan, implement, review, assess, and correct as necessary. Samples are collected and analyzed using standardized and proven methods. The resulting sample and associated QC data are reviewed, verified, validated, and incorporated into succinct and informative reports, which describe how well the lab met its QA objectives.

In 2009, WIPP Laboratories performed the radiological analyses of environmental samples from the WIPP site. Contract laboratories performed the nonradiological analyses including the Carlsbad Environmental Monitoring and Research Center (CEMRC) in Carlsbad, New Mexico, and Hall Environmental Analysis Laboratory (HEAL) in Albuquerque, New Mexico. In addition, HEAL subcontracted some groundwater analyses to Columbia Analytical Systems and Anatek Laboratories. These laboratories were contractually required to have documented QA programs, including an established QA plan along with laboratory-specific standard operating procedures (SOPs) based on published standard methods to perform the work.

The WIPP Laboratories and HEAL participated in intercomparison programs with such agencies as the National Institute of Standards and Technology (NIST), the Radiochemistry Intercomparison Program (NRIP), the Mixed Analyte Performance Evaluation Program (MAPEP), the Environmental Resource Associates interlaboratory assessment, the National Environmental Laboratory Accreditation Conference (NELAC), and/or other reputable interlaboratory comparison programs. Laboratories used by the WIPP program are also required to meet the applicable requirements of the CBFO Quality Assurance Program Document (DOE/CBFO-94-1012), as flowed down through the Washington TRU Solutions LLC Quality Assurance Program Description (WP 13-1). CEMRC was not required to participate in intercomparison programs during 2009.

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 WTS Quality Assurance Program Description. These plans contain such elements as:

- Management and organization
- Quality system and description
- Personnel qualification and training
- Procurement of products and services
- Documents and records
- Computer hardware and software

- Planning
- Management of work process (SOPs)
- Assessment and response
- Quality improvement

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

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

The QA objectives for the sampling and analysis program are completeness, precision, accuracy, comparability, and representativeness.

Sections 7.1, 7.2, and 7.3 discuss the QC results for the WIPP Laboratories, CEMRC, and HEAL, 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 anthropogenic radionuclides contained in the transuranic waste buried at the WIPP site. The reported concentrations at various locations in 2009 were representative of the baseline concentrations for radionuclides of interest at the WIPP facility.

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 WTS sampling programs." For radiological sampling and analysis programs, this contract requirement translates into the following quantitative definition.

Completeness is expressed as the number of samples analyzed with valid results as a percent 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 2009.

7.1.2 Precision

The SOW states that analytical precision (as evaluated through replicate measurements) will meet or surpass 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 both 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. The precision of field duplicates and laboratory duplicates can be calculated for non-detected as well as detected radionuclide analytes, but only the precision of detected radionuclides is presented in this report.

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

$$RER = \frac{\left|(MeanActivity)_{ori} - (MeanActivity)_{dup}\right|}{\sqrt{(2 \times SD)^2_{ori} + (2 \times SD)^2_{dup}}}$$

Where:

$(\text{Mean Activity})_{ori}$	=	Mean Activity of the Original or Primary Sample
$(\text{Mean Activity})_{dup}$	=	Mean Activity of the Duplicate Sample
SD	=	Standard Deviation of Original and Duplicate Samples

The laboratory performed duplicate analyses on separate portions of the same homogenized sample on at least one sample from each batch for each type of sample matrix in order to generate analysis precision data. The duplicate analyses of separate aliquots of the same sample evaluate the precision of subsampling in the laboratory, the heterogeneity of the media being sampled, and the precision of the analytical method. These laboratory precision data, as RERs, are not reported in the tables in this report, but data verification and validation review showed that all the RERs were <1 for the sample batches analyzed in 2009, demonstrating good precision for the analysis procedures.

The author calculated the RERs for the combined sample collection and analysis procedures from the analysis results of the duplicate samples collected in the field. The duplicate samples for other environmental media were collected at the same time, same place, and under similar conditions as the primary samples. In the case of animals, there were no duplicate field samples, but the laboratory generated duplicate laboratory samples for analysis from the single field samples. These data are reported in Chapter 4 for each type of sample matrix analyzed.

The QA objective for the RER results was revised by the laboratory to a value less than or equal to 2 (≤2) for 2009. Formerly the value was ≤1. However, all of the laboratory RERs were <1, meeting the more stringent objective and demonstrating good analytical reproducibility. Most of the field duplicate analysis results also yielded RERs <1 although there were some values between 1 and 2 and a few values >2, notably for the analysis of one of the duplicate groundwater samples for $^{233/234}U$ and ^{238}U and ^{40}K in two sediment samples. These were unusual situations and may represent actual differences in the composition of the duplicate field samples. This imprecision could be due to association of radionuclides with particulates.

In the case of the air particulate filters, a portable low-volume air sampler was moved to a different location each quarter and was operated along with the routine stationary air particulate samplers. No RER precision determinations were reported for the 2009 air particulate filter data since there were no instances in which a radionuclide met the detection criteria in both the primary and duplicate sample.

7.1.3 Accuracy

The accuracy of the radiochemical analyses was assured by analyzing calibration standards, method blanks, and laboratory control samples (blank spikes) as specified in the laboratory's SOPs. The radiochemistry SOW does not require the analysis of matrix spike samples. The SOW requires the measured accuracy to meet or surpass control criteria or guidelines established in the industry-standard methods used for sample analysis. Instrument accuracy was assured by using NIST-traceable radiochemistry standards for instrument calibration.

NIST-traceable standards were also spiked into clean water or a clean solid matrix to prepare laboratory control samples (LCSs). Laboratory control samples are QC samples that check whether the analysis procedure is in control. Analysis of LCSs containing the isotopes of interest was performed on a minimum 10 percent basis (one per batch of ten or fewer samples). The QA objective for the analysis results was that the measured concentration be within ± 20 percent of the known expected concentration. If this criterion was not met, the entire batch of samples was reanalyzed. LCS results for each isotope were tracked on a running basis using control charts. All radiological LCS results fell within the established recovery ranges, indicating good accuracy.

Accuracy was also ensured through participation of WIPP Laboratories in the DOE MAPEP, the DOE Laboratory Accreditation Program (DOELAP), and the NRIP interlaboratory comparison program (through NIST), as discussed in more detail in Section 7.1.4. Under these programs, WIPP Laboratories analyzed blind check samples, and the analysis results were compared with the official results measured by the DOELAP, MAPEP, and NRIP agency laboratories. Performance was established by percent bias, calculated as shown below.

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

Where:

% Bias	=	Percent Bias
Am	=	Measured Sample Activity
Ak	=	Known Sample Activity

The DOELAP and NRIP programs 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 DOELAP program performance evaluation (PE) 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. The analysis results for the WIPP target radionuclides in the samples (^{241}Am, ^{238}Pu, ^{240}Pu, ^{90}Sr, and ^{137}Cs) all met the accuracy criteria in a feces and urine sample with results turnaround times ranging from 2.7 to 11.9 hours.

WIPP Laboratories analyzed eight MAPEP environmental samples consisting of two each of soil, water, air filter, and vegetation samples. In addition, the laboratory analyzed one environmental soil sample from NRIP (NIST). 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 PE 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 PE samples as part of interlaboratory comparison programs administered by reputable agencies. During 2009, WIPP Laboratories participated in four rounds of the NIST NRIP Emergency Preparedness Program and two rounds of the DOE MAPEP.

The DOELAP, MAPEP, and the NIST NRIP programs 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 interlaboratory comparisons in that results from the participants are compared with the analysis data 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 (W) may be issued for a result near the borderline of acceptability.

Table 7. 1 presents the analysis results for the first 2009 set of MAPEP soil, water, air filter, and vegetation PE samples. Table 7.2 presents the results for the second 2009 set of MAPEP soil, water, air filter, and vegetation PE samples. The results for the first set show that the MAPEP bias results met the acceptance criteria (-25 percent/ +50 percent) for all the radionuclides and media of interest at the WIPP site except that a W (warning) was given for $^{233/234}$U on the air particulate filter and a not-acceptable (N) result was determined for ^{241}Am in the second sample set due to a false positive report. The ^{241}Am had not been spiked into the samples but was reported with a low concentration by the laboratory.

Table 7.1 – Mixed Analyte Performance Evaluation Program Review for WIPP Laboratories, 2009, First Set

	MATRIX: Air Filter (Bq/Filter) MAPEP-09- RdF20				MATRIX: Water (Bq/ L) MAPEP- 09- MaW20			
[RN][a]	Reported Value	MAPEP [b] Value	E[c]	% Bias	Reported Value	MAPEP Value	E	% Bias
^{241}Am	0.169	0.205	A	-17.6	0.580	0.636	A	-8.8
^{60}Co	1.20	1.22	A	-1.6	17.6	17.21	A	2.3
^{134}Cs	2.66	2.93	A	-9.2	21.1	22.5	A	-6.2
^{137}Cs	1.55	1.52	A	2.0	-1.89	f	A	f
^{238}Pu	0.188	0.1763	A	6.6	1.01	1.18	A	-14.4
$^{239/240}$Pu	0.155	0.157	A	-1.3	0.778	0.853	A	-8.8
^{90}Sr	0.640	0.640	A	0.0	6.99	7.21	A	-3.1
$^{233/234}$U	0.247	0.198	W[g]	24.7	2.95	2.77	A	6.5
^{238}U	0.249	0.21	A	18.6	3.03	2.88	A	5.2

Table 7.1 – Mixed Analyte Performance Evaluation Program Review for WIPP Laboratories, 2009, First Set

	MATRIX: Soil (Bq/kg) MAPEP-0 9-MaS20				MATRIX: Vegetation (Bq/Sample) MAPEP-0 9-RdV20			
[RN]	Reported Value	MAPEP Value	E	% Bias	Reported Value	MAPEP Value	E	% Bias
^{241}Am	36.6	38.3	A	-4.4	0.283	0.306	A	-7.5
^{60}Co	3.38	4.113	A	f	0.275	f	A	f
^{134}Cs	480	467	A	2.8	3.22	3.40	A	-5.3
^{137}Cs	569	605	A	-6.0	0.945	0.93	A	1.6
^{238}Pu	27.8	25.3	A	9.9	0.220	0.213	A	3.3
$^{239/240}$Pu	0.346	0.29	A	f	0.180	0.168	A	7.1
^{90}Sr	235	257	A	-8.6	1.15	1.260	A	-8.7
$^{233/234}$U	146	149	A	-2.0	0.487	0.460	A	5.9
^{238}U	149	155	A	-3.9	0.484	0.477	A	1.5

[a] Radionuclide
[b] Mixed Analyte Performance Evaluation Program
[c] Evaluation Rating (A = acceptable, W = Acceptable with warning, N = Not acceptable)
[d] Not applicable for non-detect per MAPEP
[e] Not applicable statistically zero result per MAPEP
[f] Information not provided by MAPEP
[g] W = warning

Table 7.2 – Mixed Analyte Performance Evaluation Program Review for WIPP Laboratories, 2009, Second Set

Table 7.2 - Mixed Analyte Performance Evaluation Program Review for WIPP Laboratories, 2009, Second Set

	MATRIX: Air Filter (Bq/Filter) MAPEP-09- RdF21				MATRIX: Water (Bq/ L) MAPEP- 09- MaW21			
[RN][a]	Reported Value	MAPEP[b] Value	E[c]	% Bias	Reported Value	MAPEP Value	E	% Bias
^{241}Am	0.0432	0.0	N[h]	False Pos.	1.06	1.04	A	1.9
^{60}Co	0.977	1.03	A	-5.1	15.0	15.4	A	-2.6
^{134}Cs	-0.0608	f	A	f	30.0	32.2	A	-6.8
^{137}Cs	1.36	1.40	A	3.4	40.3	41.2	A	-2.2
^{238}Pu	0.108	0.091	A	18.7	0.0223	0.018	A	f
$^{239/240}$Pu	0.154	0.138	A	11.6	1.76	1.64	A	7.3
^{90}Sr	0.845	0.835	A	1.2	12.7	12.99	A	-2.2
$^{233/234}$U	0.338	0.300	A	12.7	3.09	2.96	A	4.4
^{238}U	0.338	0.312	A	9.2	3.19	3.03	A	5.3

Table 7.2 - WIPP Mixed Analyte Performance Evaluation Program Review for Laboratories, 2009, Second Set

	MATRIX: Soil (Bq/kg) MAPEP-09-MaS21				MATRIX: Vegetation (Bq/Sample) MAPEP-09-RdV21			
[RN]	Reported Value	MAPEP Value	E	% Bias	Reported Value	MAPEP Value	E	% Bias
^{241}Am	80.6	89.8	A	-10.2	0.163	0.171	A	-4.7
^{60}Co	3.38	4.113	A	f	2.62	2.57	A	1.9
^{134}Cs	-3.77	f	A	f	0.214	f	A	f
^{137}Cs	585	669	A	-12.6	2.36	2.43	A	-2.9
^{238}Pu	68.9	63.2	A	9.0	0.00347	0.0016	A	f
$^{239/240}$Pu	120	116.3	A	3.2	0.279	0.258	A	8.1
^{90}Sr	421	455	A	-7.5	1.65	1.78	A	-7.3
$^{233/234}$U	191	209	A	-8.6	0.582	0.525	A	10.9
^{238}U	196	217	A	-9.7	0.582	0.544	A	7.0

[a] Radionuclide
[b] Mixed Analyte Performance Evaluation Program
[c] Evaluation Rating (A = acceptable, W = Acceptable with warning, N = Not acceptable)
[d] Not applicable for non-detect per MAPEP
[e] Not applicable statistically zero result per MAPEP
[f] Information not provided by MAPEP[g] W: warning
[h] N not acceptable

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 environmental monitoring is to protect the health and safety of the population surrounding the WIPP facility.

According to the SOW, analytical representativeness is assured 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 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 and laboratory method blanks were used to check for cross-contamination and to ensure sample integrity.

7.2 CEMRC

CEMRC performed the analyses of VOC and hydrogen/methane samples collected in the WIPP underground during 2009.

7.2.1 Completeness

Completeness is defined in WP 12-VC.01, Confirmatory Volatile Organic Compound Monitoring Plan; and WP 12-VC.04, Quality Assurance Project Plan for Hydrogen and Methane Monitoring, as being "the percentage of the ratio of the number of valid sample results received versus the total number of samples collected." For 2009, CEMRC was required to maintain a completeness of 95 percent.

For 2009, 482 VOC samples (including field duplicates) were submitted to CEMRC for analysis; 481 of these produced valid data. For repository, disposal room, and ongoing VOC monitoring, the program completion percentage was 99.8 percent.

For 2009, 356 hydrogen and methane samples (including field duplicates) were submitted to CEMRC for analysis (12 of these samples were also analyzed for VOCs); 152 of these produced valid data. For hydrogen and methane monitoring, the program completion percentage was 100 percent.

7.2.2 Precision

Precision is evaluated by two means in both the VOC monitoring and the hydrogen and methane monitoring programs: comparing both laboratory duplicate samples and field duplicate samples. The laboratory duplicate samples consist of an LCS and laboratory control sample duplicate (LCSD). The field duplicate is a duplicate sample that is collected parallel with the original sample. Both of these 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: A = Original Sample Result
B = Duplicate Sample Result

During 2009, an LCS and an LCSD were generated and evaluated for all data packages discussed in Section 7.2.1. The result from the evaluation of the comparison resulted in 100 percent of the data within the acceptable range.

Field duplicate samples are also collected and compared for precision. The acceptable range for the RPD between measured concentrations is ± 35 percent. For each value reported over the MRL in 2009, each field duplicate met the acceptance criteria.

7.2.3 Accuracy

The VOC monitoring program evaluates both quantitative and qualitative accuracy. The quantitative evaluation includes performance verification for instrument calibrations, LCS recoveries, and sample internal standard areas. Qualitative evaluation consists of the evaluation of standard ion abundance for the instrument tune; that is, a mass calibration check 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 30 percent for each analyte of the calibration. This is calculated by first calculating the relative response factor as indicated below:

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

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

During 2009, 100 percent of instrument calibrations met the ± 30 percent criteria.

LCS recoveries

LCS recoveries are required to have a percent recovery of ± 25 (75-125%R) percent. LCS recoveries are calculated as follows:

$$\text{Percent Recovery} = \frac{\text{Concentration Result}}{\text{Introduced Concentration} \times 100}$$

During 2009, 100 percent of the LCS recoveries met the ± 25 percent criterion.

Internal Standard Area

For VOC analyses, internal standard areas are compared to a calibrated standard to evaluate accuracy. The acceptance criteria is ± 40 percent.

During 2009, 100 percent of all standards met this criterion.

Sensitivity

To meet sensitivity requirements, the method detection limit for each of the nine target compounds must be evaluated before sampling begins. The initial and annual method detection limit evaluation is performed in accordance with 40 CFR Part 136, "Guidelines Establishing Test Procedures for the Analysis of Pollutants," and with EPA/530-SW-90-021, as revised and retitled, "Quality Assurance and Quality Control" (Chapter 1 of SW-846, Test Methods for Evaluating Solid Waste, Physical/Chemical Methods) (1996). For

2009, CEMRC completed method detection limit studies for VOC analyses in October and for hydrogen methane analysis in August.

7.2.3.2 Qualitative Accuracy

For VOC analyses, the standard ion abundance criteria for bromofluorobenzene is used to evaluate the accuracy of the analytical system in the identification of target analytes as well as unknown contaminants (qualitative accuracy). This ensures that the instrumentation is correctly identifying individual compounds during the analysis of air samples.

During 2009, all ion abundance criteria were within tolerance.

7.2.4 Comparability

There is no HWFP 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 standard operating procedures for sample collection and analyses.

7.2.5 Representativeness

There is no HWFP requirement for representativeness in the VOC monitoring program or the hydrogen and methane monitoring program.

7.3 Hall Environmental Analysis Laboratory

Hall Environmental Analysis Laboratory (HEAL) was awarded the groundwater analysis contract in February 2008 and performed the chemical analyses for the spring and fall sampling in 2009 (Rounds 28 and 29). HEAL followed SOPs based on standard analytical methods from EPA and from *Standard Methods for the Examination of Water and Wastewater*.

7.3.1 Completeness

The seven WQSP monitoring wells were sampled twice during 2009, March through May, and September through November, for the WIPP groundwater detection monitoring program. The completeness objective was met as analytical results were received for all the samples submitted (100 percent completeness).

7.3.2 Precision

The groundwater samples generally contained detectable concentrations of the major cations including calcium, magnesium, potassium, and sodium, as well as chloride, sulfate, TOC, density, total dissolved solids (TDS), total suspended solids (TSS), pH, conductivity, and alkalinity. Total organic carbon (TOC) and total organic halogen (TOX) were detected in many of the groundwater samples at concentrations between the method detection limit (MDL) and method reporting limit (MRL). HEAL subcontracted the TOX analyses to Columbia Analytical Services and subcontracted the trace metals analysis for antimony, arsenic, selenium, and thallium by inductively coupled plasma emission spectroscopy combined with inductively coupled plasma mass spectrometry (ICP-MS) to Anatek Laboratories in order to achieve the requisite detection limit requirements.

Precision was based on the analysis results of the duplicate well samples, duplicate analyses of a single well sample for some general chemistry parameter methods, as well as the precision of the recoveries of LCS/LCSD and MS/MSD pairs.

There were no detects for the volatile organics or semivolatile organics in any of the samples and very few detects for trace metals, and thus the precision data for these parameters was primarily based on the analysis results of the QC samples.

Table 7.3 shows the analysis results for which the precision objective of ≤20 RPD was not met for groundwater samples taken in 2009 (Rounds 28 and 29).

Table 7.3 – Individual Cases Where the Precision Objective Was Not Met in 2009 for Groundwater Sample Analyses

Well	Parameter	Primary Sample	Duplicate	RPD
WQSP-1	2,4-dinitrophenol	30.9 (MS)	53.7 (MSD)	54
WQSP-1	TOX	118 (primary)	182 (dup)	42

As can be seen in Table 7.3, analytical data met the precision QA objectives for all groundwater and QC samples with two minor exceptions for difficult analytes including the MS and MSD recovery for 2,4-dinitrophenol and the sample analysis results for TOX. Thus >99 percent of the precision analysis results met the objective.

7.3.3 Accuracy

The accuracy of the groundwater sample analyses was based on the presence or absence of the target compounds in the method blank samples as well as the percent recovery of each constituent and applicable general chemistry parameter from the LCS and LCSD and/or MS and MSD QC samples.

The QA objective for the accuracy of the LCS/LCSD recoveries was generally 75-125 percent for the general chemistry parameters and metals and 70-130 percent for the VOCs and SVOCs.

The QA objective for the recoveries of the target analytes from the high-brine MS/MSD samples were generally wider than for the LCS/LCSD samples, which used clean water as the sample matrix. The laboratories used WQSP well groundwater samples for all the MS/MSD samples, and thus the MS/MSD recoveries provided relevant information about the effect of the groundwater matrix on the accuracy of measuring the target analytes.

Table 7.4 summarizes the QC samples for which the accuracy QA objective, as measured by percent recovery, was not met. None of the target analytes were detected in method blank samples as contaminants, and thus accuracy was not adversely affected by contamination. The recoveries of analytes which 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 7.4. Parameters not spiked as LCS and LCSD or MS and MSD samples included conductivity, pH, and total suspended solids.

Table 7.4 – Individual Cases Where the Accuracy Objective Was Not Met in 2009 for Groundwater QA Sample Analyses

Well	Parameter	Sample	% Rec	Sample	% Rec
WQSP-1 (28)	Isobutanol	MS	188	MSD	181
WQSP-1 (28)	2-Butanone	MS	147	MSD	146
WQSP-2 (28)	Isobutanol	MS	143	MSD	176
WQSP-2 (28)	2-Butanone	MS	144	MSD	141
WQSP-3 (28)	Isobutanol	MS	761	MSD	796
WQSP-3 (28)	2-Butanone	MS	284	MSD	285
WQSP-3 (28)	Mercury	MS	73.2	MSD	72.8
WQSP-4 (28)	Isobutanol	MS	338	MSD	313
WQSP-4 (28)	2-Butanone	MS	148	MSD	132
WQSP-5 (28)	Isobutanol	MS	212	MSD	207
WQSP-5 (28)	1,1,2,2-tetrachloroethane	MS	153	MSD	148
WQSP-5 (28)	TDS	MS	95.9(a)	MSD	132
WQSP-6 (28)	Isobutanol	MS	174	MSD	175
WQSP-6A (28)	Isobutanol	MS	128(a)	MSD	146
WQSP-2 (29)	Nitrate	MS	155	MSD	154
WQSP-2 (29)	Isobutanol	MS	228	MSD	231
WQSP-2 (29)	2-Butanone	MS	147	MSD	138
WQSP-2 (29)	1,1,2,2-Tetrachloroethane	MS	150	MSD	147
WQSP-3 (29)	Mercury	MS	63.5	MSD	63.6
WQSP-3 (29)	Isobutanol	MS	676	MSD	815
WQSP-3 (29)	2-Butanone	MS	276	MSD	309
WQSP-3 (29)	1,1,2,2-Tetrachloroethane	MS	199	MSD	190
WQSP-3 (29)	TOX	MS	49.4	MSD	12.4
WQSP-4 (29)	Isobutanol	MS	326	MSD	354
WQSP-4 (29)	2-Butanone	MS	175	MSD	178
WQSP-4 (29)	1,1,2,2-Tetrachloroethane	MS	138	MSD	138
WQSP-4 (29)	TOX	MS	274	MSD	265
WQSP-5 (29)	Isobutanol	MS	213	MSD	205
WQSP-5 (29)	2-Butanone	MS	130 (a)	MSD	131
WQSP-6 (29)	Nitrate	MS	162	MSD	137

(a) Recovery meets QA objective. (Round No. in parentheses.)

Not included in Table 7.4 are some recoveries of SVOC target compounds from the MS and MSD samples. In some cases, the recoveries were lower than the laboratory's historical control chart limits (where the lower limit recoveries were about 50 percent), but were higher than the recoveries specified in EPA guidance documents where the recovery limits are 40 to140 percent for base/neutral compounds and 30 to 130 percent for acidic compounds. In a few other cases the recoveries were higher than the laboratory's historical control chart limits but were lower than the recoveries specified in the EPA guidance documents. The SVOC compounds for which recoveries were adversely affected by the groundwater matrix and yielded relatively low recoveries included the compounds 2,4-dinitrophenol, 2,4-dinitrotoluene, hexachlorobenzene, 2-methylphenol, 3+4-methylphenol, and pentachlorophenol. None of these compounds were detected in the groundwater samples.

Some of the recovery issues with the data in 2009 were the same as those observed in previous years with the high-brine groundwater samples. For example, the recoveries of isobutanol and 2-butanone were often higher than the objective in matrix spike samples, likely due to a higher purging efficiency from brine solution than from the aqueous calibration standards. The 1,1,2,2-tetrachloroethane recoveries appear to be higher than the objective in a few MS/MSD samples, probably due to degradation of another chlorinated organic compound. For example, tetrachloroethene showed lower but acceptable recoveries in samples with high 1,1,2,2-tetrachloroethane recoveries.

Nitrate was difficult to analyze using ion chromatography in the brine samples when high concentrations of chloride were present. Nitrate has only been detected in the Dewey Lake WQSP-6A well, which has relatively low brine concentrations. TOX yielded high spike recoveries in Round 29 WQSP-3 and WQSP-4 samples. These wells contained the highest concentrations of chloride, which can interfere with TOX measurement. The mercury MS/MSD recoveries were slightly lower than the QA objective in the high-brine WQSP-3 groundwater samples.

Overall, the quality of the accuracy QC data was excellent with nearly all the data meeting the QA objective.

7.3.4 Comparability

The HWFP 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 standard operating procedures for sample collection and analyses. The normal reporting units for metals and general chemistry parameters were mg/L, and the normal reporting limits for organics were ug/L.

HEAL and its subcontract laboratories are certified by several states and by the National Environmental Laboratory Accreditation Program (NELAP) through Oregon for HEAL and Anatek and through Florida for Columbia Analytical Services. HEAL's state certifications include Oregon, Utah, Texas, New Mexico, and Arizona. As such the labs participate in interlaboratory evaluation programs including on-site NELAC QA audits. The labs also regularly analyze performance evaluation samples provided by a NELAC-accredited Proficiency Standard Vendor such as Wibby Environmental. HEAL also analyzed MAPEP performance evaluation samples as part of the DOE performance evaluation program. The Wibby Water Supply performance evaluation samples included trace metals, mercury, pH, TOC, regulated VOCs, unregulated VOCs, and the Wibby Water Pollution performance evaluation samples included TDS, TSS, nitrate, TKN, alkalinity, trace metals, mercury, specific conductance, pH, VOCs, SVOCs (acids and base-neutrals), and the MAPEP performance evaluation samples included SVOCs.

Of the target analytes that HEAL analyzed in both sets of proficiency testing samples, HEAL obtained acceptable results for all the parameters except for Ni and V in the water pollution proficiency samples. The concentrations of the metals are higher in the water pollution samples than in the water supply samples, where Hall obtained acceptable results for all the trace metals. HEAL reported 4.80 mg/L for Ni where the low end of the acceptable range was 4.85 mg/L and reported 0.131 mg/L for V where the low end of the acceptable range was 0.137 mg/L.

For the analytes that HEAL subcontracted to other analytical laboratories, Columbia Analytical Services obtained acceptable analysis results for TOX in various performance evaluation samples, and Anatek Laboratory obtained acceptable results for trace metals by ICP/MS in various performance evaluation 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, alkalinity, specific conductance, chlorides, divalent cations, and total iron. The final samples for analysis of VOCs, SVOCs, metals and general chemistry parameters were collected only when it had been determined from serial sampling and analysis that the water being pumped was representative of the natural groundwater at each location.

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Appendix B – Active Environmental Permits

Table B.1 – Active Environmental Permits and Approvals for the Waste Isolation Pilot Plant as of March 1, 2010						
	Granting Agency	**Type of Permit**	**Permit Number**	**Granted/ Submitted**	**Expiration**	**Current Permit Status**
1.	Department of the Interior Bureau of Land Management	Right-of-Way for the North Access Road	NM55676	08/24/83	None	Active
2.	Department of the Interior Bureau of Land Management	Right-of-Way for Railroad	NM55699	09/27/83	None	Active
3.	Department of the Interior Bureau of Land Management	Right-of-Way for Dosimetry and Aerosol Sampling Sites	NM63136	07/31/86	07/31/11	Active
4.	Department of the Interior Bureau of Land Management	Right-of-Way for Seven Subsidence Monuments	NM65801	11/07/86	None	Active
5.	Department of the Interior Bureau of Land Management	Right-of-Way for Aerosol Sampling Site	NM77921	08/18/89	08/18/19	Active
6.	Department of the Interior Bureau of Land Management	Right-of-Way for 2 Survey Monuments	NM82245	12/13/89	12/13/19	Active
7.	Department of the Interior Bureau of Land Management	Right-of-Way for Telephone Cable	NM46092	07/03/90	09/04/11	Active
8.	Department of the Interior Bureau of Land Management	Right-of-Way for SPS Powerline	NM43203	02/20/96	10/19/11	Active
9.	Department of the Interior Bureau of Land Management	Right-of-Way for South Access Road	NM123703	1/27/10	12/31/39	Active
10.	Department of the Interior Bureau of Land Management	Right-of-Way for Duval Telephone Line	NM60174	11/06/96	03/08/15	Active
11.	Department of the Interior Bureau of Land Management	Right-of-Way for Wells AEC-7 and AEC-8	NM108365	8/30/02	08/30/32	Active
12.	Department of the Interior Bureau of Land Management	Right-of-Way for ERDA-6	NM108365	8/30/02	08/30/32	Active
13.	Department of the Interior Bureau of Land Management	Right-of-Way for Well C-2756 (P18)	NM108365	8/30/02	08/30/32	Active
14.	Department of the Interior Bureau of Land Management	Right-of-Way for Monitoring Well C-2664 (Cabin Baby)	NM107944	04/23/02	04/23/32	Active
15.	Department of the Interior Bureau of Land Management	Right-of-Way for Seismic Stations C-2725 (H4A), C-2775 (H-4B), and C-2776 (H4C) Right-of-Way for Seismic Stations C-2723 (WIPP-25), C-2724 (WIPP26), C-2722 (WIPP-27), C-2636 (WIPP-28), C-2743 (WIPP-29), and C-2727 (WIPP-30)	NM120413	07/16/08	12/31/2037	Active

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Table B.1 – Active Environmental Permits and Approvals for the Waste Isolation Pilot Plant as of March 1, 2010

	Granting Agency	Type of Permit	Permit Number	Granted/ Submitted	Expiration	Current Permit Status
16.	Department of the Interior Bureau of Land Management	Right-of-Way for Aerosol Sampling Sites	NM77921	10/03/89	08/18/19	Active
17.	New Mexico State Land Office	Right-of-Way Easement for Accessing State Trust Lands in Eddy and Lea Counties	R25430	9/28/04	9/28/14	Active
18.	Department of Interior Bureau of Land Management	Right-of-Way for Valor Telecom	NM113339	8/9/05	12/31/34	Active
19.	Department of Interior Bureau of Land Management	Right-of-Way for South Access Road Fence	NM094304	3/15/95	In Perpetuity	Active
20.	New Mexico Commissioner of Public Lands	Right-of-Way for High Volume Air Sampler	RW-22789	10/03/85	10/03/20	Active
21.	New Mexico Environment Department Groundwater Bureau	Discharge Permit	DP-831	9/9/08	9/9/13	Active
22.	New Mexico Environment Department Air Quality Bureau	Operating Permit for Two Backup Diesel Generators	310-M-2	12/07/93	None	Active
23.	New Mexico Environment Department-UST Bureau	Underground Storage Tanks	NMED11811 (Number changes annually)	07/01/02	Expires June Annually	Active
24.	New Mexico State Engineer Office	Monitoring Well Exhaust Shaft Exploratory Borehole	C-2801	02/23/01	None	Active
25.	New Mexico State Engineer Office	Monitoring Well Exhaust Shaft Exploratory Borehole	C-2802	02/23/01	None	Active
26.	New Mexico State Engineer Office	Monitoring Well Exhaust Shaft Exploratory Borehole	C-2803	02/23/01	None	Active
27.	New Mexico State Engineer Office	Monitoring Well	C-2811	03/02/02	None	Active
28.	New Mexico State Engineer Office	Appropriation: WQSP-1 Well	C-2413	10/21/96	None	Active
29.	New Mexico State Engineer Office	Appropriation: WQSP-2 Well	C-2414	10/21/96	None	Active
30.	New Mexico State Engineer Office	Appropriation: WQSP-3 Well	C-2415	10/21/96	None	Active
31.	New Mexico State Engineer Office	Appropriation: WQSP-4 Well	C-2416	10/21/96	None	Active

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Table B.1 – Active Environmental Permits and Approvals for the Waste Isolation Pilot Plant as of March 1, 2010						
	Granting Agency	**Type of Permit**	**Permit Number**	**Granted/ Submitted**	**Expiration**	**Current Permit Status**
32.	New Mexico State Engineer Office	Appropriation: WQSP-5 Well	C-2417	10/21/96	None	Active
33.	New Mexico State Engineer Office	Appropriation: WQSP-6 Well	C-2418	10/21/96	None	Active
34.	New Mexico State Engineer Office	Appropriation: WQSP-6a Well	C-2419	10/21/96	None	Active
35.	New Mexico State Engineer Office	Monitoring Well AEC-7	C-2742	11/06/00	None	Active
36.	New Mexico State Engineer Office	Monitoring Well AEC-8	C-2744	11/06/00	None	Active
37.	New Mexico State Engineer Office	Monitoring Well Cabin Baby	C-2664	07/30/99	None	Active
38.	New Mexico State Engineer Office	Monitoring Well D-268 Plugged to 220'. Livestock Watering	C-2638	01/12/99	None	Active
39.	New Mexico State Engineer Office	Monitoring Well DOE-1	C-2757	11/06/00	None	Active
40.	New Mexico State Engineer Office	Monitoring Well DOE-2	C-2682	04/17/00	None	Active
41.	New Mexico State Engineer Office	Monitoring Well ERDA-9	C-2752	11/06/00	None	Active
42.	New Mexico State Engineer Office	Monitoring Well H-1	C-2765	11/06/00	None	Active
43.	New Mexico State Engineer Office	Monitoring Well H-2A	C-2762	11/06/00	None	Active
44.	New Mexico State Engineer Office	Monitoring Well H-2B1	C-2758	11/06/00	None	Active
45.	New Mexico State Engineer Office	Monitoring Well H-2B2	C-2763	11/06/00	None	Active
46.	New Mexico State Engineer Office	Monitoring Well H-2C	C-2759	11/06/00	None	Active
47.	New Mexico State Engineer Office	Monitoring Well H-3B1	C-2764	11/06/00	None	Active
48.	New Mexico State Engineer Office	Monitoring Well H-3B2	C-2760	11/06/00	None	Active

Appendix B – Active Environmental Permits

Table B.1 – Active Environmental Permits and Approvals for the Waste Isolation Pilot Plant as of March 1, 2010

	Granting Agency	Type of Permit	Permit Number	Granted/ Submitted	Expiration	Current Permit Status
49.	New Mexico State Engineer Office	Monitoring Well H-3B3	C-2761	11/06/00	None	Active
50.	New Mexico State Engineer Office	Monitoring Well H-3D	C-3207	11/06/00	None	Active
51.	New Mexico State Engineer Office	Monitoring Well H-4A	C-2725	11/06/00	None	Active
52.	New Mexico State Engineer Office	Monitoring Well H-4B	C-2775	11/06/00	None	Active
53.	New Mexico State Engineer Office	Monitoring Well H-4C	C-2776	11/06/00	None	Active
54.	New Mexico State Engineer Office	Monitoring Well H-5A	C-2746	11/06/00	None	Active
55.	New Mexico State Engineer Office	Monitoring Well H-5B	C-2745	11/06/00	None	Active
56.	New Mexico State Engineer Office	Monitoring Well H-5C	C-2747	11/06/00	None	Active
57.	New Mexico State Engineer Office	Monitoring Well H-6A	C-2751	11/06/00	None	Active
58.	New Mexico State Engineer Office	Monitoring Well H-6B	C-2749	11/06/00	None	Active
59.	New Mexico State Engineer Office	Monitoring Well H-6C	C-2750	11/06/00	None	Active
60.	New Mexico State Engineer Office	Monitoring Well H-7A	C-2694	04/17/00	None	Active
61.	New Mexico State Engineer Office	Monitoring Well H-7B1	C-2770	11/06/00	None	Active
62.	New Mexico State Engineer Office	Monitoring Well H-7B2	C-2771	11/06/00	None	Active
63.	New Mexico State Engineer Office	Monitoring Well H-7C	C-2772	11/06/00	None	Active
64.	New Mexico State Engineer Office	Monitoring Well H-8A	C-2780	11/06/00	None	Active
65.	New Mexico State Engineer Office	Monitoring Well H-8B	C-2781	11/06/00	None	Active

Appendix B – Active Environmental Permits

Table B.1 – Active Environmental Permits and Approvals for the Waste Isolation Pilot Plant as of March 1, 2010						
	Granting Agency	**Type of Permit**	**Permit Number**	**Granted/ Submitted**	**Expiration**	**Current Permit Status**
66.	New Mexico State Engineer Office	Monitoring Well H-8C	C-2782	11/06/00	None	Active
67.	New Mexico State Engineer Office	Monitoring Well H-9A	C-2785	11/06/00	None	Active
68.	New Mexico State Engineer Office	Monitoring Well H-9B	C-2783	11/06/00	None	Active
69.	New Mexico State Engineer Office	Monitoring Well H-9C	C-2784	11/06/00	None	Active
70.	New Mexico State Engineer Office	Monitoring Well H-10A	C-2779	11/06/00	None	Active
71.	New Mexico State Engineer Office	Monitoring Well H-10B	C-2778	11/06/00	None	Active
72.	New Mexico State Engineer Office	Monitoring Well H-10C	C-2695	04/17/00	None	Active
73.	New Mexico State Engineer Office	Monitoring Well H-11B1	C-2767	11/06/00	None	Active
74.	New Mexico State Engineer Office	Monitoring Well H-11B2	C-2687	04/17/00	None	Active
75.	New Mexico State Engineer Office	Monitoring Well H-11B3	C-2768	11/06/00	None	Active
76.	New Mexico State Engineer Office	Monitoring Well H-11B4	C-2769	11/06/00	None	Active
77.	New Mexico State Engineer Office	Monitoring Well H-12	C-2777	11/06/00	None	Active
78.	New Mexico State Engineer Office	Monitoring Well H-14	C-2766	11/06/00	None	Active
79.	New Mexico State Engineer Office	Monitoring Well H-15	C-2685	04/17/00	None	Active
80.	New Mexico State Engineer Office	Monitoring Well H-16	C-2753	11/06/00	None	Active
81.	New Mexico State Engineer Office	Monitoring Well H-17	C-2773	11/06/00	None	Active
82.	New Mexico State Engineer Office	Monitoring Well H-18	C-2683	04/17/00	None	Active

Appendix B – Active Environmental Permits

Table B.1 – Active Environmental Permits and Approvals for the Waste Isolation Pilot Plant as of March 1, 2010						
	Granting Agency	**Type of Permit**	**Permit Number**	**Granted/ Submitted**	**Expiration**	**Current Permit Status**
83.	New Mexico State Engineer Office	Monitoring Well H-19B0	C-2420	01/25/95	None	Active
84.	New Mexico State Engineer Office	Monitoring Well H-19B1	C-2420	01/25/95	None	Active
85.	New Mexico State Engineer Office	Monitoring Well H-19B2	C-2421	01/25/95	None	Active
86.	New Mexico State Engineer Office	Monitoring Well H-19B3	C-2422	01/25/95	None	Active
87.	New Mexico State Engineer Office	Monitoring Well H-19B4	C-2423	01/25/95	None	Active
88.	New Mexico State Engineer Office	Monitoring Well H-19B5	C-2424	01/25/95	None	Active
89.	New Mexico State Engineer Office	Monitoring Well H-19B6	C-2425	01/25/95	None	Active
90.	New Mexico State Engineer Office	Monitoring Well H-19B7	C-2426	01/25/95	None	Active
91.	New Mexico State Engineer Office	Monitoring Well P-14	C-2637	01/02/99	None	P&A
92.	New Mexico State Engineer Office	Monitoring Well P-15	C-2686	04/17/00	None	P&A
93.	New Mexico State Engineer Office	Monitoring Well P-17	C-2774	11/06/00	None	Active
94.	New Mexico State Engineer Office	Monitoring Well P-18	C-2756	11/06/00	None	P&A
95.	New Mexico State Engineer Office	Monitoring Well WIPP-12	C-2639	01/12/99	None	Active
96.	New Mexico State Engineer Office	Monitoring Well WIPP-13	C-2748	11/06/00	None	Active
97.	New Mexico State Engineer Office	Monitoring Well WIPP-18	C-2684	04/17/00	None	Active
98.	New Mexico State Engineer Office	Monitoring Well WIPP-19	C-2755	11/06/00	None	Active
99.	New Mexico State Engineer Office	Monitoring Well WIPP-21	C-2754	11/06/00	None	Active

Appendix B – Active Environmental Permits

Table B.1 – Active Environmental Permits and Approvals for the Waste Isolation Pilot Plant as of March 1, 2010

	Granting Agency	Type of Permit	Permit Number	Granted/ Submitted	Expiration	Current Permit Status
100.	New Mexico State Engineer Office	Monitoring Well WIPP-25	C-2723	07/26/00	None	Active
101.	New Mexico State Engineer Office	Monitoring Well WIPP-26	C-2724	11/06/00	None	Active
102.	New Mexico State Engineer Office	Monitoring Well WIPP-27	C-2722	11/06/00	None	Active
103.	New Mexico State Engineer Office	Monitoring Well WIPP28	C-2636	01/12/99	None	P&A
104.	New Mexico State Engineer Office	Monitoring Well WIPP-29	C-2743	11/06/00	None	Active
105.	New Mexico State Engineer Office	Monitoring Well WIPP-30	C-2727	08/04/00	None	Active
106.	New Mexico State Engineer Office	Monitoring Well H-6BR	C-3362	12/27/07	None	Active
107.	New Mexico State Engineer Office	Monitoring Well H-15R	C-3361	12/27/07	None	Active
108.	New Mexico State Engineer Office	Monitoring Well SNL-2	C-2948	2/14/03	None	Active
109.	New Mexico State Engineer Office	Monitoring Well SNL-9	C-2950	2/14/03	None	Active
110.	New Mexico State Engineer Office	Monitoring Well SNL-12	C-2954	2/25/03	None	Active
111.	New Mexico State Engineer Office	Monitoring Well SNL-1	C-2953	2/25/03	None	Active
112.	New Mexico State Engineer Office	Monitoring Well SNL-3	C-2949	2/14/03	None	Active
113.	New Mexico State Engineer Office	Monitoring Well SNL-5	C-3002	10/1/03	None	Active
114.	New Mexico State Engineer Office	Monitoring Well IMC-461	C-3015	11/25/03	None	Active
115.	New Mexico State Engineer Office	Monitoring Well SNL-10	C-3221	7/26/05	None	Active
116.	New Mexico State Engineer Office	Monitoring Well SNL-16	C-3220	7/26/05	None	Active

Appendix B – Active Environmental Permits

Table B.1 – Active Environmental Permits and Approvals for the Waste Isolation Pilot Plant as of March 1, 2010						
	Granting Agency	**Type of Permit**	**Permit Number**	**Granted/ Submitted**	**Expiration**	**Current Permit Status**
117.	New Mexico State Engineer Office	Monitoring Well SNL-17	C-3222	7/26/05	None	Active
118.	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	4/30/08	4/30/13	Active
119.	U.S. Fish and Wildlife Service	Migratory Bird Special Purpose – Relocate	MB155189-0	6/1/09	5/31/10	Active

P&A – Plugged and Abandoned

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Appendix C – Location Codes

Appendix C – Location Codes

Table C.1 – Codes Used to Identify the Sites from Which Sample Were Collected

Code	Location	Code	Location
BHT	Bottom of the Hill Tank	RCP1	Rainwater Catchment Pond (1)
BRA	Brantley Lake	RCP2	Rainwater Catchment Pond (2)
CBD	Carlsbad	RED	Red Tank
COW	Coyote Well (distilled water blank)	SEC	South East Control
COY	Blind Duplicate for IDN	SMR	Smith Ranch
FWT	Fresh Water Tank	SOO	Sample of Opportunity*
HIL	Hill Tank	SWL	Sewage Lagoons
IDN	Indian Tank	TUT	Tut Tank
LST	Lost Tank	UPR	Upper Pecos River
MLR	Mills Ranch	WAB	WIPP Air Blank
NOY	Noya Tank	WEE	WIPP East
PCN	Pierce Canyon	WFF	WIPP Far Field
PEC	Pecos River	WQSP	Water Quality Sampling Program
PKT	Poker Trap	WSS	WIPP South

* Sample taken where found

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Appendix D – Radiochemical Equations

Appendix D – Radiochemical Equations

Detection

All radionuclides with the exception of the gamma spectroscopy targets (^{137}Cs, ^{60}Co, and ^{40}K) are considered "detected" if the radionuclide activity or concentration [RN] is greater than the minimum detectable concentration and greater than the total propagated uncertainty at the 2 sigma level. The gamma radionuclides are considered detected when the above criteria are met and the gamma spectroscopy software used to identify the peak generates an associated identification confidence of 90 percent or greater (ID Confidence ≥0.90).

Minimum Detectable Concentration (MDC)

The MDC is the smallest amount (activity or mass) of a radionuclide in a 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 WIPP Laboratories uses 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 method blank counts = 0, 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 (TPU)

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.

Appendix D – Radiochemical Equations

The TPU for each data point must be reported at the 2σ level (2 x TPU). $TPU_{2\sigma}$ is found by multiplying $TPU_{1\sigma}$ by 1.96 after using the following equation:

$$TPU_{1\sigma} = \frac{\sqrt{\sigma_{NCR}{}^2 + (NCR)^2 * (RE_{EFF}^2 + RE_{ALI}^2 + RE_R^2 + \Sigma\ RE_{CF}^2)}}{2.22 * EFF * ALI * R * ABN_S * e^{-\lambda\Delta t} * CF}$$

Where:

EFF	=	Detector Efficiency
ALI	=	Sample Aliquot Volume or Mass
R	=	Sample Tracer/Carrier Recovery
ABN_s	=	Abundance Fraction of the Emissions Used for Identification/Quantification
σ^2NCR	=	Variance of the Net Sample Count Rate
NCR	=	Net Sample Count Rate
RE^2_{EFF}	=	Square of the Relative Error of the Efficiency Term
RE^2_{ALI}	=	Square of the Relative Error of the Aliquot
RE^2_{R}	=	Square of the Relative Error of the Sample Recovery
RE^2_{CF}	=	Square of the Relative Error of Other Correction Factors
λ	=	Radionuclide Decay Constant = ln 2/(half-life) (same units as the half-life used to compute $_\Delta$t)
$_\Delta$t	=	Time from Sample Collection to Radionuclide Separation or Mid-Point of Count Time (same units as half-life)
CF	=	Other Correction Factors as Appropriate (i.e., ingrowth factor, self-absorption factor).

For further discussion of TPU, refer to ANSI N13.30 and/or *Waste Acceptance Criteria for Off-Site Generators*, Fernald Environmental Management Project (DOE, 1994).

Appendix D – Radiochemical Equations

Relative Error Ratio (RER)

The RER is a method, similar to a t-test, with which to compare duplicate results (see Chapters 4 and 8; WP 02-EM3004, Radiological Data Verification and Validation).

$$RER = \frac{| x_A - x_B |}{\sqrt{(2\sigma_A)^2 + (2\sigma_B)^2}}$$

Where:

$\overline{X}_A$	=	Mean Activity of Population A
$\overline{X}_B$	=	Mean Activity of Population B
σ_A	=	Standard Deviation of Population A
σ_B	=	Standard Deviation of Population B

Percent Bias (% 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.

$$\% \ BIAS = [\frac{A_m - A_k}{A_k}] * 100\%$$

Where:

% BIAS	=	Percent Bias
Am	=	Measured Sample Activity
Ak	=	Known Sample Activity

Appendix D – Radiochemical Equations

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Appendix E – Time Trend Plots for Detectable Constituents in Groundwater

Appendix E – Time Trend Plots for Detectable Constituents in Groundwater

The seven WQSP wells had been sampled 27 times prior to the two sampling rounds conducted in 2009. The first 10 sampling rounds conducted from 1995 through 2000 (prior to receiving mixed waste at the WIPP site) were used to establish the original baseline for groundwater chemistry at each sampling location. The baseline sample set is used to determine whether statistically significant changes have occurred at any well. The following time trend charts show the Round 28 and Round 29 results with respect to the established baseline.

The baseline was established incorporating data from three different laboratories. The wide ranges of target analyte concentrations measured during the baseline resulted from past difficulties in analyzing the high-brine groundwater from the WIPP site. The contract laboratories used variable dilution factors when analyzing the samples resulting in variable detection limits for some analytes.

The analytes include constituents that are defined as the target 20 volatile and 12 semivolatile organics, as well as 14 trace metals. Time trend plots are not included for these. The other analytes include the general chemistry indicator parameters. The general chemistry parameters include the common cation metals, calcium, magnesium, potassium, and sodium; the anions chloride and sulfate; density, pH, specific conductance, total dissolved solids, total suspended solids, total organic carbon, and total organic halogens. Time trend plots are provided below for the following general chemistry parameters: dissolved calcium, chloride, dissolved magnesium, pH, dissolved potassium, sulfate and total dissolved solids. These plots show the concentrations in the primary sample and the duplicate sample for all sampling rounds.

The current laboratory analytical results were verified and validated in accordance with WIPP procedures and U.S. Environmental Protection Agency technical guidance. Sampling Round 28 samples were taken March through May 2009 and Sampling Round 29 samples were taken September through November 2009. See Appendix F for the concentrations of all the target analytes in the WQSP groundwater wells.

Some notable observations from the trend plots include:

- There was no evidence of any external contamination in any of the groundwater samples.
- Most of the measurements reported for Rounds 28 and 29 were less than the 95th Upper Tolerance Limit Value (UTLV) or within the range of previous measurements with a few minor exceptions as discussed below. The UTLV establishes a concentration range that contains a specified proportion of the population (established from baseline data collected in Rounds 1 through 10) with a specified confidence. Analyte data from the current sampling rounds (28 and 29) were compared to the baseline range to determine suspect outliers.
- With respect to the major metal cations, calcium, magnesium, and potassium concentrations were within the normal range of past values, although the concentrations did fluctuate.

Appendix E – Time Trend Plots for Detectable Constituents in Groundwater

- Chemical analysis data from Rounds 28 and 29 showed only a few instances where target analyte concentrations exceeded the 95th UTLV. Each instance involved the concentration of anions.

- WQSP-1 contained chloride concentrations in both the primary and duplicate sample that were higher than the 95th UTLV (42,000 and 45,000 mg/L versus 40,472 mg/L) in Round 28.

- In Round 28, chloride concentration in the primary sample was slightly above the 95th UTLV for WQSP-2 (40,400 mg/L vs. 39,670 mg/L). The duplicate sample was slightly lower than the UTLV (39,500 mg/L vs. 39,670 mg/L).

- The sulfate concentration in the duplicate sample from WQSP-3 was higher in Round 28 than the 95th UTLV (8,570 mg/L vs. 8,015 mg/L). In Round 29, sulfate concentrations were higher that the 95th UTLV in both the primary and duplicate samples collected from WQSP-3 (8,120 and 8,120 mg/L vs. 8,015 mg/L).

- The duplicate, but not the primary sample from WQSP-4 contained chloride concentrations that exceeded the 95th UTLV (68,000 mg/L vs. 63,960 mg/L) during Round 28. During Round 29, both the primary and duplicate samples contained sulfate concentrations greater than the UTLV (67,700 and 67,300 mg/L vs. 63,960 mg/L).

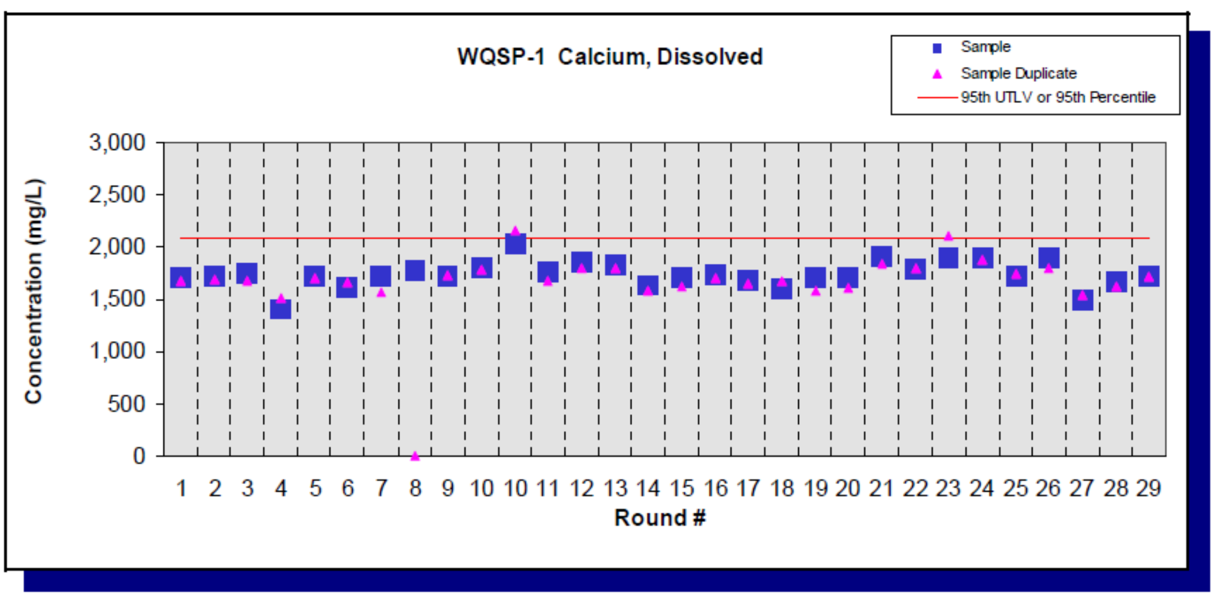

Figure E.1 - Time Trend Plot for Chloride at WQSP-1

Appendix E – Time Trend Plots for Detectable Constituents in Groundwater

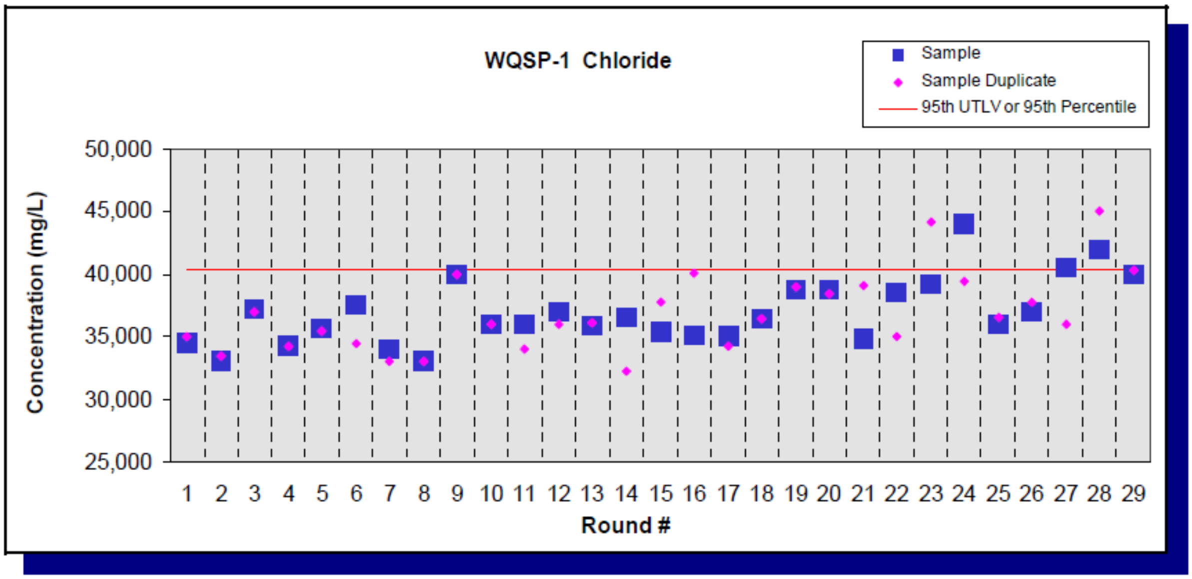

Figure E.2 - Time Trend Plot for Chloride at WQSP-1

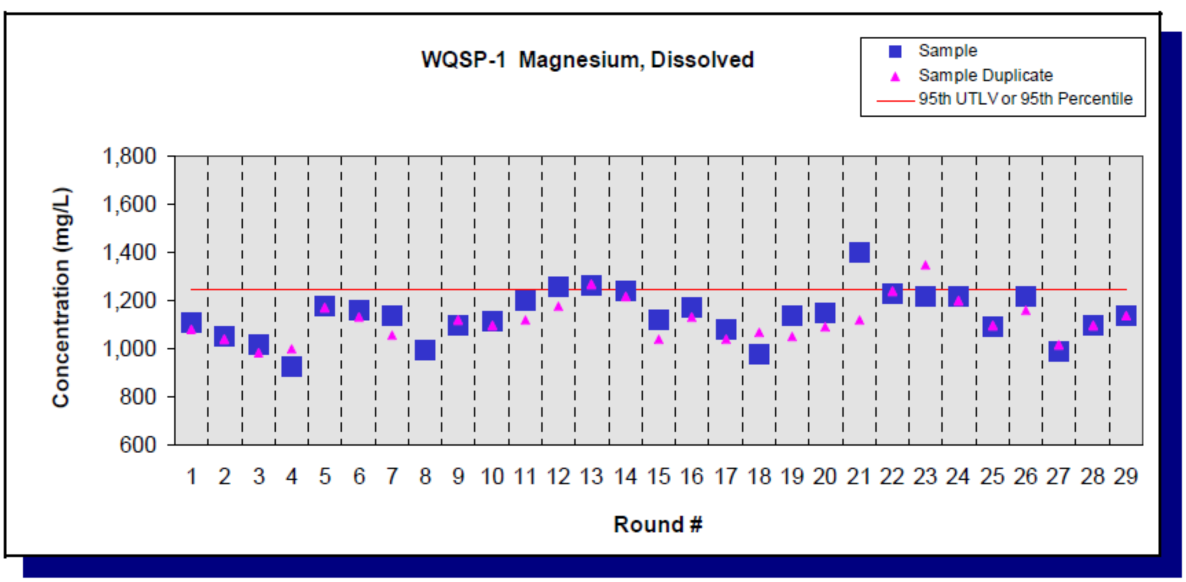

Figure E.3 - Time Trend Plot for Magnesium, Dissolved, at WQSP-1

Appendix E – Time Trend Plots for Detectable Constituents in Groundwater

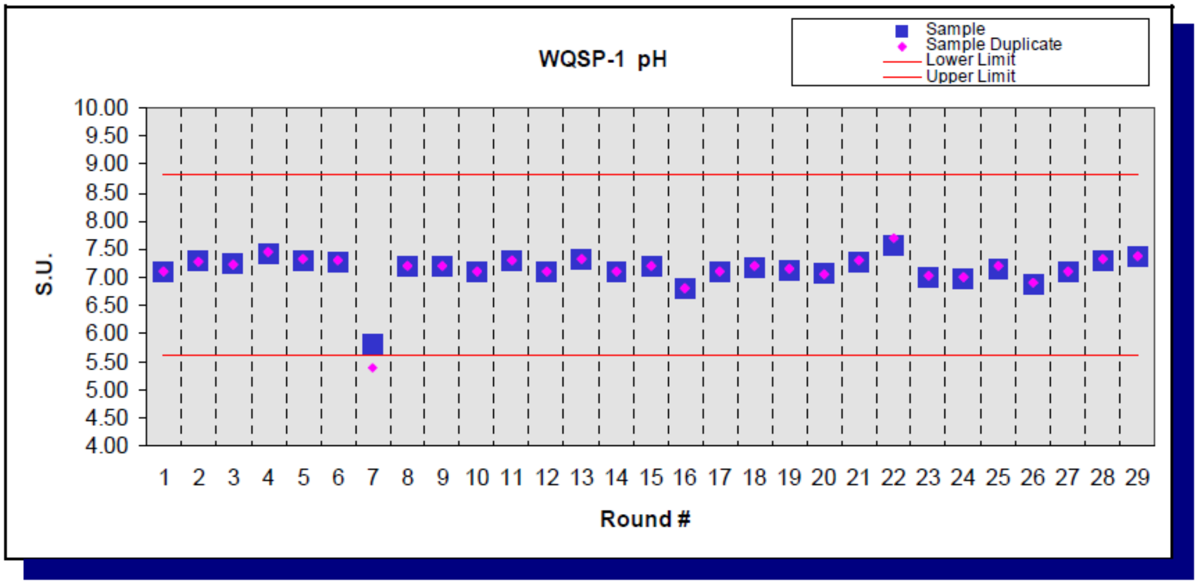

Figure E.4 - Time Trend Plot for pH at WQSP-1

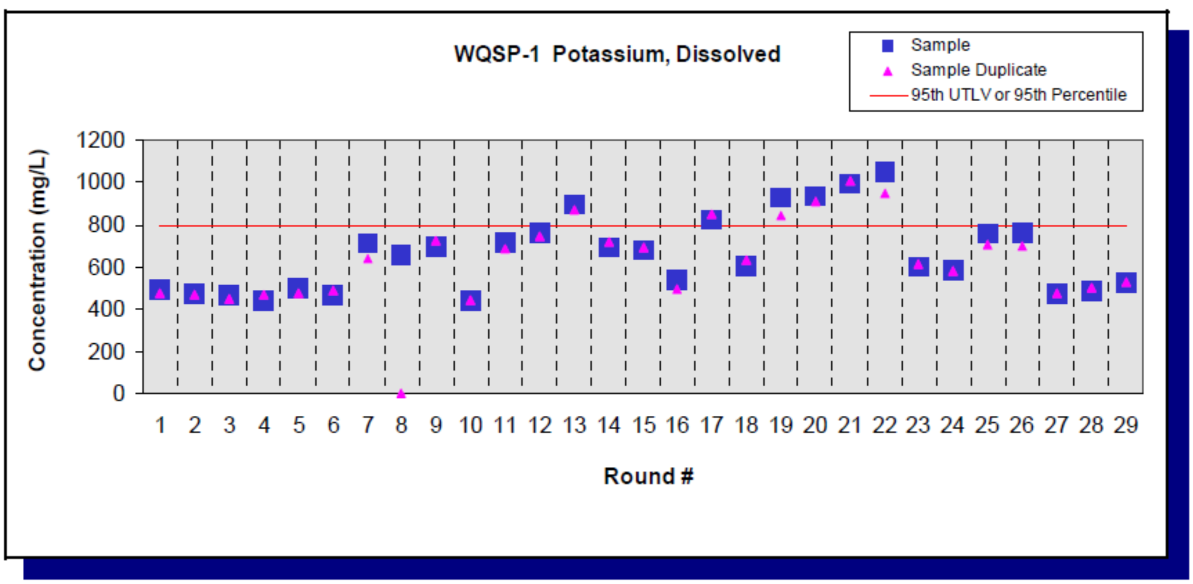

Figure E.5 - Time Trend Plot for Potassium, Dissolved, at WQSP-1

Appendix E – Time Trend Plots for Detectable Constituents in Groundwater

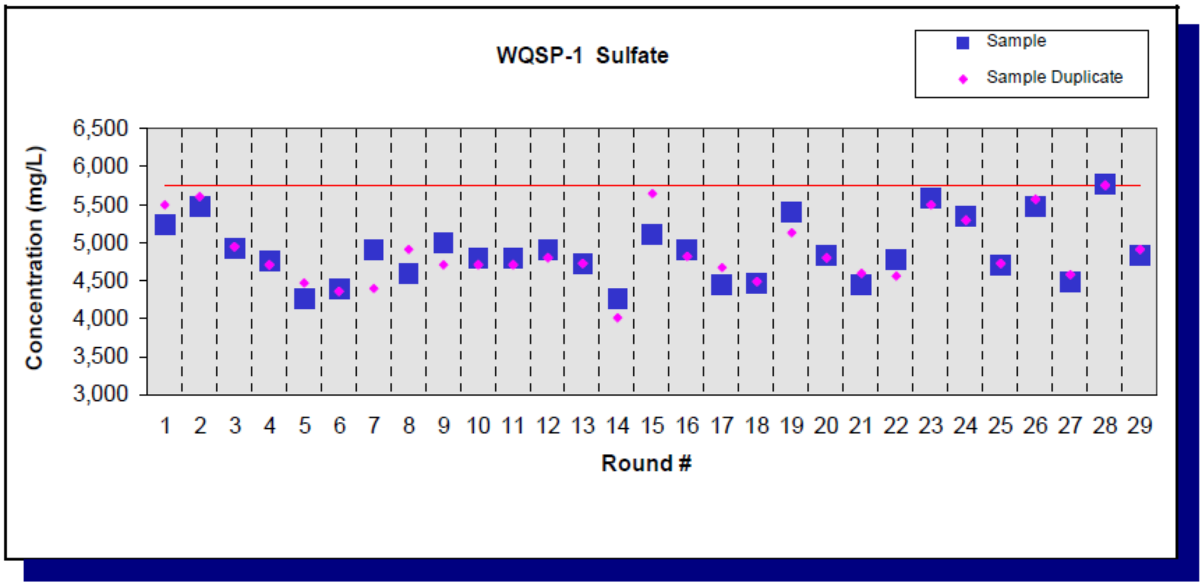

Figure E.6 - Time Trend Plot for Sulfate at WQSP-1

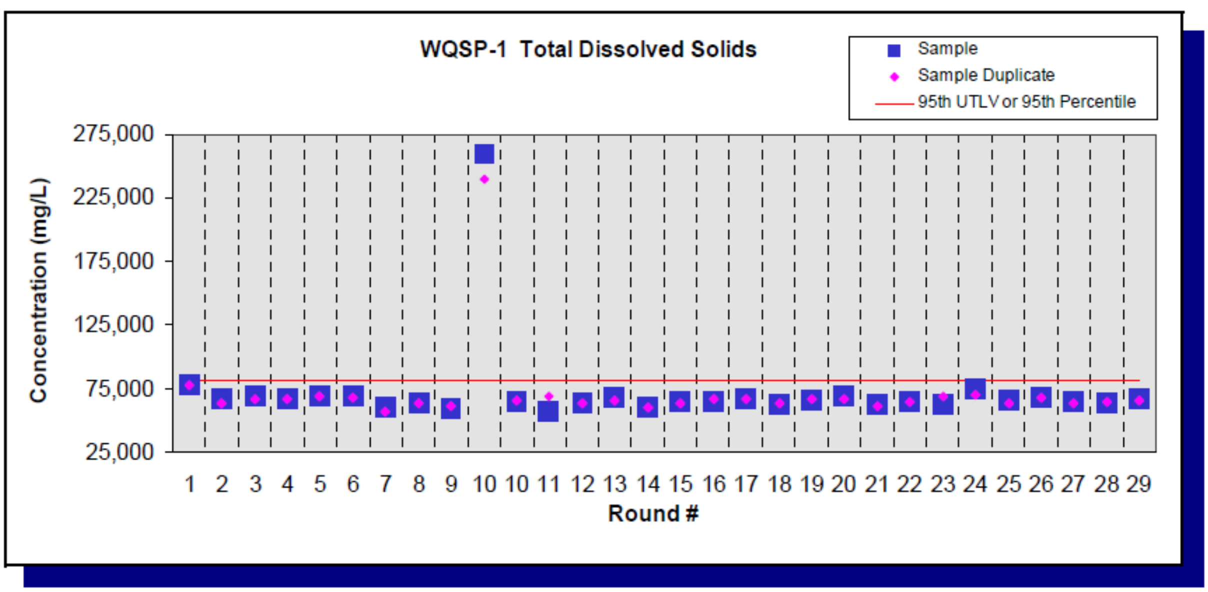

Figure E.7 - Time Trend Plot for Total Dissolved Solids at WQSP-1

Appendix E – Time Trend Plots for Detectable Constituents in Groundwater

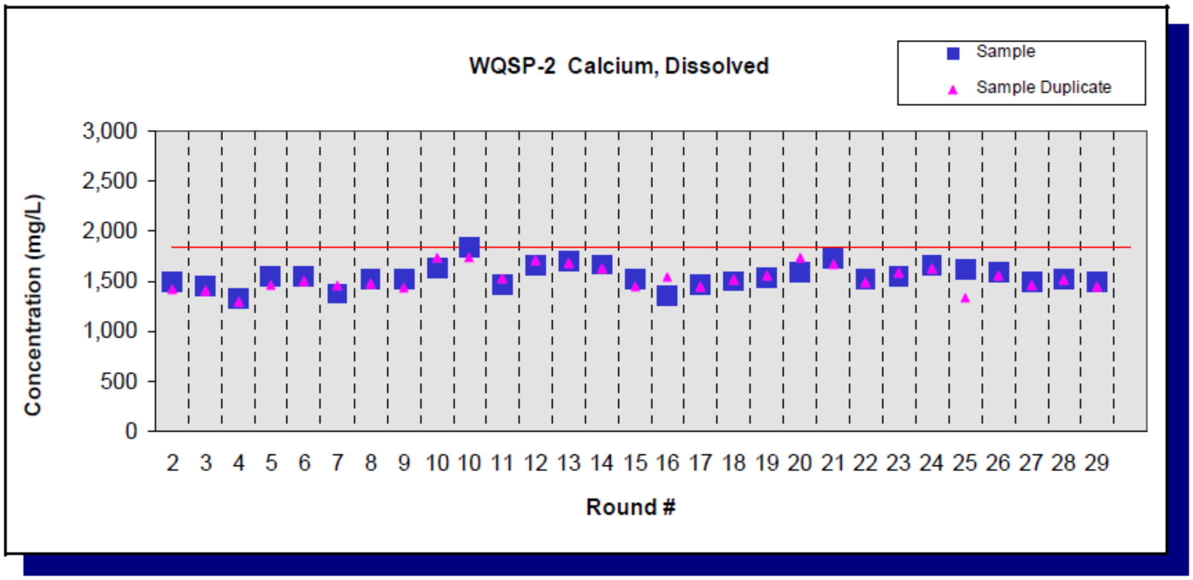

Figure E.8 - Time Trend Plot for Calcium at WQSP-2

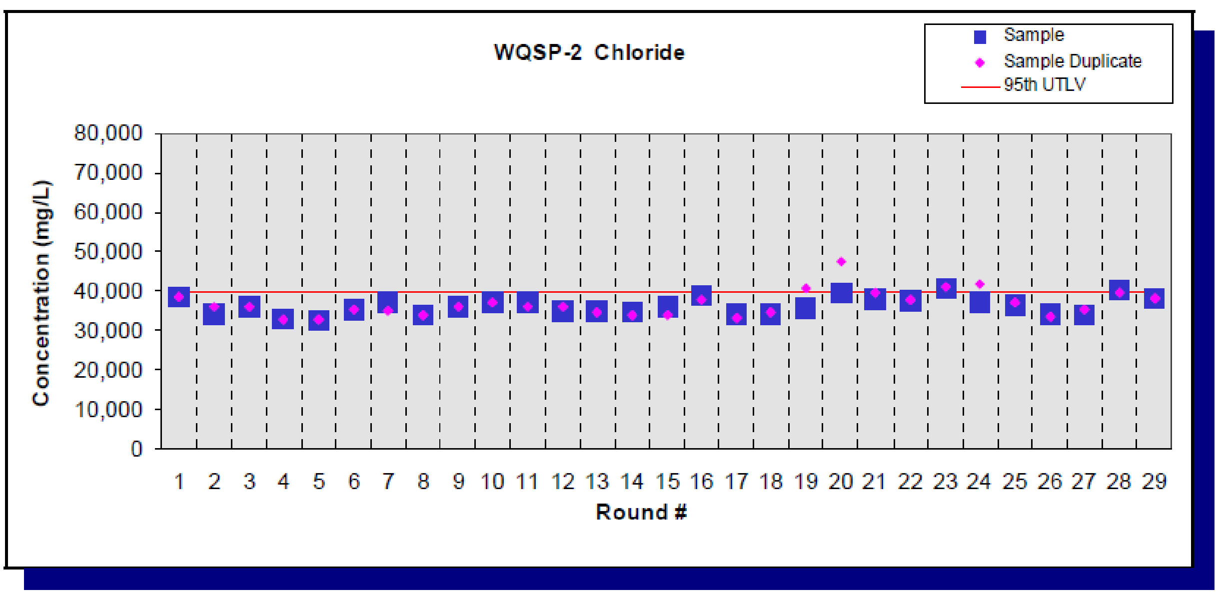

Figure E.9 - Time Trend Plot for Chloride at WQSP-2

Appendix E – Time Trend Plots for Detectable Constituents in Groundwater

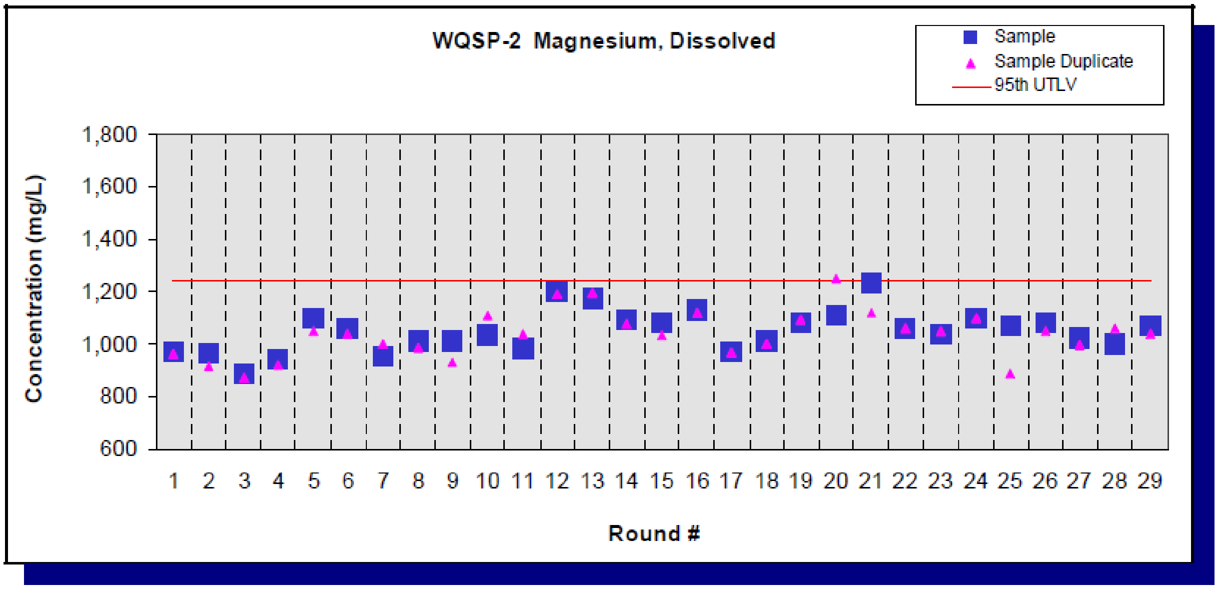

Figure E.10 - Time Trend Plot for Magnesium, Dissolved, at WQSP-2

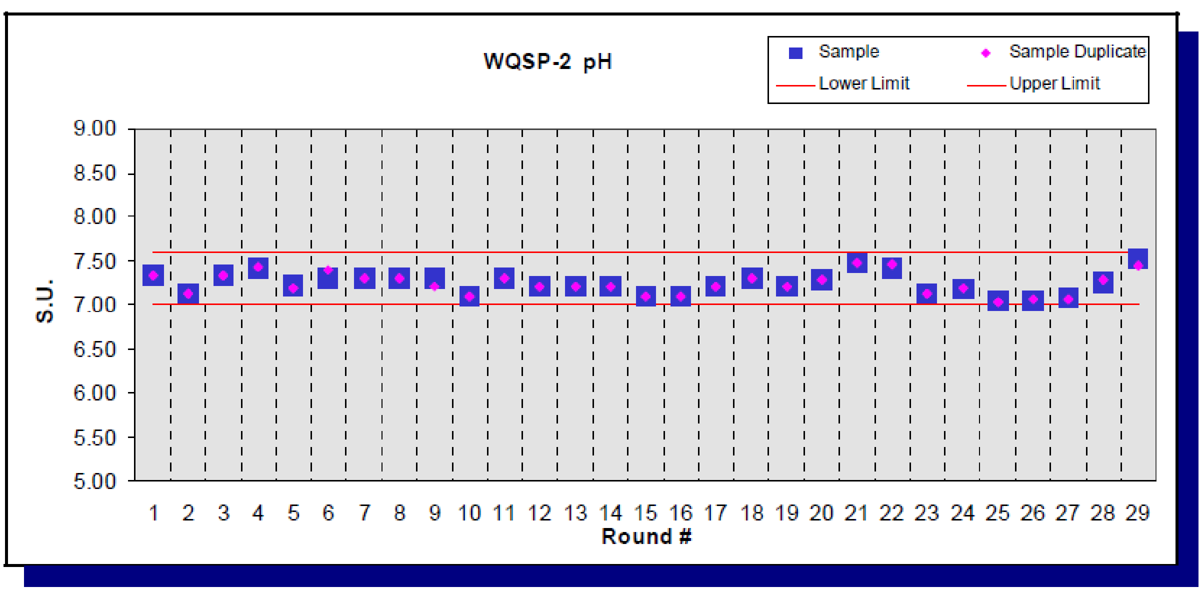

Figure E.11 - Time Trend Plot for pH at WQSP-2

Appendix E – Time Trend Plots for Detectable Constituents in Groundwater

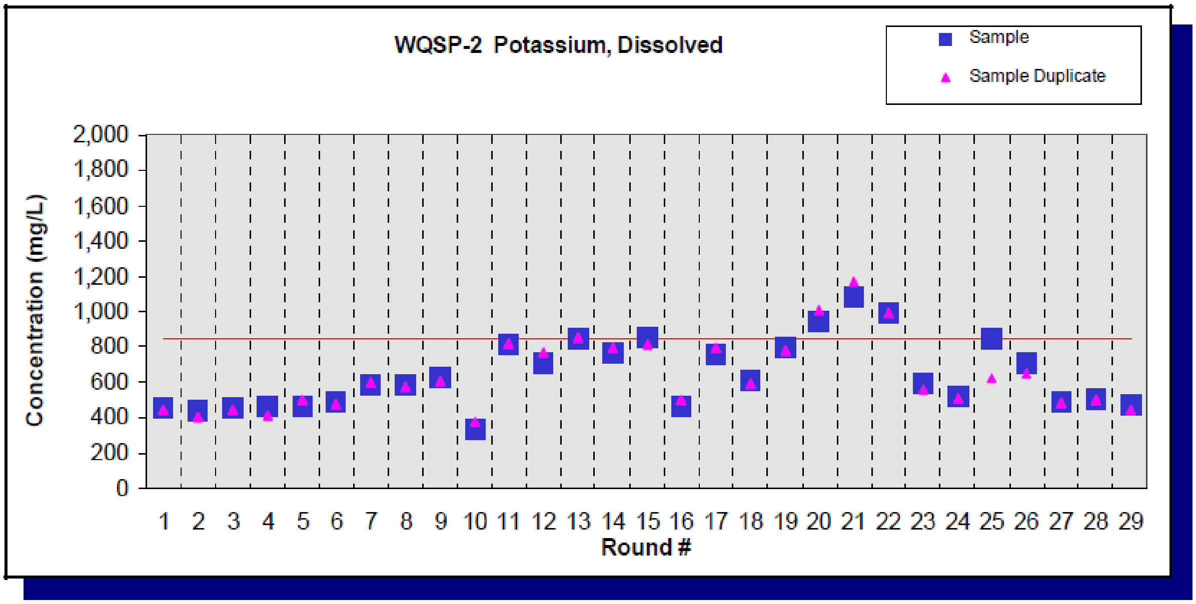

Figure E.12 - Time Trend Plot for Potassium, Dissolved, at WQSP-2

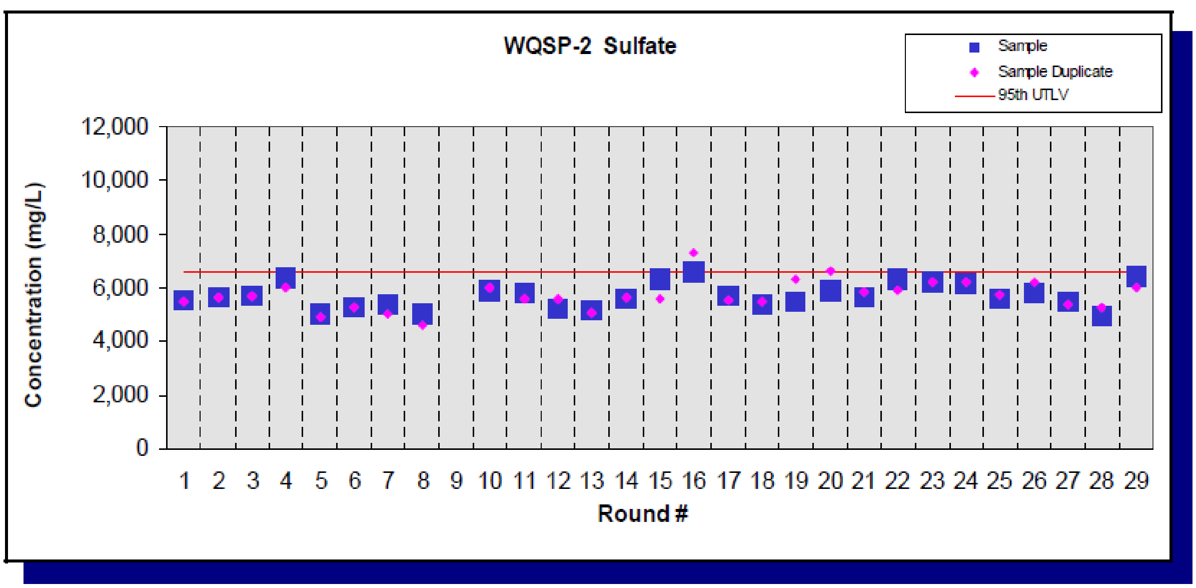

Figure E.13 - Time Trend Plot for Sulfate at WQSP-2

Appendix E – Time Trend Plots for Detectable Constituents in Groundwater

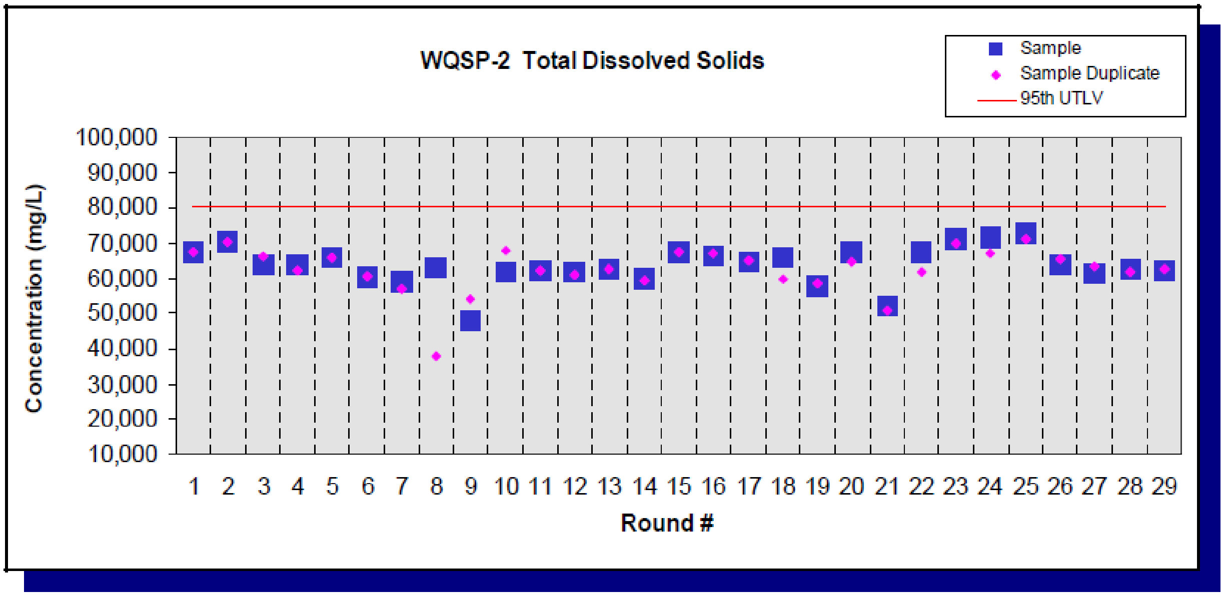

Figure E.14 - Time Trend Plot for Total Dissolved Solids at WQSP-2

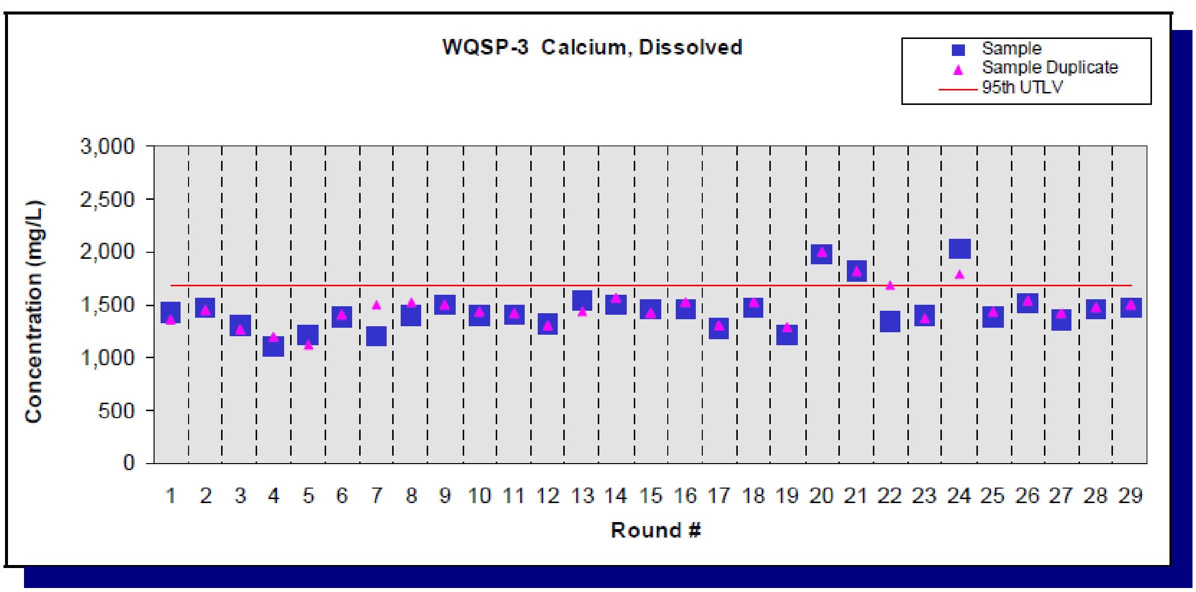

Figure E.15 - Time Trend Plot for Calcium, Dissolved, at WQSP-3

Appendix E – Time Trend Plots for Detectable Constituents in Groundwater

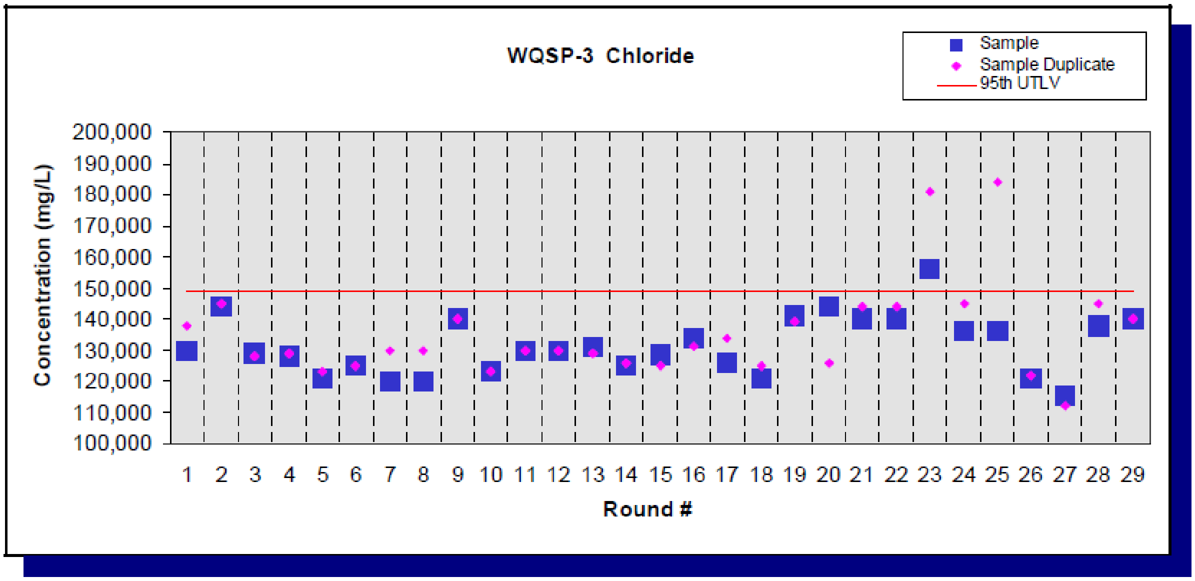

Figure E.16 - Time Trend Plot for Chloride at WQSP-3

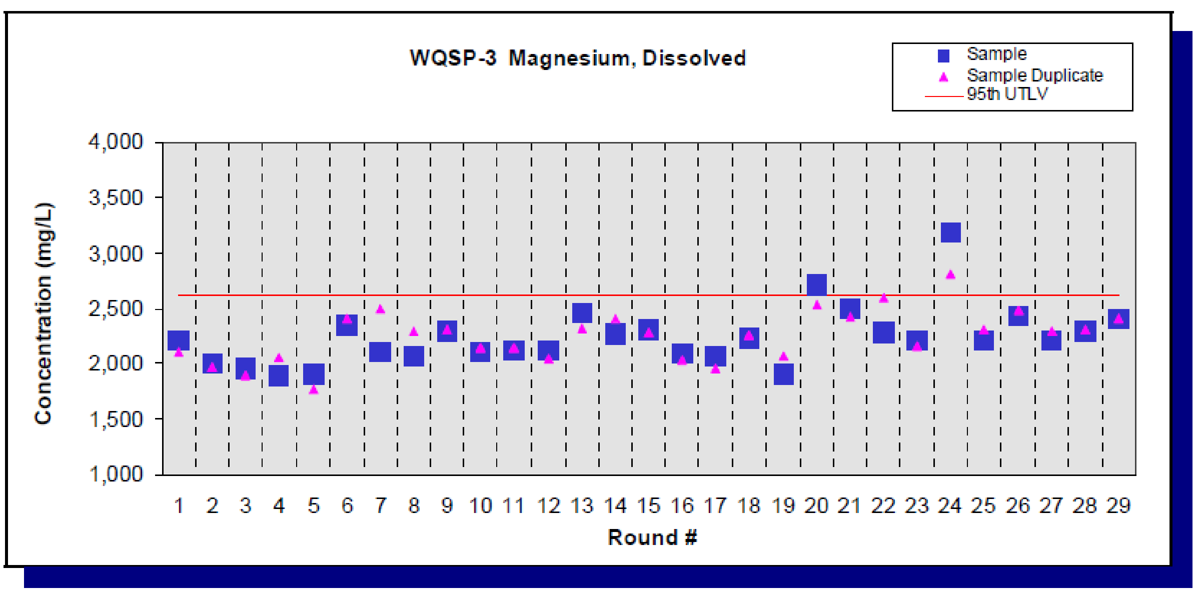

Figure E.17 - Time Trend Plot for Magnesium, Dissolved, at WQSP-3

Appendix E – Time Trend Plots for Detectable Constituents in Groundwater

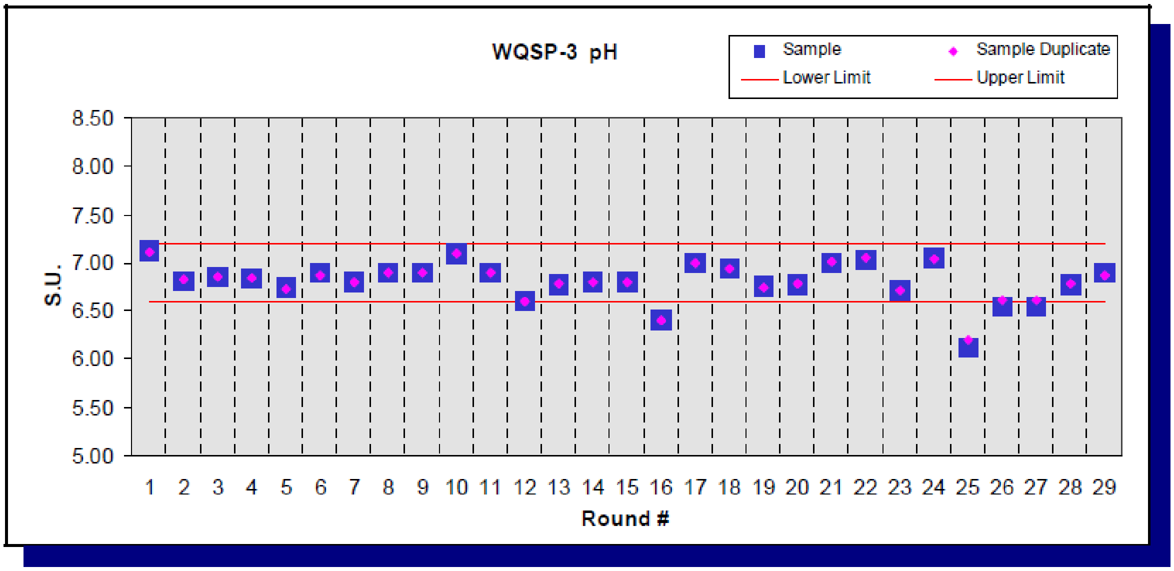

Figure E.18 - Time Trend Plot for pH at WQSP-3

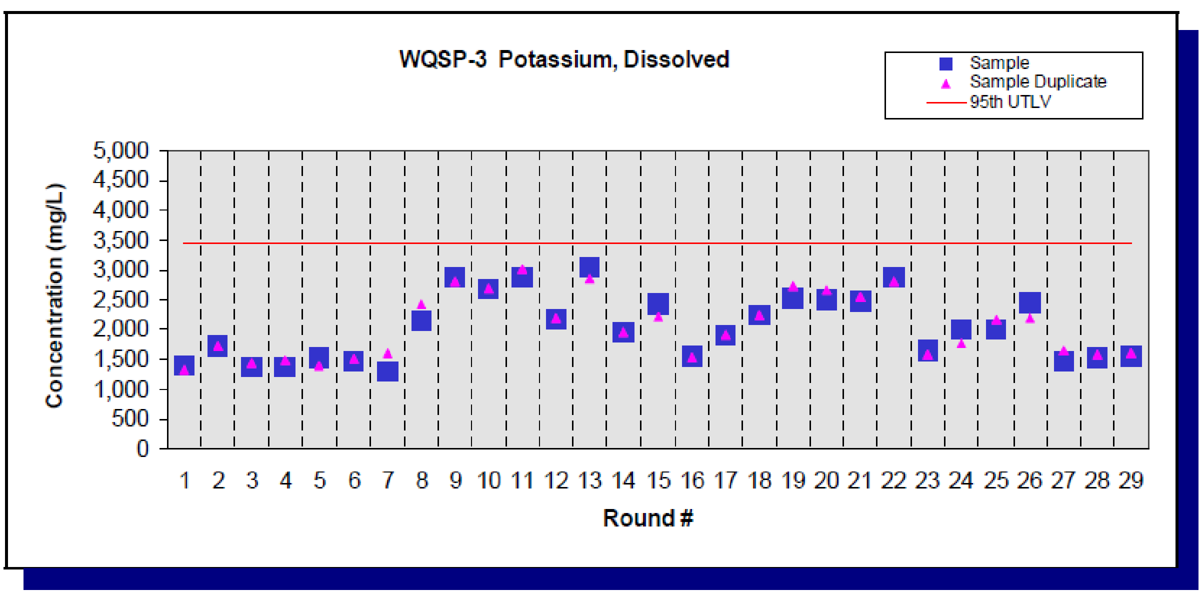

Figure E.19 - Time Trend Plot for Potassium at WQSP-3

Appendix E – Time Trend Plots for Detectable Constituents in Groundwater

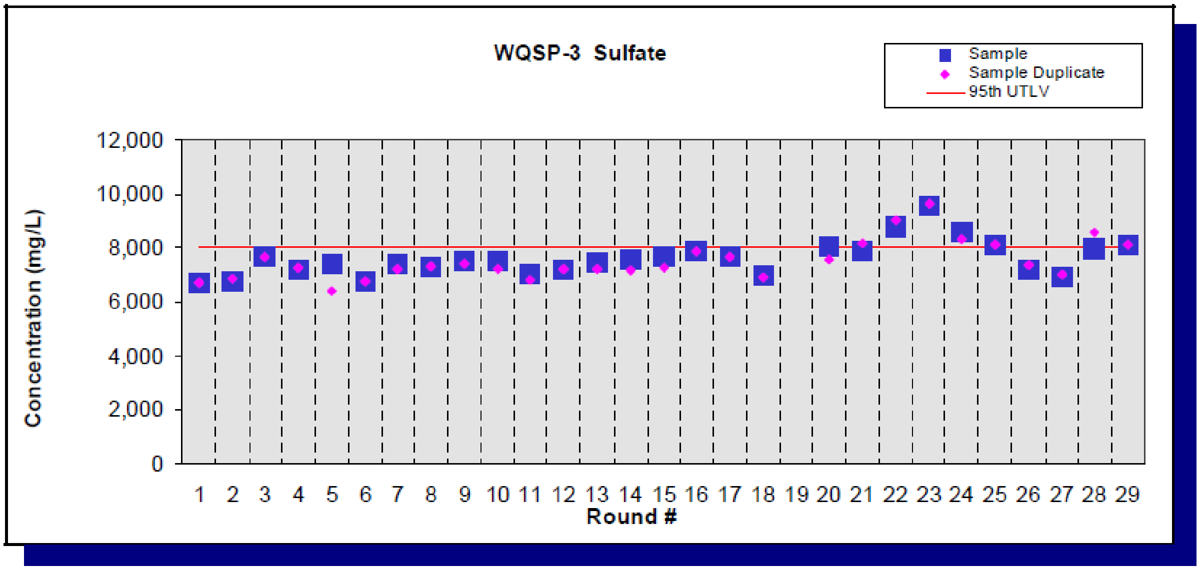

Figure E.20 - Time Trend Plot for Sulfate at WQSP-3

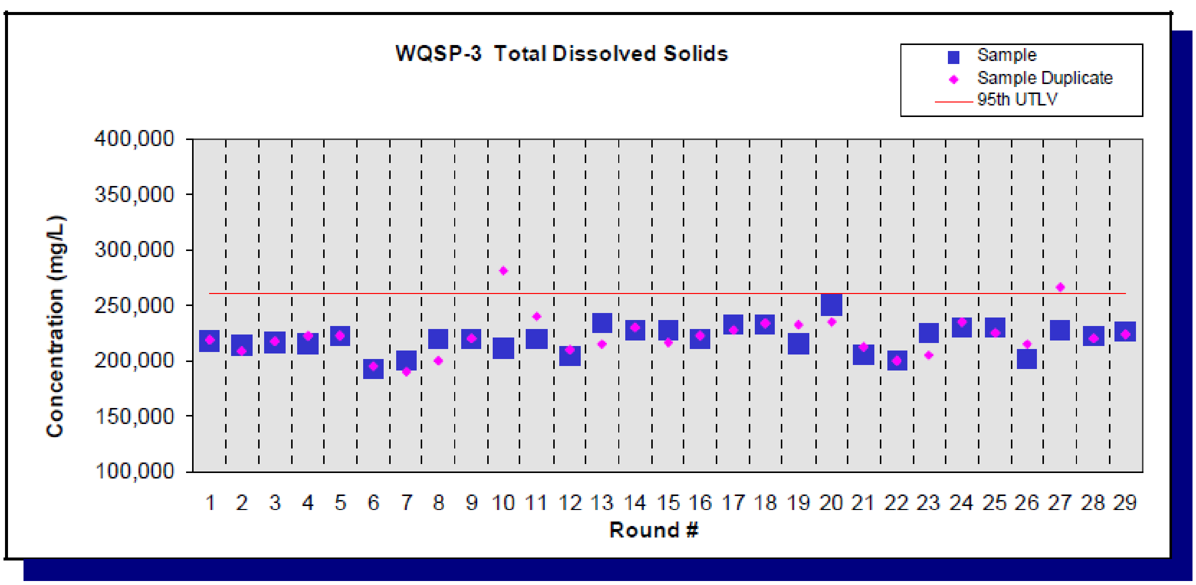

Figure E.21 - Time Trend Plot for Total Dissolved Solids at WQSP-3

Appendix E – Time Trend Plots for Detectable Constituents in Groundwater

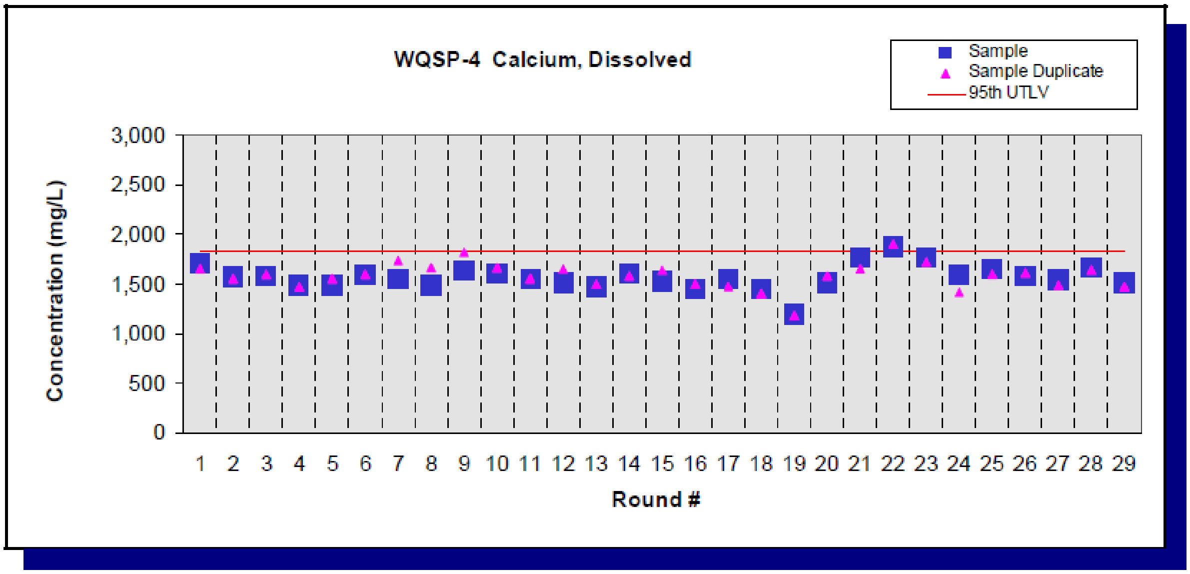

Figure E.22 - Time Trend Plot for Calcium at WQSP-4

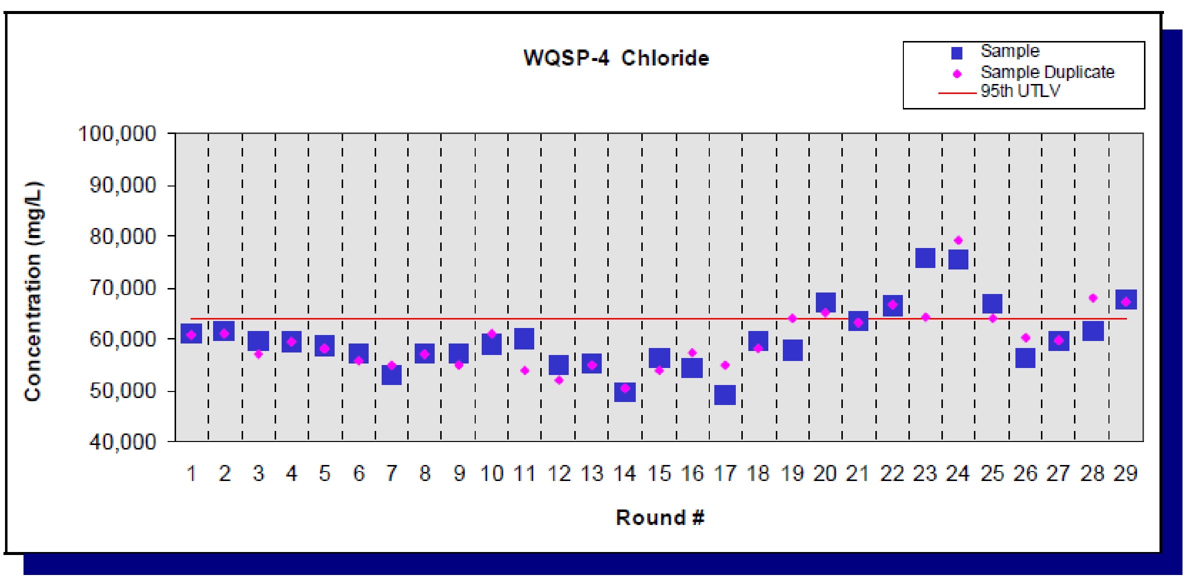

Figure E.23 - Time Trend Plot for Chloride at WQSP-4

Appendix E – Time Trend Plots for Detectable Constituents in Groundwater

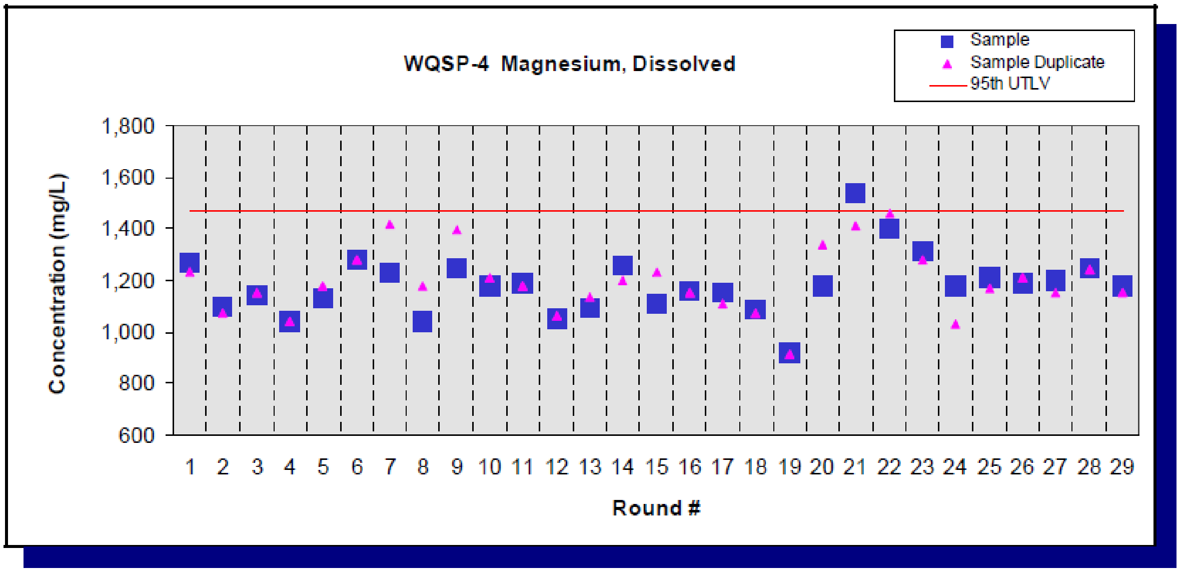

Figure E.24 - Time Trend Plot for Magnesium at WQSP-4

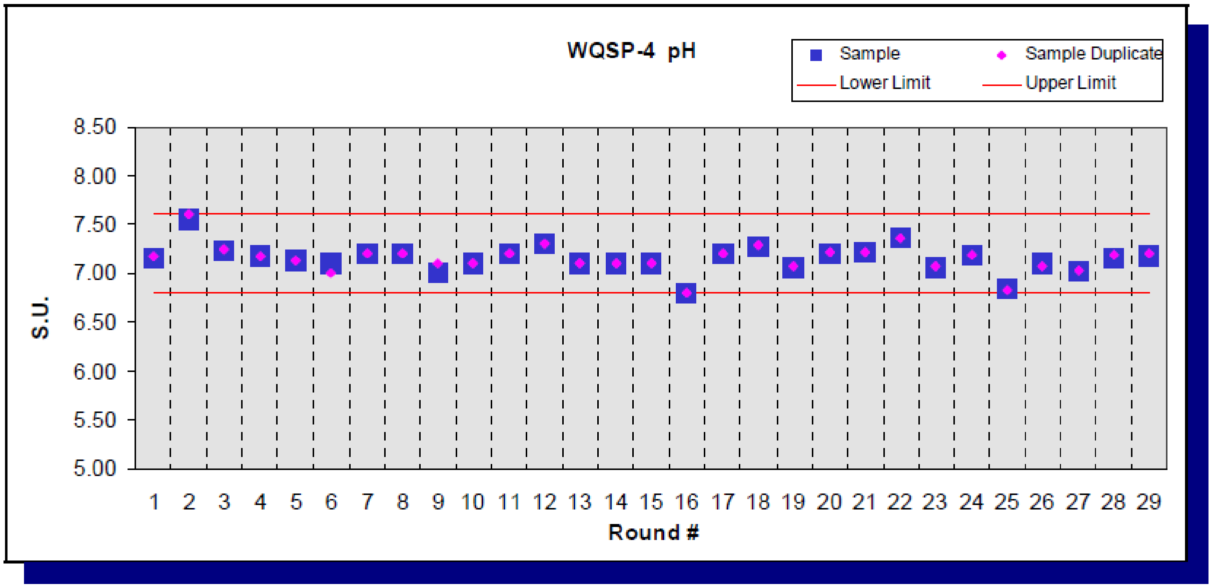

Figure E.25 - Tme Trend Plot for pH at WQSP-4

Appendix E – Time Trend Plots for Detectable Constituents in Groundwater

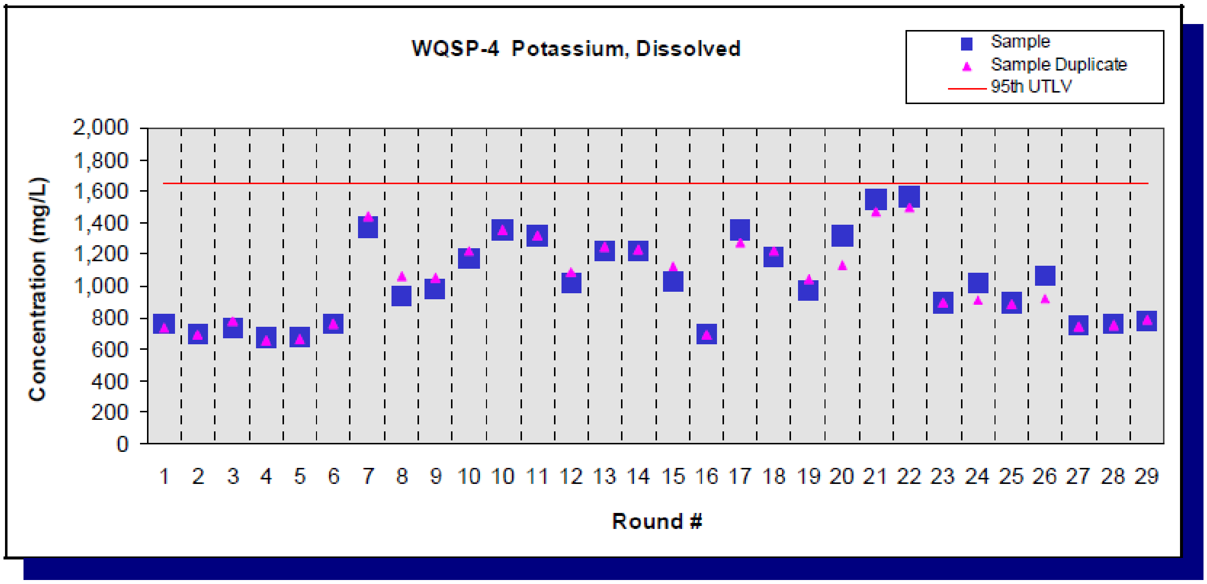

Figure E.26 - Time Trend Plot for Potassium at WQSP-4

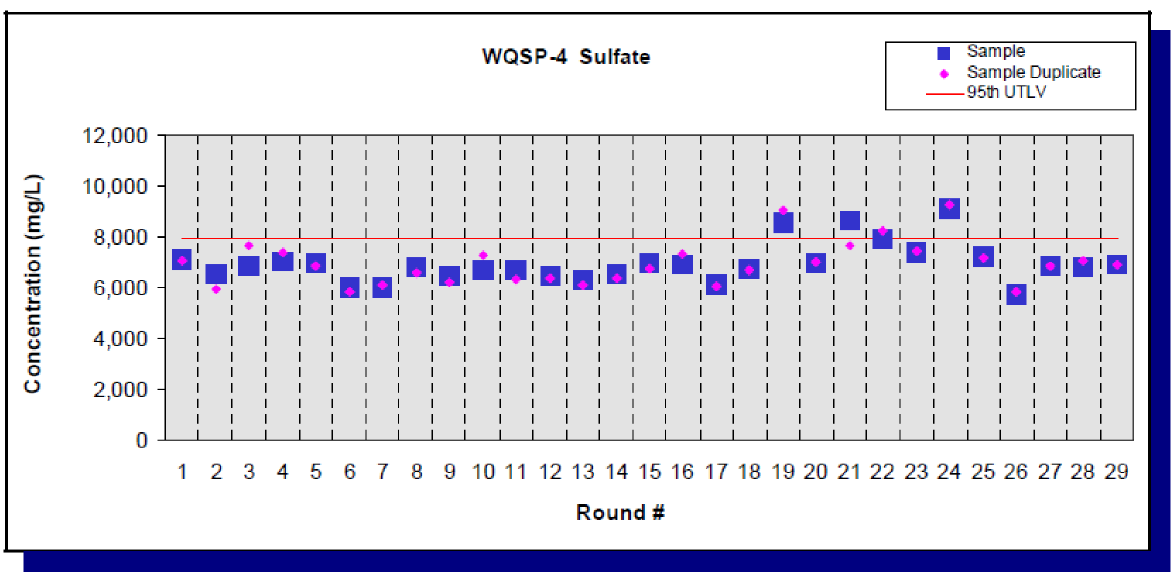

Figure E.27 - Time Trend Plot for Sulfate at WQSP-4

Appendix E – Time Trend Plots for Detectable Constituents in Groundwater

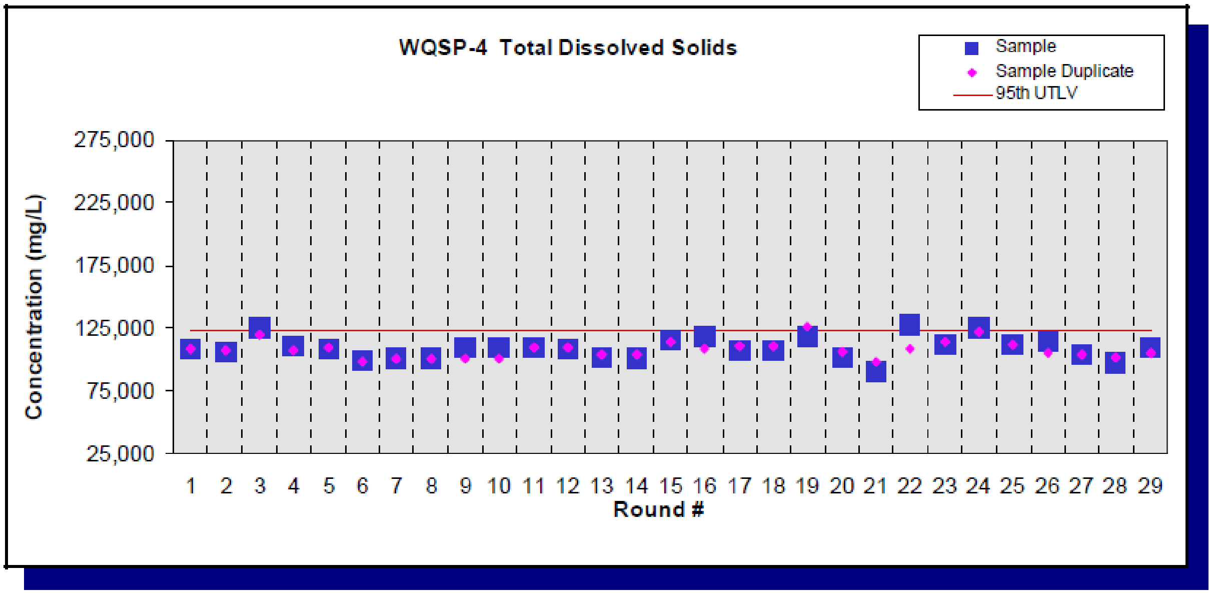

Figure E.28 - Time Trend Plot for Total Dissolved Solids at WQSP-4

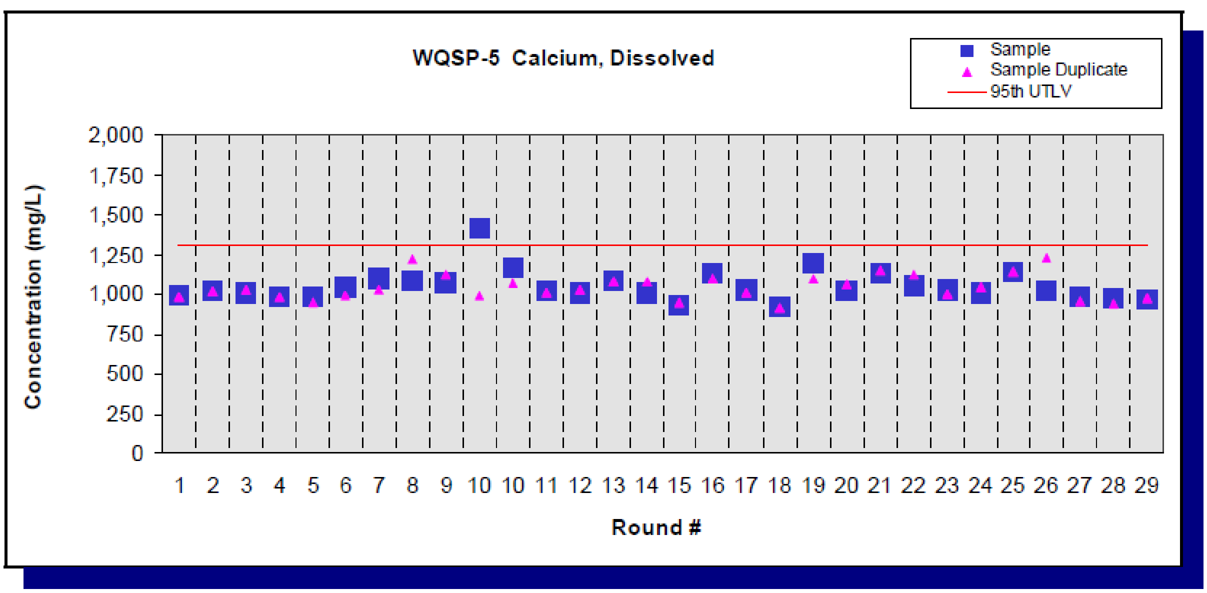

Figure E.29 - Time Trend Plot for Calcium, Dissolved, at WQSP-5

Appendix E – Time Trend Plots for Detectable Constituents in Groundwater

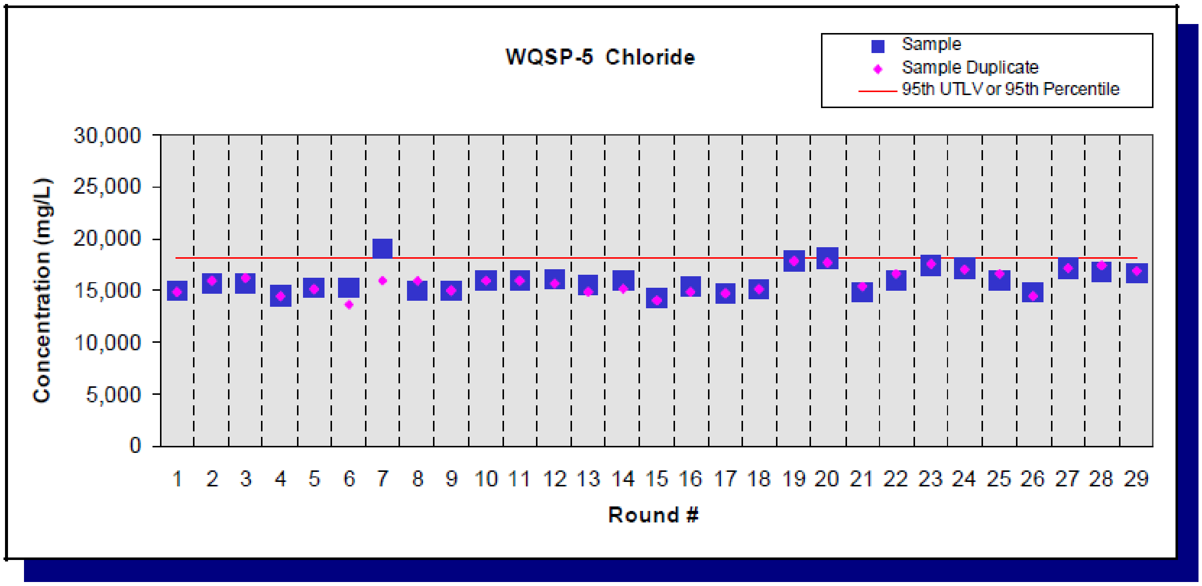

Figure E.30 - Time Trend Plot for Chloride at WQSP-5

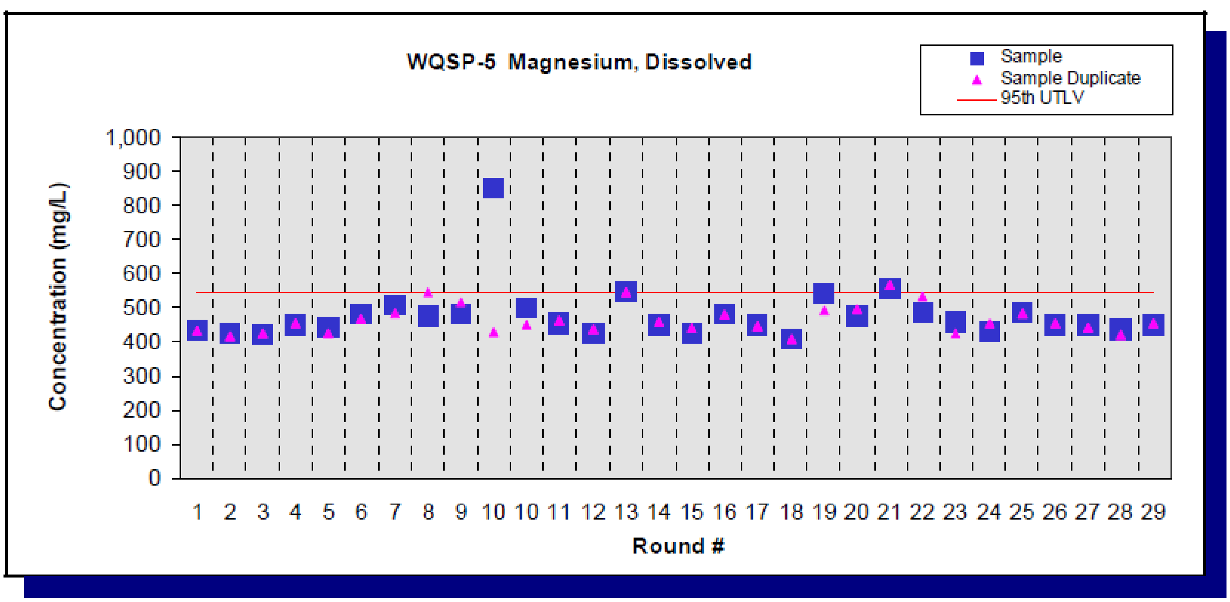

Figure E.31 - Time Trend Plot for Magnesium at WQSP-5

Appendix E – Time Trend Plots for Detectable Constituents in Groundwater

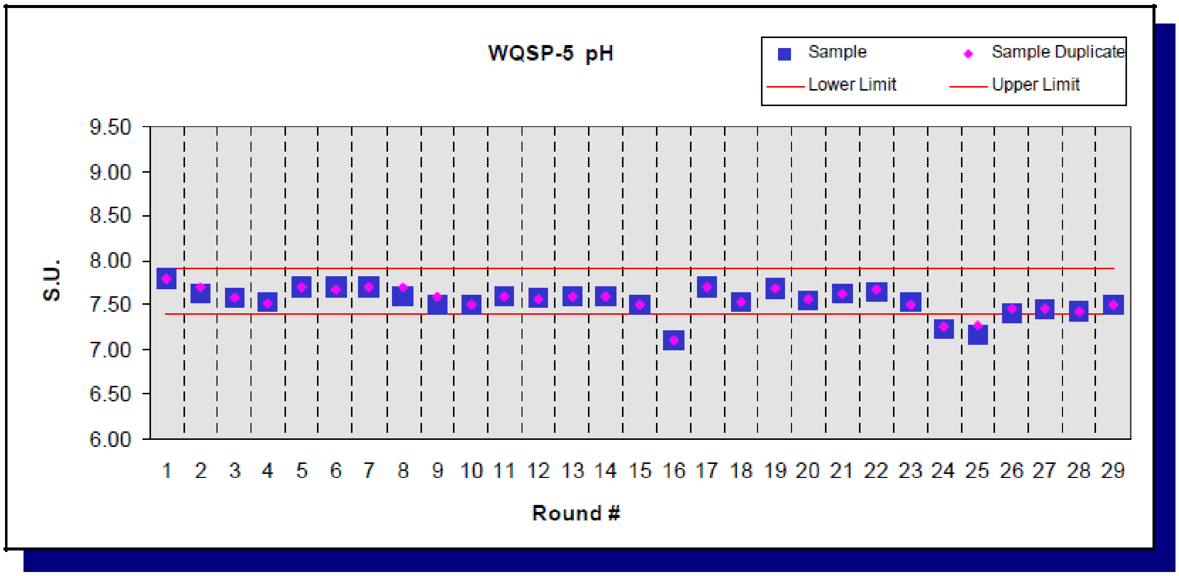

Figure E.32 - Time Trend Plot for pH at WQSP-5

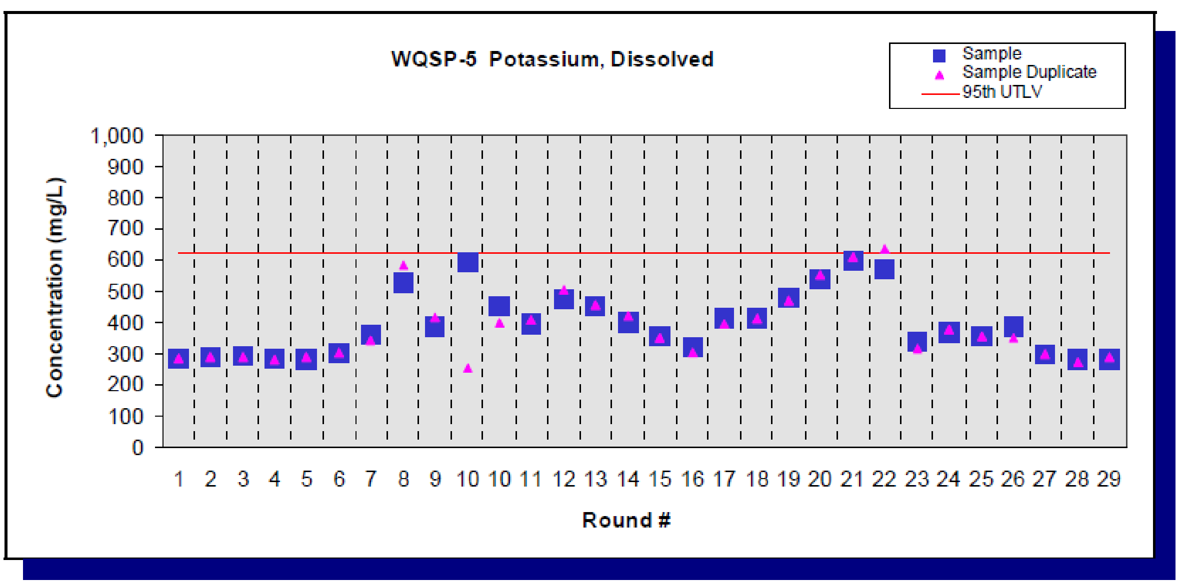

Figure E.33 - Time Trend Plot for Potassium, Dissolved, at WQSP-5

Appendix E – Time Trend Plots for Detectable Constituents in Groundwater

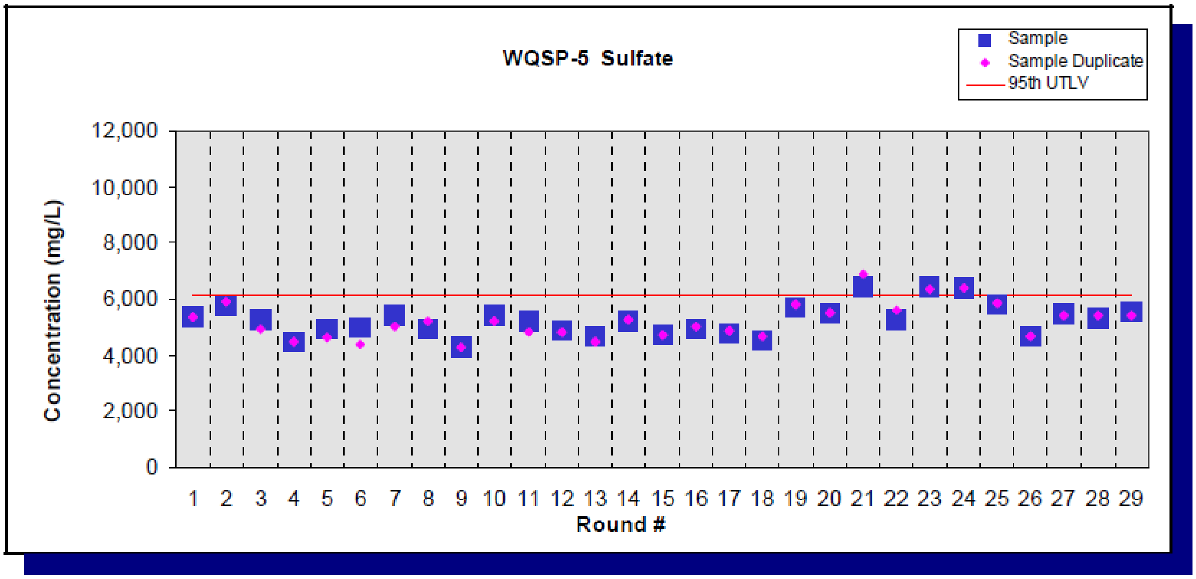

Figure E.34 - Time Trend Plot for Sulfate at WQSP-5

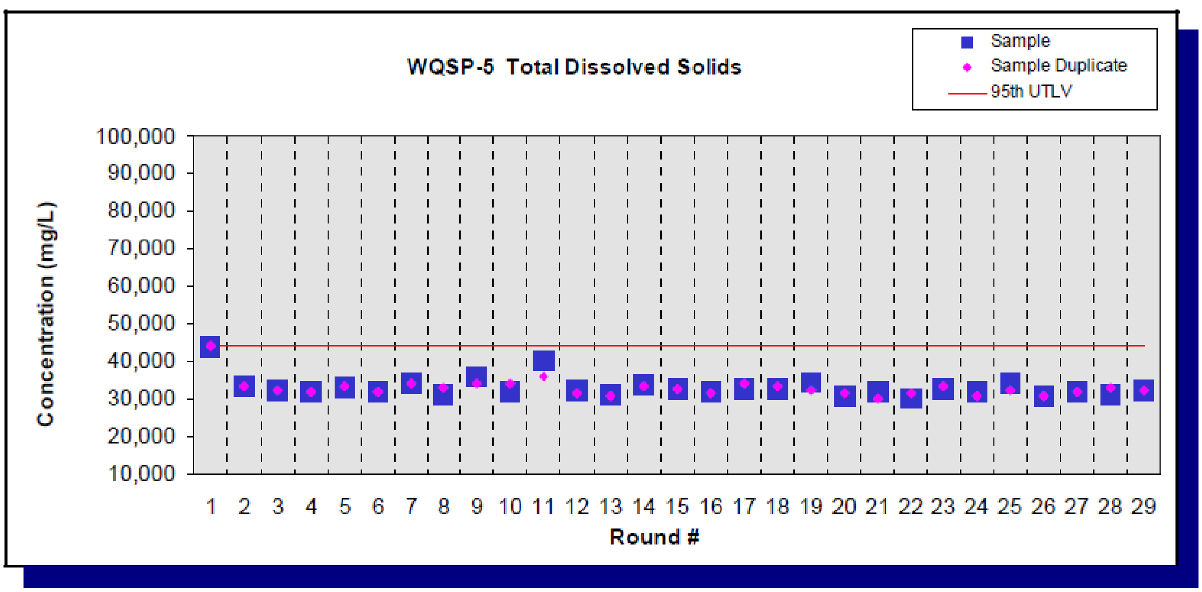

Figure E.35 - Time Trend Plot for Total Dissolved Solids at WQSP-5

Appendix E – Time Trend Plots for Detectable Constituents in Groundwater

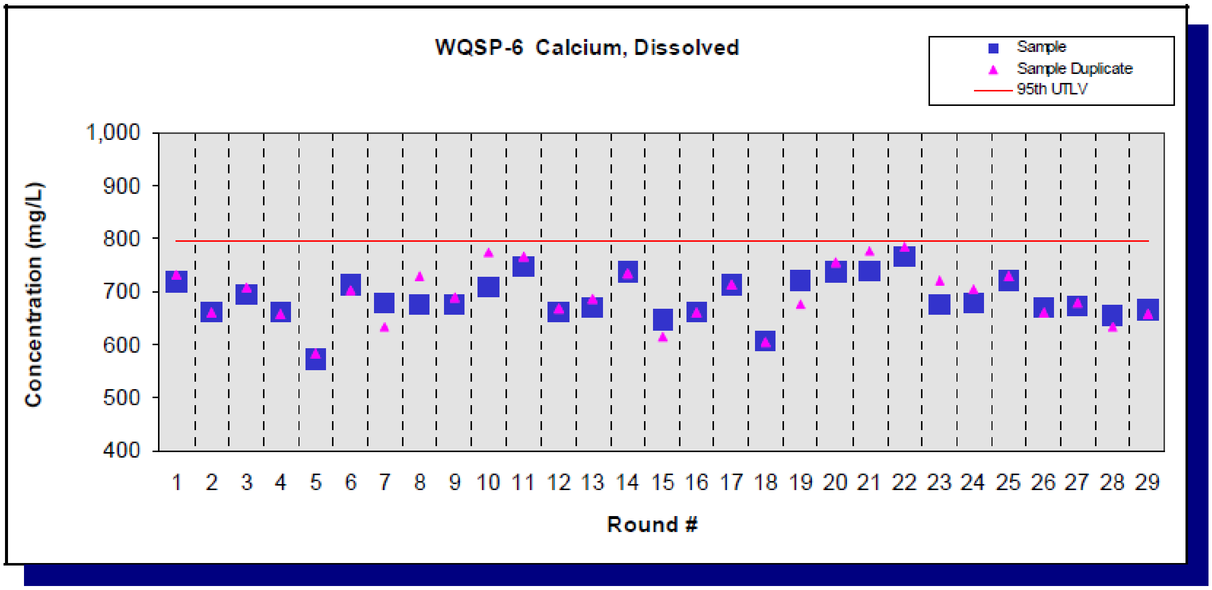

Figure E.36 - Time Trend Plot for Calcium, Dissolved, at WQSP-6

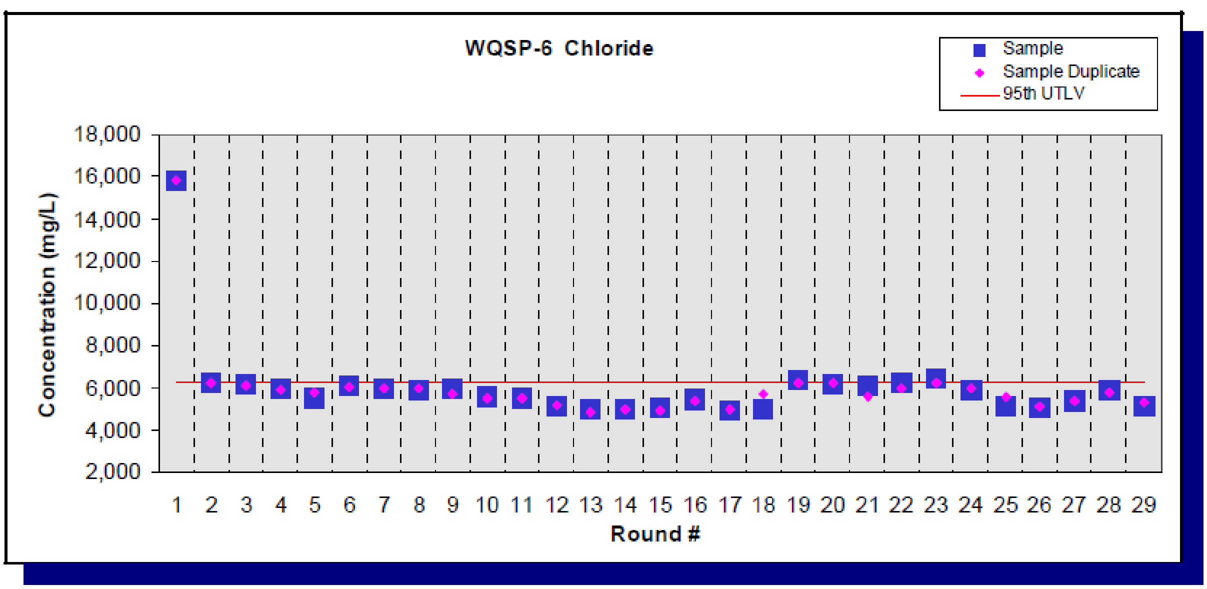

Figure E.37 - Time Trend Plot for Chloride at WQSP-6

Appendix E – Time Trend Plots for Detectable Constituents in Groundwater

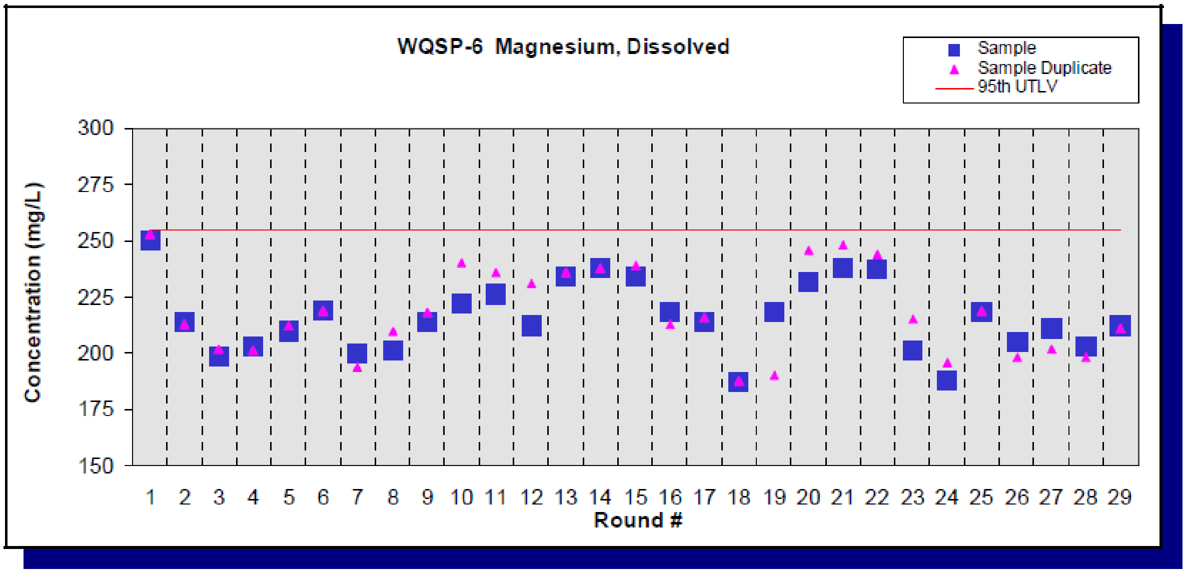

Figure E.38 - Time Trend Plot for Magnesium, Dissolved, at WQSP-6

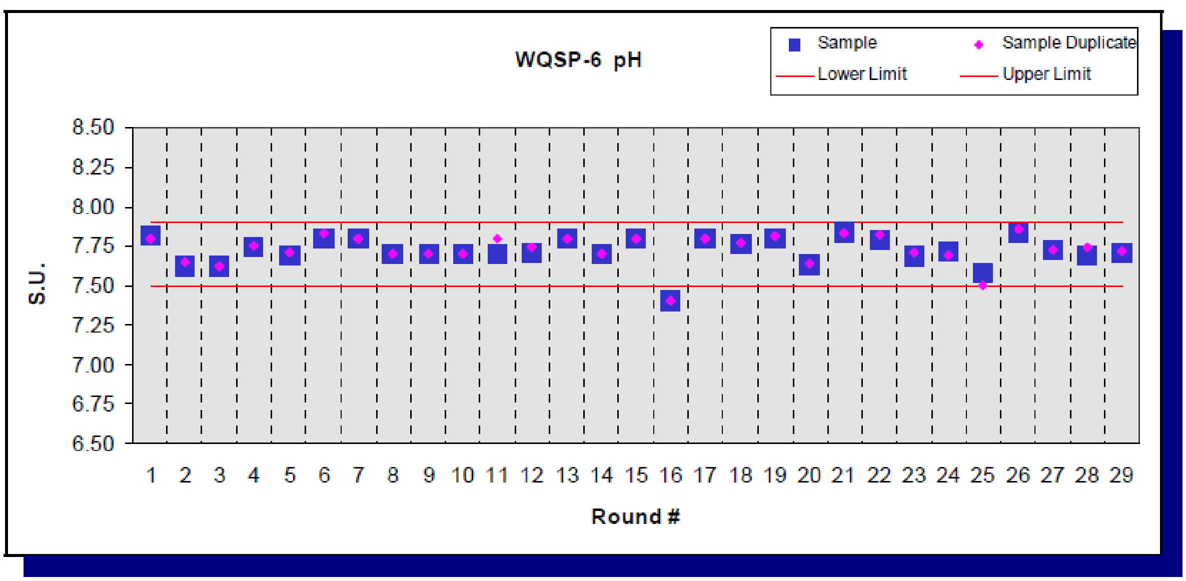

Figure E.39 - Time Trend Plot for pH at WQSP-6

Appendix E – Time Trend Plots for Detectable Constituents in Groundwater

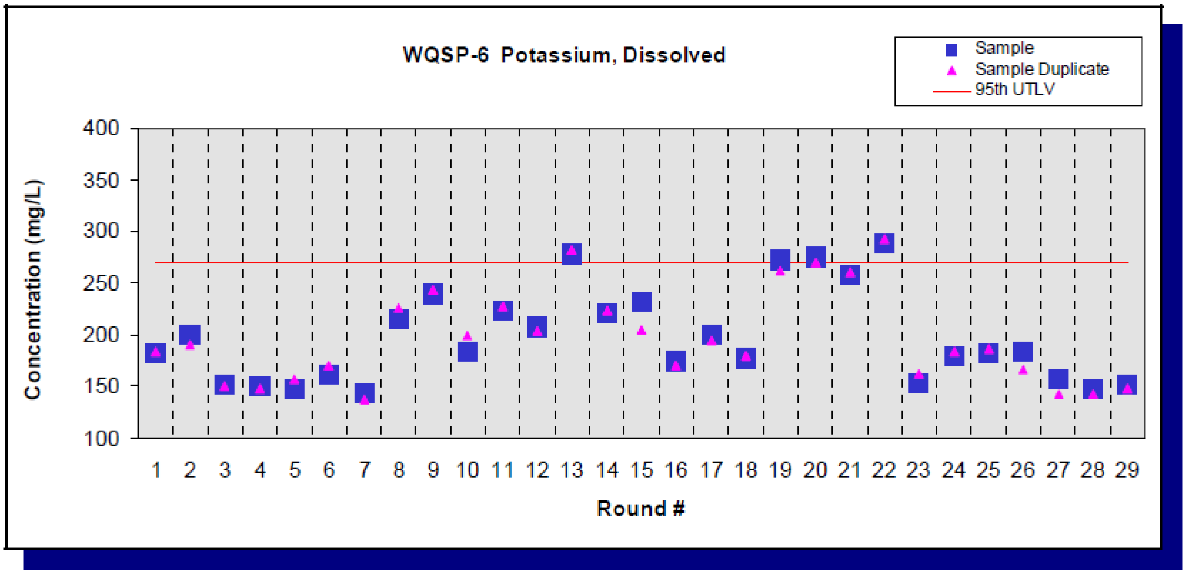

Figure E.40 - Time Trend Plot for Potassium, Dissolved, at WQSP-6

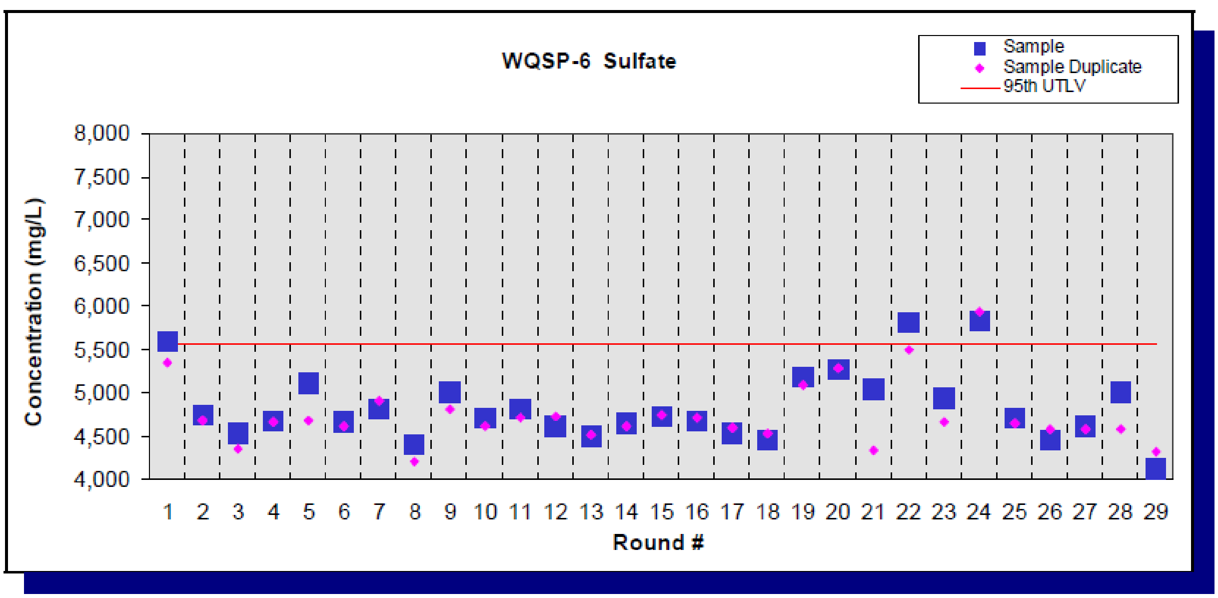

Figure E.41 - Time Trend Plot for Sulfate at WQSP-6

Appendix E – Time Trend Plots for Detectable Constituents in Groundwater

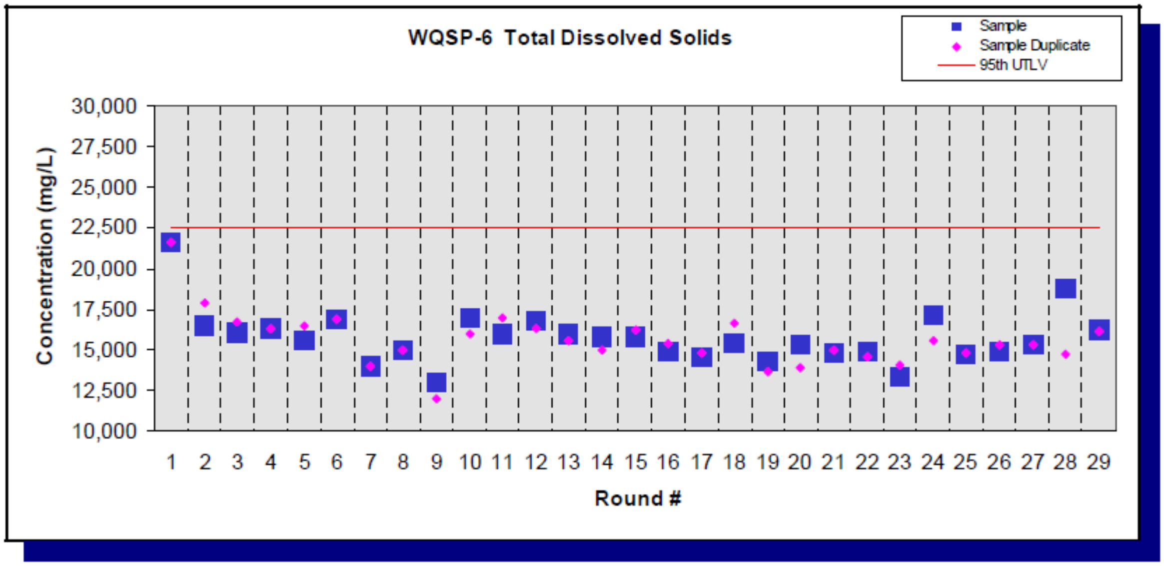

Figure E.42 - Time Trend Plot for Total Dissolved Solids at WQSP-6

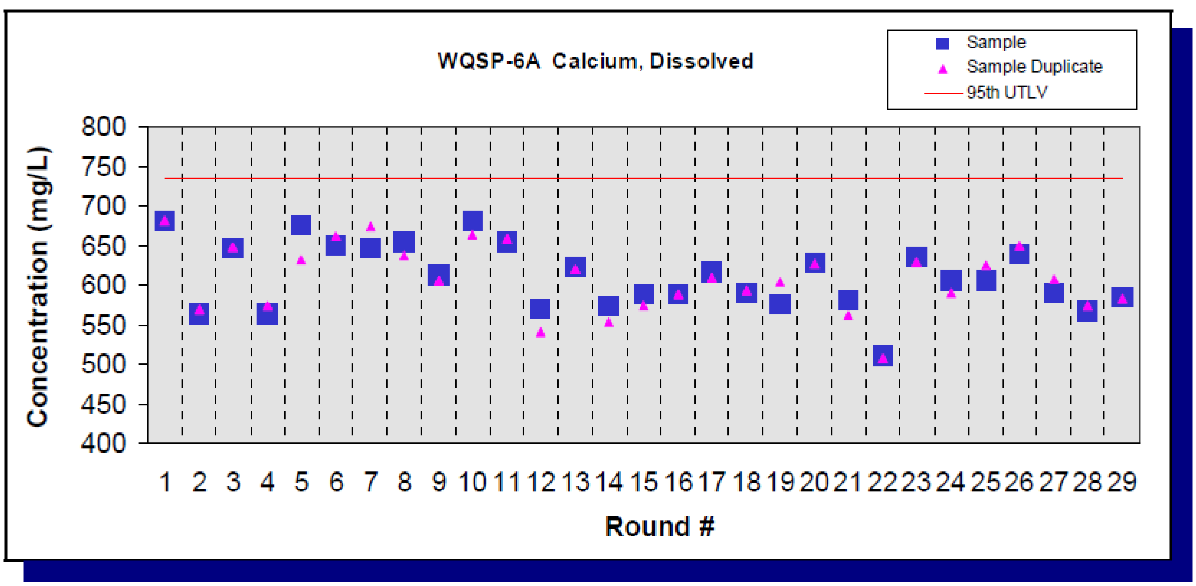

Figure E.43 - Time Trend Plot for Calcium, Dissolved, at WQSP-6A

Appendix E – Time Trend Plots for Detectable Constituents in Groundwater

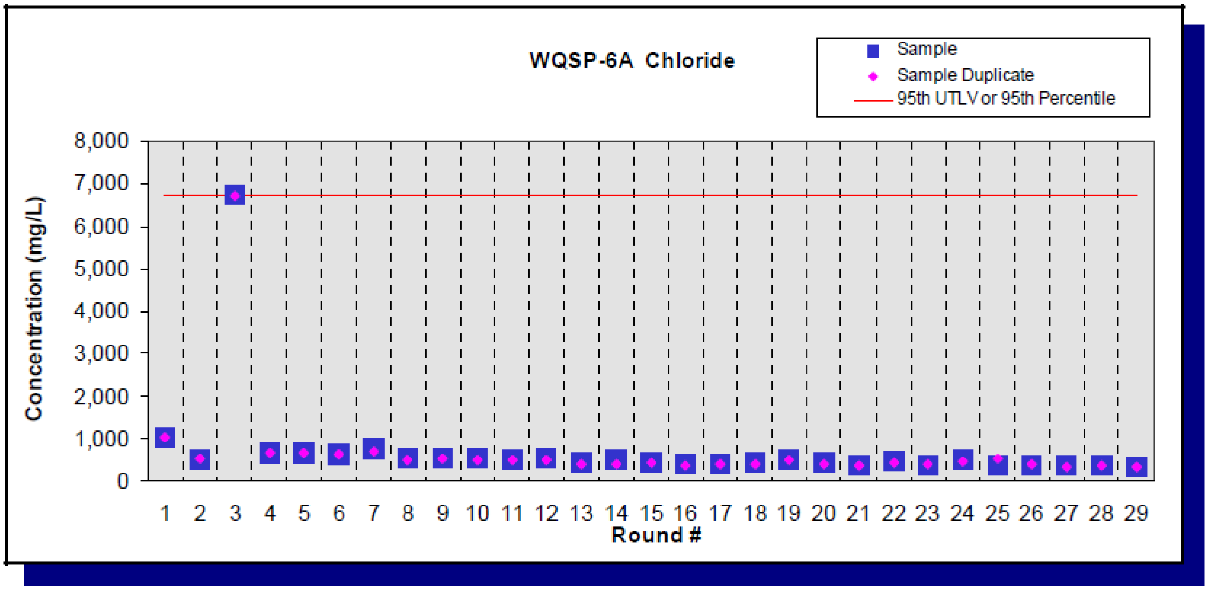

Figure E.44 - Time Trend Plot for Chloride at WQSP-6A

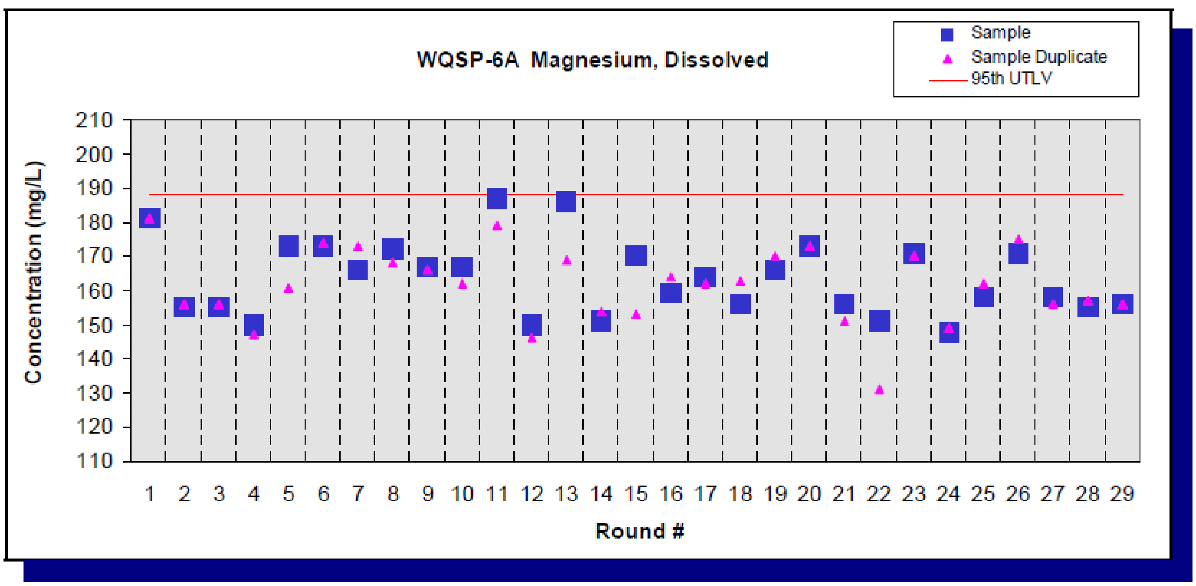

Figure E.45 - Time Trend Plot for Magnesium, Dissolved, at WQSP-6A

Appendix E – Time Trend Plots for Detectable Constituents in Groundwater

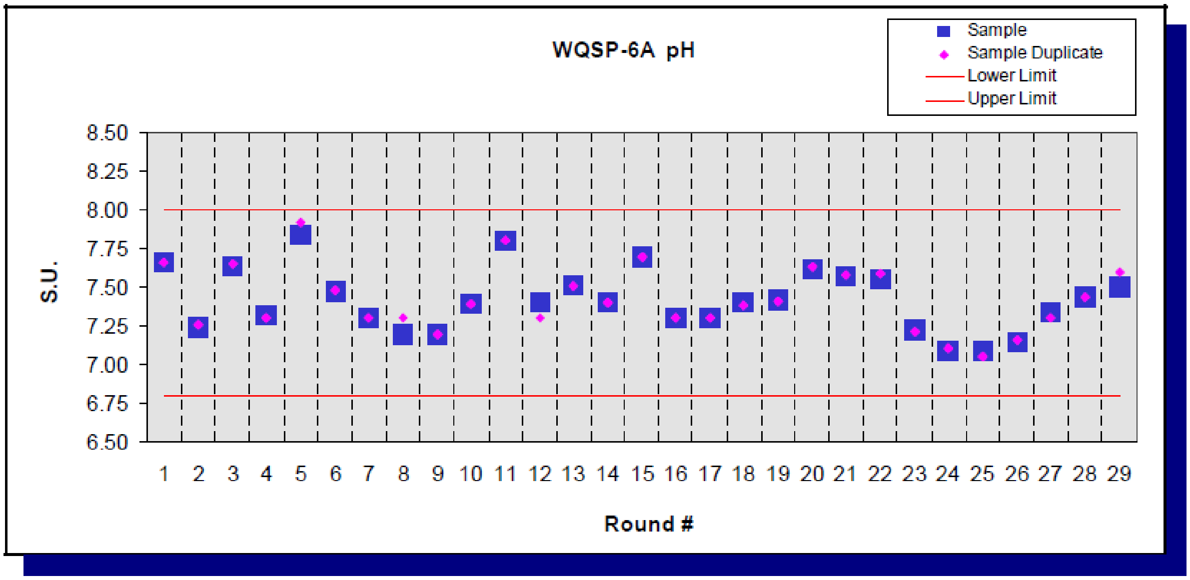

Figure E.46 - Time Trend Plot for pH at WQSP-6A

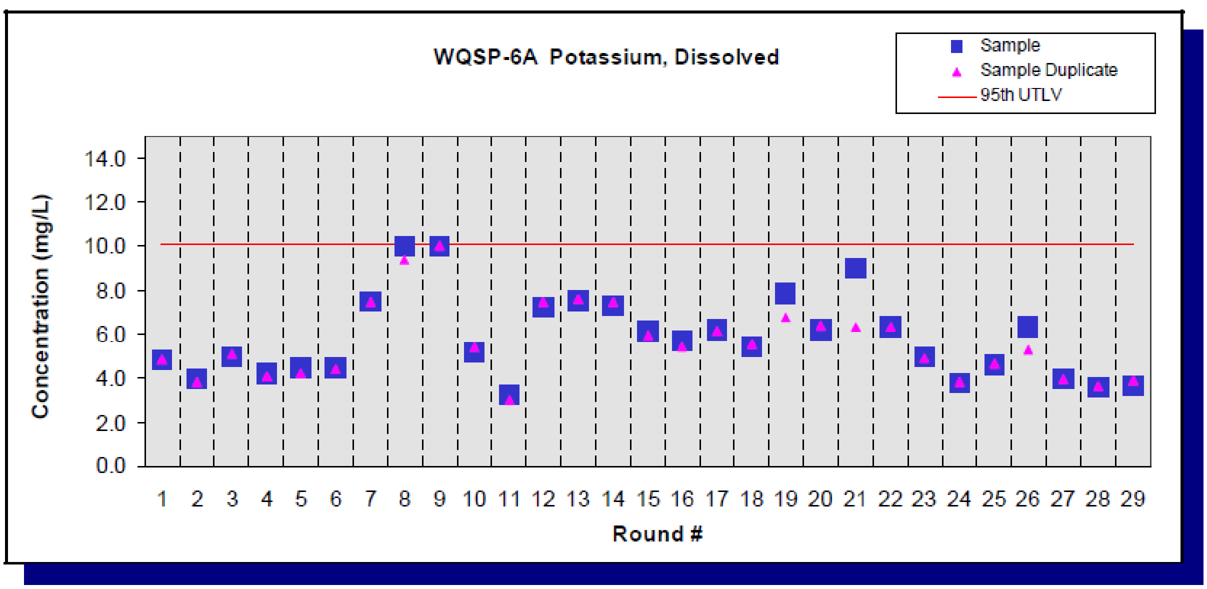

Figure E.47 - Time Trend Plot for Potassium, Dissolved, at WQSP-6A

Appendix E – Time Trend Plots for Detectable Constituents in Groundwater

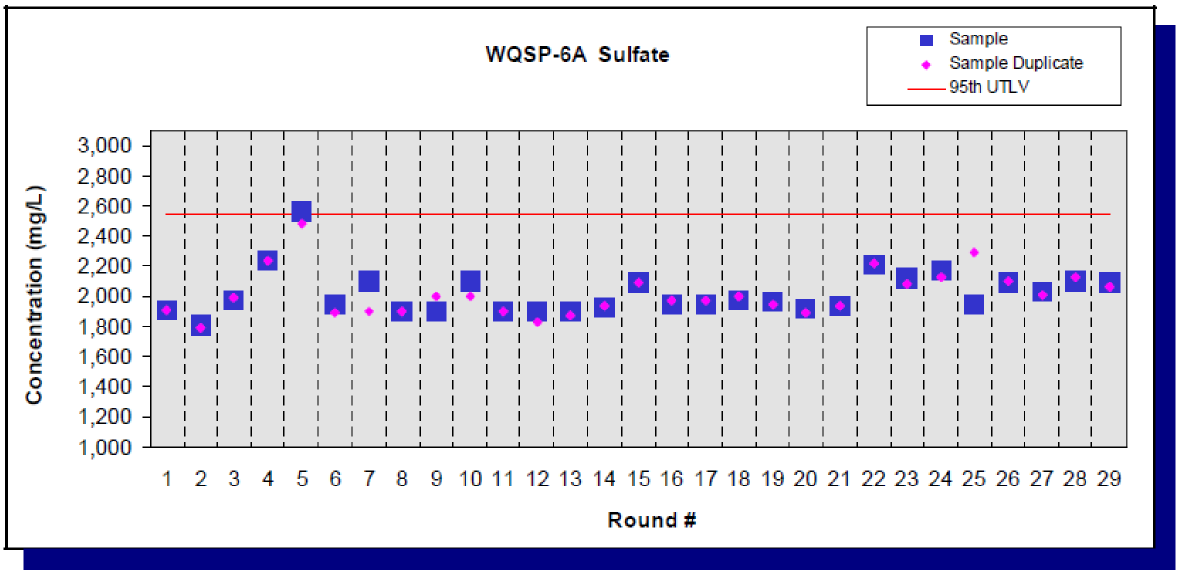

Figure E.48 - Time Trend Plot for Sulfate at WQSP-6A

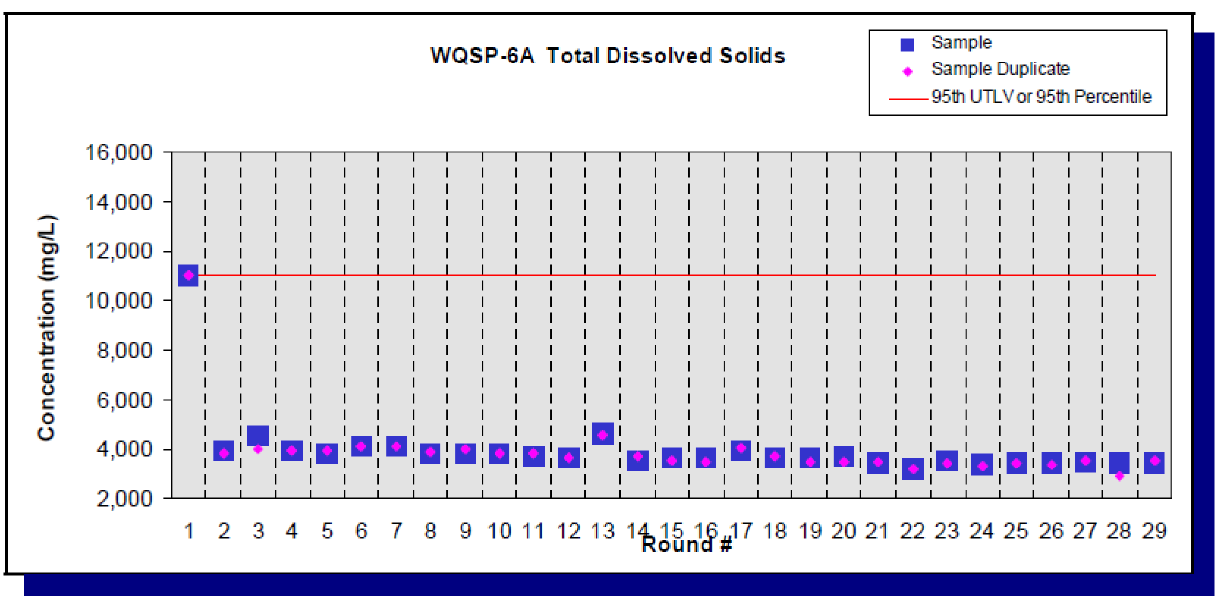

Figure E.49 - Time Trend Plot for Total Dissolved Solids at WQSP-6A

Appendix F – Groundwater Data Tables

Appendix F – Groundwater Data Tables

Table F.1 – Analytical Results for Groundwater Sampled from Well WQSP-1

	Concentration, ug/L							
	Round 28		Round 29			Reporting Limit		
Parameter	Sample	Duplicate	Sample	Duplicate	Units	Round 28	Round 29	95^{th} UTLV[a]
1,1,1-Trichloroethane	<1	<1	<1	<1	µg/L	1	1	<RL[b]
1,1,2,2-Tetrachloroethane	<1	<1	<1	<1	µg/L	1	1	<RL
1,1,2-Trichloroethane	<1	<1	<1	<1	µg/L	1	1	<RL
1,1-Dichloroethane	<1	<1	<1	<1	µg/L	1	1	<RL
1,1-Dichloroethylene	<1	<1	<1	<1	µg/L	1	1	<RL
1,2-Dichloroethane	<1	<1	<1	<1	µg/L	1	1	<RL
Carbon tetrachloride	<1	<1	<1	<1	µg/L	1	1	<RL
Chlorobenzene	<1	<1	<1	<1	µg/L	1	1	<RL
Chloroform	<1	<1	<1	<1	µg/L	1	1	<RL
cis-1,2-Dichloroethylene	<1	<1	<1	<1	µg/L	1	1	<RL
trans-1, 2-Dichloroethylene	<1	<1	<1	<1	µg/L	1	1	<RL
2-butanol	<5	<5	<5	<5	µg/L	5	5	<RL
Methyl ethyl ketone	<5	<5	<5	<5	µg/L	5	5	<RL
Methylene chloride	<5	<5	<5	<5	µg/L	5	5	<RL
Tetrachloroethylene	<1	<1	<1	<1	µg/L	1	1	<RL
Toluene	<1	<1	<1	<1	µg/L	1	1	<RL
Trichloroethylene	<1	<1	<1	<1	µg/L	1	1	<RL
Trichlorofluoromethane	<1	<1	<1	<1	µg/L	1	1	<RL
Vinyl chloride	<1	<1	<1	<1	µg/L	1	1	<RL
Xylene	<1	<1	<1	<1	µg/L	1	1	<RL
1,2-Dichlorobenzene	<5	<5	<5	<5	µg/L	5	5	<RL
1,4-Dichlorobenzene	<5	<5	<5	<5	µg/L	5	5	<RL
2,4-Dinitrophenol	<5	<5	<5	<5	µg/L	5	5	<RL
2,4-Dinitrotoluene	<5	<5	<5	<5	µg/L	5	5	<RL
2-Methylphenol	<5	<5	<5	<5	µg/L	5	5	<RL
3-Methylphenol/ 4-Methylphenol	<5	<5	<5	<5	µg/L	5	5	<RL
Hexachlorobenzene	<5	<5	<5	<5	µg/L	5	5	<RL
Hexachloroethane	<5	<5	<5	<5	µg/L	5	5	<RL
Nitrobenzene	<5	<5	<5	<5	µg/L	5	5	<RL
Pentachlorophenol	<5	<5	<5	<5	µg/L	5	5	<RL
Pyridine	<5	<5	<5	<5	µg/L	5	5	<RL
Isobutanol	<5	<5	<5	<5	µg/L	5	5	<RL
Alkalinity	46.3	46.4	54.0	46.5	mg/L	20	20	70.3
Chloride	40,000	39,500	38,300	38,200	mg/L	20	500	39,670
Density	1.042	1.035	1.042	1.042	g/ml	N/A[c]	N/A[c]	1.06
Nitrate (as N)	<1.0	<1.0	<1.06	<1.06	mg/L	1.0	1.06	<10.0
pH	7.26	7.28	7.52	7.44	SU[d]	0.1	0.1	7.0 -7.6
Specific conductance	108,000	108,000	110,000	110,000	µmhos/cm	0.1	0.5	124,000
Sulfate	4,940	5,270	6,400	6,000	mg/L	20	100	6,590
Total dissolved solids	62,900	61,900	62,400	62,700	mg/L	20	2000	80,500
Total organic carbon	0.79	1.16	0.62	0.93	mg/L	0.5	1.0	7.97
Total organic halogen	0.06	<0.06	0.15	0.19	mg/L	0.06	0.5	63.8
Total suspended solids	<2	3	5.0	13	mg/L	5	2	43.0
Antimony	<0.010	<0.010	<0.010	<0.010	mg/L	0.010	0.010	<0.5

Appendix F – Groundwater Data Tables

Table F.1 – Analytical Results for Groundwater Sampled from Well WQSP-1

Parameter	Concentration, ug/L Round 28 Sample	Round 28 Duplicate	Round 29 Sample	Round 29 Duplicate	Units	Reporting Limit Round 28	Reporting Limit Round 29	95th UTLV[a]
Arsenic	<0.010	<0.010	<0.010	<0.010	mg/L	0.010	0.010	0.062
Barium	<0.1	<0.1	<0.03	0.032	mg/L	0.1	0.03	<1.0
Beryllium	<0.03	<0.03	<0.015	<0.015	mg/L	0.03	0.015	<1.0
Cadmium	<0.02	<0.02	<0.02	<0.02	mg/L	0.02	0.02	<0.5
Calcium	1,490	1,450	1,420	1,450	mg/L	20	50	1,827
Chromium	<0.06	<0.06	<0.08	<0.08	mg/L	0.06	0.08	<0.5
Iron	<0.5	<0.5	<0.34	<0.34	mg/L	0.5	0.34	0.910
Lead	<0.05	<0.05	0.11	<0.1	mg/L	0.05	0.1	0.163
Magnesium	1,020	1,000	1,020	1.050	mg/L	5.0	50	1,244
Mercury	<0.001	<0.001	<0.002	<0.002	mg/L	0.001	0.002	<0.002
Nickel	<0.1	<0.1	<0.045	<0.045	mg/L	0.1	0.045	0.370
Potassium	470	460	478	492	mg/L	5.0	50	845
Selenium	<0.010	<0.010	<0.010	<0.010	mg/L	0.010	0.010	0.150
Silver	<0.05	<0.05	<0.025	<0.025	mg/L	0.05	0.025	<0.5
Sodium	19,800	18,300	19,000	18,000	mg/L	20	500	21,900
Thallium	<0.010	<0.010	<0.010	<0.010	mg/L	0.010	0.010	0.980
Vanadium	<0.05	<0.05	<0.05	<0.05	mg/L	0.05	0.05	<0.1

[a] 95th Upper tolerance limit value, equivalent to 95% confidence limit. 95th percentile for nitrate, TOC, TOX, TSS, and trace metals.
[b] Reporting limit. Value corresponds to method reporting limit (MRL) except method detection limit (MDL) used for nitrate.
[c] Standard unit
[d] Not applicable

Table F.2 – Analytical Results for Groundwater Sampled from Well WQSP-2

Parameter	Concentration, ug/L Round 28 Sample	Round 28 Duplicate	Round 29 Sample	Round 29 Duplicate	Units	Reporting Limit Round 28	Reporting Limit Round 29	95th UTLV[a]
1,1,1-Trichloroethane	<1	<1	<1	<1	µg/L	1	1	<RL[b]
1,1,2,2-Tetrachloroethane	<1	<1	<1	<1	µg/L	1	1	<RL
1,1,2-Trichloroethane	<1	<1	<1	<1	µg/L	1	1	<RL
1,1-Dichloroethane	<1	<1	<1	<1	µg/L	1	1	<RL
1,1-Dichloroethylene	<1	<1	<1	<1	µg/L	1	1	<RL
1,2-Dichloroethane	<1	<1	<1	<1	µg/L	1	1	<RL
Carbon tetrachloride	<1	<1	<1	<1	µg/L	1	1	<RL
Chlorobenzene	<1	<1	<1	<1	µg/L	1	1	<RL
Chloroform	<1	<1	<1	<1	µg/L	1	1	<RL
cis-1,2-Dichloroethylene	<1	<1	<1	<1	µg/L	1	1	<RL
trans-1, 2-Dichloroethylene	<1	<1	<1	<1	µg/L	1	1	<RL
2-butanol	<5	<5	<5	<5	µg/L	5	5	<RL
Methyl ethyl ketone	<5	<5	<5	<5	µg/L	5	5	<RL
Methylene chloride	<5	<5	<5	<5	µg/L	5	5	<RL
Tetrachloroethylene	<1	<1	<1	<1	µg/L	1	1	<RL
Toluene	<1	<1	<1	<1	µg/L	1	1	<RL
Trichloroethylene	<1	<1	<1	<1	µg/L	1	1	<RL
Trichlorofluoromethane	<1	<1	<1	<1	µg/L	1	1	<RL
Vinyl chloride	<1	<1	<1	<1	µg/L	1	1	<RL
Xylene	<1	<1	<1	<1	µg/L	1	1	<RL

Appendix F – Groundwater Data Tables

Table F.2 – Analytical Results for Groundwater Sampled from Well WQSP-2

Parameter	Concentration, ug/L Round 28 Sample	Round 28 Duplicate	Round 29 Sample	Round 29 Duplicate	Units	Reporting Limit Round 28	Reporting Limit Round 29	95th UTLV[a]
1,2-Dichlorobenzene	<5	<5	<5	<5	µg/L	5	5	<RL
1,4-Dichlorobenzene	<5	<5	<5	<5	µg/L	5	5	<RL
2,4-Dinitrophenol	<5	<5	<5	<5	µg/L	5	5	<RL
2,4-Dinitrotoluene	<5	<5	<5	<5	µg/L	5	5	<RL
2-Methylphenol	<5	<5	<5	<5	µg/L	5	5	<RL
3-Methylphenol/ 4-Methylphenol	<5	<5	<5	<5	µg/L	5	5	<RL
Hexachlorobenzene	<5	<5	<5	<5	µg/L	5	5	<RL
Hexachloroethane	<5	<5	<5	<5	µg/L	5	5	<RL
Nitrobenzene	<5	<5	<5	<5	µg/L	5	5	<RL
Pentachlorophenol	<5	<5	<5	<5	µg/L	5	5	<RL
Pyridine	<5	<5	<5	<5	µg/L	5	5	<RL
Isobutanol	<5	<5	<5	<5	µg/L	5	5	<RL
Alkalinity	46.3	46.4	48.6	50.8	mg/L	4.0	4.0	55.8
Chloride	40,000	39,500	40,000	40,300	mg/L	0.5	0.5	40,472
Density	1.042	1.035	1.047	1.048	g/ml	N/A[d]	N/A[d]	1.07
Nitrate (as N)	<1.0	<1.0	<1.1	<1.1	mg/L	0.1	0.1	<10.0
pH	7.26	7.28	7.38	7.38	SU[c]	N/A[d]	N/A[d]	5.6-8.8
Specific conductance	108,000	108,000	115,000	115,000	µmhos/cm	N/A	N/A	175,000
Sulfate	4,940	5,270	4,830	4,900	mg/L	0.5	0.5	5,757
Total dissolved solids	62,900	61,900	66,400	66,000	mg/L	10	10	80,700
Total organic carbon	0.79	1.16	1.00	1.04	mg/L	1	1	<5.0
Total organic halogen	0.06	<0.06	0.27	0.33	mg/L	0.06	0.05	14.6
Total suspended solids	<2	3	7	3	mg/L	10	2	33.3
Antimony	<0.010	<0.010	<0.010	<0.010	mg/L	0.010	0.010	0.33
Arsenic	<0.010	<0.010	<0.010	<0.010	mg/L	0.010	0.010	<0.1
Barium	<0.1	<0.1	0.034	0.031	mg/L	0.10	0.02	<1.0
Beryllium	<0.03	<0.03	<0.07	<0.07	mg/L	0.007	0.007	<0.02
Cadmium	<0.02	<0.02	<0.01	<0.01	mg/L	0.02	0.01	<0.2
Calcium	1,490	1,450	1,750	1,770	mg/L	20	1.0	2,087
Chromium	<0.06	<0.06	<0.042	<0.042	mg/L	0.060	0.042	<0.5
Iron	<0.5	<0.5	<0.5	<0.5	mg/L	0.5	0.5	0.91
Lead	<0.05	<0.05	<0.05	<0.05	mg/L	0.05	0.05	0.105
Magnesium	1,020	1,000	1,160	1,170	mg/L	5.0	50	1,247
Mercury	<0.001	<0.001	<0.0002	<0.0002	mg/L	0.001	0.001	<0.002
Nickel	<0.1	<0.1	<0.025	<0.025	mg/L	0.025	0.025	0.490
Potassium	470	460	510	523	mg/L	5.0	50	799
Selenium	<0.010	<0.010	<0.010	<0.010	mg/L	0.010	0.010	0.150
Silver	<0.05	<0.05	<0.013	<0.013	mg/L	0.013	0.013	<0.5
Sodium	19,800	18,300	20,300	19,100	mg/L	20	14	22,090
Thallium	<0.010	<0.010	<0.010	<0.010	mg/L	0.010	0.010	0.98
Vanadium	<0.05	<0.05	<1.25	<1.25	mg/L	0.50	<1.25	<0.1

Appendix F – Groundwater Data Tables

Table F.2 – Analytical Results for Groundwater Sampled from Well WQSP-2

Parameter	Concentration, ug/L				Units	Reporting Limit		95th UTLV[a]
	Round 28		Round 29					
	Sample	Duplicate	Sample	Duplicate		Round 28	Round 29	

[a] 95th Upper tolerance limit value, equivalent to 95% confidence limit. 95th percentile for nitrate, TOC, TOX, TSS, and trace metals.
[b] Reporting limit. Value corresponds to method reporting limit (MRL) except method detection limit (MDL) used for nitrate.
[c] Standard unit
[d] Not applicable

Table F.3 – Analytical Results for Groundwater Sampled from Well WQSP-3

Parameter	Concentration, ug/L				Units	Reporting Limit		95th UTLV[a]
	Round 28		Round 29					
	Sample	Duplicate	Sample	Duplicate		Round 28	Round 29	
1,1,1-Trichloroethane	<1	<1	<1	<1	µg/L	1	1	<RL[b]
1,1,2,2-Tetrachloroethane	<1	<1	<1	<1	µg/L	1	1	<RL
1,1,2-Trichloroethane	<1	<1	<1	<1	µg/L	1	1	<RL
1,1-Dichloroethane	<1	<1	<1	<1	µg/L	1	1	<RL
1,1-Dichloroethylene	<1	<1	<1	<1	µg/L	1	1	<RL
1,2-Dichloroethane	<1	<1	<1	<1	µg/L	1	1	<RL
Carbon tetrachloride	<1	<1	<1	<1	µg/L	1	1	<RL
Chlorobenzene	<1	<1	<1	<1	µg/L	1	1	<RL
Chloroform	<1	<1	<1	<1	µg/L	1	1	<RL
cis-1,2-Dichloroethylene	<1	<1	<1	<1	µg/L	1	1	<RL
trans-1, 2-Dichloroethylene	<1	<1	<1	<1	µg/L	1	1	<RL
2-butanol	<5	<5	<5	<5	µg/L	5	5	<RL
Methyl ethyl ketone	<5	<5	<5	<5	µg/L	5	5	<RL
Methylene chloride	<5	<5	<5	<5	µg/L	5	5	<RL
Tetrachloroethylene	<1	<1	<1	<1	µg/L	1	1	<RL
Toluene	<1	<1	<1	<1	µg/L	1	1	<RL
Trichloroethylene	<1	<1	<1	<1	µg/L	1	1	<RL
Trichlorofluoromethane	<1	<1	<1	<1	µg/L	1	1	<RL
Vinyl chloride	<1	<1	<1	<1	µg/L	1	1	<RL
Xylene	<1	<1	<1	<1	µg/L	1	1	<RL
1,2-Dichlorobenzene	<5	<5	<5	<5	µg/L	5	5	<RL
1,4-Dichlorobenzene	<5	<5	<5	<5	µg/L	5	5	<RL
2,4-Dinitrophenol	<20	<20	<5	<5	µg/L	20	5	<RL
2,4-Dinitrotoluene	<5	<5	<5	<5	µg/L	5	5	<RL
2-Methylphenol	<5	<5	<5	<5	µg/L	5	5	<RL
3-Methylphenol/ 4-Methylphenol	<5	<5	<5	<5	µg/L	5	5	<RL
Hexachlorobenzene	<5	<5	<5	<5	µg/L	5	5	<RL
Hexachloroethane	<5	<5	<5	<5	µg/L	5	5	<RL
Nitrobenzene	<5	<5	<5	<5	µg/L	5	5	<RL
Pentachlorophenol	<5	<5	<5	<5	µg/L	5	5	<RL
Pyridine	<5	<5	<5	<5	µg/L	5	5	<RL
Isobutanol	<5	<5	<5	<5	µg/L	5	5	<RL
Alkalinity	30.2	30.2	36.7	33.1	mg/L	20	20	54.4
Chloride	138,000	145,000	140,000	140,000	mg/L	100	1000	149,100
Density	1.134	1.147	1.138	1.143	g/ml	N/A[c]	N/A[c]	1.17
Nitrate (as N)	<5.0	<5.0	<5.0	<5.0	mg/L	5.0	5.0	<12.0

Appendix F – Groundwater Data Tables

Table F.3 – Analytical Results for Groundwater Sampled from Well WQSP-3

Parameter	Concentration, ug/L Round 28 Sample	Round 28 Duplicate	Round 29 Sample	Round 29 Duplicate	Units	Reporting Limit Round 28	Reporting Limit Round 29	95th UTLV[a]
pH	6.77	6.79	6.90	6.87	SU[d]	0.1	0.1	6.6 - 7.2
Specific conductance	328,000	329,000	340,000	340,000	µmhos/cm	N/A[c]	N/A[c]	517,000
Sulfate	7,950	8,570	8,120	8,120	mg/L	100	100	8,015
Total dissolved solids	222,000	220,00	226,000	224,000	mg/L	20	10,000	261,000
Total organic carbon	<0.5	<0.5	0.44 J[e]	0.43 J[e]	mg/L	0.5	1.0	<5.0
Total organic halogen	<0.06	0.43	0.28	0.40	mg/L	0.06	0.10	55.0
Total suspended solids	3 J[e]	4 J[e]	82	127	mg/L	10	10	107.0
Antimony	<0.025	<0.025	<0.010	<0.010	mg/L	0.025	0.010	<1.0
Arsenic	<0.025	<0.025	<0.010	<0.010	mg/L	0.025	0.010	<1.0
Barium	0.049 J[e]	0.045 J[e]	0.049 J[e]	0.047 J[e]	mg/L	0.25	0.50	<1.0
Beryllium	0.026 J[e]	0.027 J[e]	0.016 J[e]	0.014 J[e]	mg/L	0.075	0.150	<0.1
Cadmium	<0.050	<0.050	<0.10	<0.10	mg/L	0.050	0.10	<0.5
Calcium	1,480	1,440	1,480	1,500	mg/L	100	50	1,680
Chromium	<0.15	<0.15	<0.30	<0.30	mg/L	0.15	0.30	<2.0
Iron	0.45 J[e]	0.34 J[e]	<0.27	<0.27	mg/L	1.25	2.5	<4.0
Lead	<0.125	<0.125	<0.25	<0.25	mg/L	0.125	0.25	0.80
Magnesium	2,390	2,340	2,400	2,410	mg/L	20	50	2,625
Mercury	<0.001	<0.001	0.0012 J[e]	0.0014 J[e]	mg/L	0.001	0.004	<0.002
Nickel	<0.25	<0.25	<0.50	<0.50	mg/L	0.25	0.50	<5.0
Potassium	1,570	1,550	1,550	1,610	mg/L	20	50	3,438
Selenium	<0.025	<0.025	<0.010	<0.010	mg/L	0.025	0.010	<2.0
Silver	0.028 J[e]	0.022 J[e]	<0.03	<0.03	mg/L	0.125	0.250	0.310
Sodium	75,100	75,200	81,200	79,700	mg/L	100	1,000	140,400
Thallium	<0.025	<0.025	<0.010	<0.010	mg/L	0.025	0.010	5.80
Vanadium	0.20 J[e]	0.21 J[e]	0.15 J[e]	0.13 J[e]	mg/L	1.25	2.50	<5.0

[a] 95th Upper tolerance limit value, equivalent to 95% confidence limit. 95th percentile for nitrate, TOC, TOX, TSS, and trace metals.
[b] Reporting limit. Value corresponds to method reporting limit (MRL) except method detection limit (MDL) used for nitrate.
[c] Standard unit
[d] Not applicable
J[e] Estimated concentration below method reporting limit.

Table F.4 – Analytical Results for Groundwater Sampled from Well WQSP-4

Parameter	Concentration, ug/L Round 28 Sample	Round 28 Duplicate	Round 29 Sample	Round 29 Duplicate	Units	Reporting Limit Round 28	Reporting Limit Round 29	95th UTLV[a]
1,1,1-Trichloroethane	<1	<1	<1	<1	µg/L	1	1	<RL[b]
1,1,2,2-Tetrachloroethane	<1	<1	<1	<1	µg/L	1	1	<RL
1,1,2-Trichloroethane	<1	<1	<1	<1	µg/L	1	1	<RL
1,1-Dichloroethane	<1	<1	<1	<1	µg/L	1	1	<RL
1,1-Dichloroethylene	<1	<1	<1	<1	µg/L	1	1	<RL
1,2-Dichloroethane	<1	<1	<1	<1	µg/L	1	1	<RL
Carbon tetrachloride	<1	<1	<1	<1	µg/L	1	1	<RL
Chlorobenzene	<1	<1	<1	<1	µg/L	1	1	<RL
Chloroform	<1	<1	<1	<1	µg/L	1	1	<RL
cis-1,2-Dichloroethylene	<1	<1	<1	<1	µg/L	1	1	<RL

Table F.4 – Analytical Results for Groundwater Sampled from Well WQSP-4

	Concentration, ug/L					Reporting Limit		
	Round 28		Round 29					
Parameter	Sample	Duplicate	Sample	Duplicate	Units	Round 28	Round 29	95th UTLV[a]
trans-1, 2-Dichloroethylene	<1	<1	<1	<1	µg/L	1	1	<RL
2-butanol	<5	<5	<5	<5	µg/L	5	5	<RL
Methyl ethyl ketone	<5	<5	<5	<5	µg/L	5	5	<RL
Methylene chloride	<5	<5	<5	<5	µg/L	5	5	<RL
Tetrachloroethylene	<1	<1	<1	<1	µg/L	1	1	<RL
Toluene	<1	<1	<1	<1	µg/L	1	1	<RL
Trichloroethylene	<1	<1	<1	<1	µg/L	1	1	<RL
Trichlorofluoromethane	<1	<1	<1	<1	µg/L	1	1	<RL
Vinyl chloride	<1	<1	<1	<1	µg/L	1	1	<RL
Xylene	<1	<1	<1	<1	µg/L	1	1	<RL
1,2-Dichlorobenzene	<5	<5	<5	<5	µg/L	5	5	<RL
1,4-Dichlorobenzene	<5	<5	<5	<5	µg/L	5	5	<RL
2,4-Dinitrophenol	<20	<20	<5	<5	µg/L	20	5	<RL
2,4-Dinitrotoluene	<5	<5	<5	<5	µg/L	5	5	<RL
2-Methylphenol	<5	<5	<5	<5	µg/L	5	5	<RL
3-Methylphenol/ 4-Methylphenol	<5	<5	<5	<5	µg/L	5	5	<RL
Hexachlorobenzene	<5	<5	<5	<5	µg/L	5	5	<RL
Hexachloroethane	<5	<5	<5	<5	µg/L	5	5	<RL
Nitrobenzene	<5	<5	<5	<5	µg/L	5	5	<RL
Pentachlorophenol	<5	<5	<5	<5	µg/L	5	5	<RL
Pyridine	<5	<5	<5	<5	µg/L	5	5	<RL
Isobutanol	<5	<5	<5	<5	µg/L	5	5	<RL
Alkalinity	38.2	38.1	39.2	37.6	mg/L	20	20	47.1
Chloride	61,700	68,000	67,700	67,300	mg/L	20	500	63,960
Density	1.069	1.067	1.069	1.070	g/ml	N/A[c]	N/A[c]	1.09
Nitrate (as N)	<1.0	<1.0	<1.06	<1.06	mg/L	1.0	1.06	<10.0
pH	7.16	7.19	7.17	7.20	SU[d]	N/A[c]	N/A[c]	6.8 - 7.6
Specific conductance	187,000	191,000	180,000	182,000	µmhos/cm	N/A[c]	N/A[c]	319,800
Sulfate	6,830	7,090	6,900	6,930	mg/L	20	100	7,927
Total dissolved solids	97,300	102,000	109,000	105,000	mg/L	20	2000	123,500
Total organic carbon	0.57	0.52	0.27 J[e]	0.11 J[e]	mg/L	0.5	10	<5.0
Total organic halogen	<0.06	<0.06	0.052	0.096	mg/L	0.06	0.01	17.0
Total suspended solids	<2.0	3.0	17	454	mg/L	2.0	2.0	57.0
Antimony	<0.010	<0.010	<0.010	<0.010	mg/L	0.010	0.010	<10.0
Arsenic	<0.010	<0.010	<0.010	<0.010	mg/L	0.010	0.010	<0.5
Barium	0.036 J[e]	0.033 J[e]	0.026 J[e]	0.026 J[e]	mg/L	0.10	0.25	1.0
Beryllium	<0.030	<0.030	<0.075	<0.075	mg/L	0.030	0.075	0.250
Cadmium	<0.02	<0.02	<0.05	<0.05	mg/L	0.02	0.02	<0.5
Calcium	1,530	1,530	1,530	1,470	mg/L	100	20	1,834
Chromium	<0.06	<0.06	<0.15	<0.15	mg/L	0.06	0.15	<2.0
Iron	<0.5	<0.5	<1.3	<1.3	mg/L	0.5	1.3	2.245
Lead	<0.05	<0.05	<0.13	<0.13	mg/L	0.05	0.13	0.525
Magnesium	1,170	1,170	1,170	1,130	mg/L	5.0	20	1,472
Mercury	<0.001	<0.001	<0.001	<0.001	mg/L	0.001	0.001	<0.002

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Table F.4 – Analytical Results for Groundwater Sampled from Well WQSP-4

Parameter	Concentration, ug/L Round 28 Sample	Round 28 Duplicate	Round 29 Sample	Round 29 Duplicate	Units	Reporting Limit Round 28	Reporting Limit Round 29	95th UTLV[a]
Nickel	<0.1	<0.1	0.016 J[e]	0.026 J[e]	mg/L	0.25	0.25	<5.0
Potassium	706	698	806	805	mg/L	5.0	10	1,648
Selenium	<0.010	<0.010	<0.010	<0.010	mg/L	0.010	0.010	2.009
Silver	<0.05	<0.05	<0.13	<0.13	mg/L	0.05	0.13	0.519
Sodium	34,400	33,400	35,300	36,400	mg/L	100	500	38,790
Thallium	<0.010	<0.010	<0.010	<0.010	mg/L	0.010	0.010	1.0
Vanadium	0.055 J[e]	0.055 J[e]	0.04 J[e]	0.039 J[e]	mg/L	0.5	1.3	<5.0

[a] 95th Upper tolerance limit value, equivalent to 95% confidence limit. 95th percentile for nitrate, TOC, TOX, TSS, and trace metals.
[b] Reporting limit. Value corresponds to method reporting limit (MRL) except method detection limit (MDL) used for nitrate.
[c] Standard unit
[d] Not applicable
J[e] Estimated concentration below method reporting limit.

Table F.5 – Analytical Results for Groundwater Sampled from Well WQSP-5

Parameter	Concentration, ug/L Round 28 Sample	Round 28 Duplicate	Round 29 Sample	Round 29 Duplicate	Units	Reporting Limit Round 28	Reporting Limit Round 29	95th UTLV[a]
1,1,1-Trichloroethane	<1	<1	<1	<1	µg/L	1	1	<RL[b]
1,1,2,2-Tetrachloroethane	<1	<1	<1	<1	µg/L	1	1	<RL
1,1,2-Trichloroethane	<1	<1	<1	<1	µg/L	1	1	<RL
1,1-Dichloroethane	<1	<1	<1	<1	µg/L	1	1	<RL
1,1-Dichloroethylene	<1	<1	<1	<1	µg/L	1	1	<RL
1,2-Dichloroethane	<1	<1	<1	<1	µg/L	1	1	<RL
Carbon tetrachloride	<1	<1	<1	<1	µg/L	1	1	<RL
Chlorobenzene	<1	<1	<1	<1	µg/L	1	1	<RL
Chloroform	<1	<1	<1	<1	µg/L	1	1	<RL
cis-1,2-Dichloroethylene	<1	<1	<1	<1	µg/L	1	1	<RL
trans-1, 2-Dichloroethylene	<1	<1	<1	<1	µg/L	1	1	<RL
2-butanol	<1	<1	<1	<1	µg/L	1	1	<RL
Methyl ethyl ketone	<5	<5	<5	<5	µg/L	5	5	<RL
Methylene chloride	<5	<5	<5	<5	µg/L	5	5	<RL
Tetrachloroethylene	<1	<1	<1	<1	µg/L	1	1	<RL
Toluene	<1	<1	<1	<1	µg/L	1	1	<RL
Trichloroethylene	<1	<1	<1	<1	µg/L	1	1	<RL
Trichlorofluoromethane	<1	<1	<1	<1	µg/L	1	1	<RL
Vinyl chloride	<1	<1	<1	<1	µg/L	1	1	<RL
Xylene	<1	<1	<1	<1	µg/L	1	1	<RL
1,2-Dichlorobenzene	<5	<5	<5	<5	µg/L	5	5	<RL
1,4-Dichlorobenzene	<5	<5	<5	<5	µg/L	5	5	<RL
2,4-Dinitrophenol	<20	<20	<5	<5	µg/L	20	5	<RL
2,4-Dinitrotoluene	<5	<5	<5	<5	µg/L	5	5	<RL
2-Methylphenol	<5	<5	<5	<5	µg/L	5	5	<RL
3-Methylphenol/ 4-Methylphenol	<5	<5	<5	<5	µg/L	5	5	<RL
Hexachlorobenzene	<5	<5	<5	<5	µg/L	5	5	<RL
Hexachloroethane	<5	<5	<5	<5	µg/L	5	5	<RL

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Table F.5 – Analytical Results for Groundwater Sampled from Well WQSP-5

Parameter	Concentration, ug/L Round 28 Sample	Round 28 Duplicate	Round 29 Sample	Round 29 Duplicate	Units	Reporting Limit Round 28	Reporting Limit Round 29	95th UTLV[a]
Nitrobenzene	<5	<5	<5	<5	µg/L	5	5	<RL
Pentachlorophenol	<5	<5	<5	<5	µg/L	5	5	<RL
Pyridine	<5	<5	<5	<5	µg/L	5	5	<RL
Isobutanol	<5	<5	<5	<5	µg/L	5	5	<RL
Alkalinity	43.5	43.2	45.0	44.9	mg/L	20	20	56
Chloride	16,800	17,400	16,600	16,900	mg/L	20	100	18,100
Density	1.023	1.026	1.019	1.019	g/ml	N/A[c]	N/A[c]	1.04
Nitrate (as N)	<1.0	<1.0	<1.06	<1.06	mg/L	1.0	1.06	<10
pH	7.42	7.43	7.50	7.51	SU[d]	N/A[c]	N/A[c]	7.4 -7.9
Specific conductance	60,200	60,200	48,100	48,800	µmhos/cm	N/A[c]	N/A[c]	67,700
Sulfate	5,330	5,570	5,560	5,420	mg/L	20	100	6,129
Total dissolved solids	31,200	33,000	32,200	32,100	mg/L	20	2,000	43,950
Total organic carbon	0.56	0.54	0.51 J[e]	0.38 J[e]	mg/L	0.5	1.0	<5.0
Total organic halogen	0.149	0.093	0.089	0.085	mg/L	0.06	0.06	8.37
Total suspended solids	<2	<2	<2	7	mg/L	2	2	<10.0
Antimony	<0.010	<0.010	<0.010	<0.010	mg/L	0.010	0.010	0.073
Arsenic	<0.010	<0.010	<0.010	<0.010	mg/L	0.010	0.010	<0.5
Barium	0.014	0.013	0.026 J[e]	0.023 J[e]	mg/L	0.10	0.50	<1.0
Beryllium	<0.030	<0.030	<0.15	<0.15	mg/L	0.030	0.15	<0.02
Cadmium	<0.020	<0.020	<0.10	<0.10	mg/L	0.02	<0.10	<0.05
Calcium	1,010	1,010	988	1,060	mg/L	20	50	1,303
Chromium	<0.060	<0.060	<0.30	<0.30	mg/L	0.060	0.30	<0.5
Iron	<0.5	<0.5	<2.5	<2.5	mg/L	0.5	2.5	0.795
Lead	<0.050	<0.050	0.25	<0.25	mg/L	0.05	0.25	<0.05
Magnesium	456	436	435	480	mg/L	5.0	50	547
Mercury	<0.0002	<0.0002	<0.0002	<0.0002	mg/L	0.0002	0.0002	<0.002
Nickel	<0.10	<0.10	<0.50	<0.50	mg/L	0.10	0.50	<0.1
Potassium	312	309	274	316	mg/L	5.0	50	622
Selenium	<0.010	<0.010	<0.010	<0.010	mg/L	0.010	0.010	<0.1
Silver	<0.05	<0.05	<0.25	<0.25	mg/L	0.05	0.25	<0.5
Sodium	10,400	10,400	9,490	9,200	mg/L	20	200	11,190
Thallium	<0.010	<0.010	<0.010	<0.010	mg/L	0.010	0.010	0.209
Vanadium	0.039 J[e]	<0.5	<0.5	<0.5	mg/L	0.5	0.5	2.70

[a] 95th Upper tolerance limit value, equivalent to 95% confidence limit. 95th percentile for nitrate, TOC, TOX, TSS, and trace metals.
[b] Reporting limit. Value corresponds to method reporting limit (MRL) except method detection limit (MDL) used for nitrate.
[c] Standard unit
[d] Not applicable
J[e] Estimated concentration below method reporting limit.

Table F.6 – Analytical Results for Groundwater Sampled from Well WQSP-6

Parameter	Concentration, ug/L Round 28 Sample	Round 28 Duplicate	Round 29 Sample	Round 29 Duplicate	Units	Reporting Limit Round 28	Reporting Limit Round 29	95th UTLV[a]
1,1,1-Trichloroethane	<1	<1	<1	<1	µg/L	1	1	<RL[b]
1,1,2,2-Tetrachloroethane	<1	<1	<1	<1	µg/L	1	1	<RL
1,1,2-Trichloroethane	<1	<1	<1	<1	µg/L	1	1	<RL

Appendix F – Groundwater Data Tables

Table F.6 – Analytical Results for Groundwater Sampled from Well WQSP-6

	Concentration, ug/L							
	Round 28		Round 29			Reporting Limit		
Parameter	Sample	Duplicate	Sample	Duplicate	Units	Round 28	Round 29	95th UTLV[a]
1,1-Dichloroethane	<1	<1	<1	<1	µg/L	1	1	<RL
1,1-Dichloroethylene	<1	<1	<1	<1	µg/L	1	1	<RL
1,2-Dichloroethane	<1	<1	<1	<1	µg/L	1	1	<RL
Carbon tetrachloride	<1	<1	<1	<1	µg/L	1	1	<RL
Chlorobenzene	<1	<1	<1	<1	µg/L	1	1	<RL
Chloroform	<1	<1	<1	<1	µg/L	1	1	<RL
cis-1,2-Dichloroethylene	<1	<1	<1	<1	µg/L	1	1	<RL
trans-1, 2-Dichloroethylene	<1	<1	<1	<1	µg/L	1	1	<RL
2-butanol	<5	<5	<5	<5	µg/L	5	5	<RL
Methyl ethyl ketone	<5	<5	<5	<5	µg/L	5	5	<RL
Methylene chloride	<5	<5	<5	<5	µg/L	5	5	<RL
Tetrachloroethylene	<1	<1	<1	<1	µg/L	1	1	<RL
Toluene	<1	<1	<1	<1	µg/L	1	1	<RL
Trichloroethylene	<1	<1	<1	<1	µg/L	1	1	<RL
Trichlorofluoromethane	<1	<1	<1	<1	µg/L	1	1	<RL
Vinyl chloride	<1	<1	<1	<1	µg/L	1	1	<RL
Xylene	<1	<1	<1	<1	µg/L	1	1	<RL
1,2-Dichlorobenzene	<5	<5	<5	<5	µg/L	5	5	<RL
1,4-Dichlorobenzene	<5	<5	<5	<5	µg/L	5	5	<RL
2,4-Dinitrophenol	<5	<5	<5	<5	µg/L	5	5	<RL
2,4-Dinitrotoluene	<5	<5	<5	<5	µg/L	5	5	<RL
2-Methylphenol	<5	<5	<5	<5	µg/L	5	5	<RL
3-Methylphenol/ 4-Methylphenol	<5	<5	<5	<5	µg/L	5	5	<RL
Hexachlorobenzene	<5	<5	<5	<5	µg/L	5	5	<RL
Hexachloroethane	<5	<5	<5	<5	µg/L	5	5	<RL
Nitrobenzene	<5	<5	<5	<5	µg/L	5	5	<RL
Pentachlorophenol	<5	<5	<5	<5	µg/L	5	5	<RL
Pyridine	<5	<5	<5	<5	µg/L	5	5	<RL
Isobutanol	<5	<5	<5	<5	µg/L	5	5	2,000
Alkalinity	45.7	45.6	47.0	45.5	mg/L	20	20	55.8
Chloride	5,900	5,760	5,100	5,5330	mg/L	20	500	15,800
Density	1.010	1.009	1.008	1.008	g/ml	N/A[c]	N/A[c]	1.02
Nitrate (as N)	<1.0	<1.0	<1.1	<1.1	mg/L	1.0	1.1	7.450
pH	7.69	7.74	7.71	7.72	SU[d]	N/A[c]	N/A[c]	7.5 - 7.9
Specific conductance	25,300	25,700	21,400	18,900	µmhos/cm	N/A[c]	N/A[c]	27,660
Sulfate	5,000	4,910	4,120	4,310	mg/L	20	4,120	5,557
Total dissolved solids	18,800	14,700	16,200	16,100	mg/L	20	2.000	22,500
Total organic carbon	0.50	0.54	0.31 J[e]	0.48 J[e]	mg/L	0.50	1.0	10.14
Total organic halogen	0.069	0.062	0.042	0.039	mg/L	0.06	0.01	1.54
Total suspended solids	3	5	2	<2	mg/L	2	2	14.8
Antimony	<0.010	<0.010	<0.010	<0.010	mg/L	0.010	0.010	0.140
Arsenic	<0.010	<0.010	<0.010	<0.010	mg/L	0.010	0.010	<0.5
Barium	0.010	0.011	<0.1	<0.1	mg/L	0.01	0.1	<1.0
Beryllium	<0.010	<0.010	<0.03	<0.03	mg/L	0.010	0.03	<0.02

Appendix F – Groundwater Data Tables

Table F.6 – Analytical Results for Groundwater Sampled from Well WQSP-6

Parameter	Concentration, ug/L Round 28 Sample	Round 28 Duplicate	Round 29 Sample	Round 29 Duplicate	Units	Reporting Limit Round 28	Reporting Limit Round 29	95th UTLV[a]
Cadmium	<0.010	<0.010	<0.020	<0.020	mg/L	0.010	0.020	<0.05
Calcium	680	691	629	648	mg/L	100	10	796
Chromium	<0.025	<0.025	<0.060	<0.060	mg/L	0.025	0.060	<0.5
Iron	<0.5	<0.5	<0.5	<0.5	mg/L	0.5	0.5	3.105
Lead	<0.020	<0.020	<0.050	<0.050	mg/L	0.02	0.05	0.150
Magnesium	213	230	201	207	mg/L	5.0	10	255
Mercury	<0.0002	<0.0002	<0.0002	<0.0002	mg/L	0.0002	0.0002	<0.002
Nickel	<0.025	<0.025	<0.10	<0.10	mg/L	0.025	0.10	<0.5
Potassium	157	173	142	149	mg/L	5.0	10	270
Selenium	<0.010	<0.010	<0.010	<0.010	mg/L	0.010	0.010	0.100
Silver	<0.013	<0.013	0.025 J[e]	<0.050	mg/L	0.013	0.05	<0.5
Sodium	4,250	4,410	4,070	4,050	mg/L	100	50	6,290
Thallium	<0.010	<0.010	<0.010	<0.010	mg/L	0.010	0.010	0.560
Vanadium	<0.050	<0.050	0.025 J[e]	0.020 J[e]	mg/L	0.050	0.50	0.070

[a] 95th Upper tolerance limit value, equivalent to 95% confidence limit. 95th percentile for nitrate, TOC, TOX, TSS, and trace metals.
[b] Reporting limit. Value corresponds to method reporting limit (MRL) except method detection limit (MDL) used for nitrate.
[c] Standard unit
[d] Not applicable
J[e] Estimated concentration below method reporting limit.

Table F.7 – Analytical Results for Groundwater Sampled from Well WQSP-6A

Parameter	Concentration, ug/L Round 28 Sample	Round 28 Duplicate	Round 29 Sample	Round 29 Duplicate	Units	Reporting Limit Round 28	Reporting Limit Round 29	95th UTLV[a]
1,1,1-Trichloroethane	<1	<1	<1	<1	µg/L	1	1	<RL[b]
1,1,2,2-Tetrachloroethane	<1	<1	<1	<1	µg/L	1	1	<RL
1,1,2-Trichloroethane	<1	<1	<1	<1	µg/L	1	1	<RL
1,1-Dichloroethane	<1	<1	<1	<1	µg/L	1	1	<RL
1,1-Dichloroethylene	<1	<1	<1	<1	µg/L	1	1	<RL
1,2-Dichloroethane	<1	<1	<1	<1	µg/L	1	1	<RL
Carbon tetrachloride	<1	<1	<1	<1	µg/L	1	1	<RL
Chlorobenzene	<1	<1	<1	<1	µg/L	1	1	<RL
Chloroform	<1	<1	<1	<1	µg/L	1	1	<RL
cis-1,2-Dichloroethylene	<1	<1	<1	<1	µg/L	1	1	<RL
trans-1, 2-Dichloroethylene	<1	<1	<1	<1	µg/L	1	1	<RL
2-butanol	<5	<5	<5	<5	µg/L	5	5	<RL
Methyl ethyl ketone	<5	<5	<5	<5	µg/L	5	5	<RL
Methylene chloride	<5	<5	<5	<5	µg/L	5	5	<RL
Tetrachloroethylene	<1	<1	<1	<1	µg/L	1	1	<RL
Toluene	<1	<1	<1	<1	µg/L	1	1	<RL
Trichloroethylene	<1	<1	<1	<1	µg/L	1	1	<RL
Trichlorofluoromethane	<1	<1	<1	<1	µg/L	1	1	<RL
Vinyl chloride	<1	<1	<1	<1	µg/L	1	1	<RL
Xylene	<1	<1	<1	<1	µg/L	1	1	<RL
1,2-Dichlorobenzene	<5	<5	<5	<5	µg/L	5	5	<RL
1,4-Dichlorobenzene	<5	<5	<5	<5	µg/L	5	5	<RL

Appendix F – Groundwater Data Tables

Table F.7 – Analytical Results for Groundwater Sampled from Well WQSP-6A

Parameter	Concentration, ug/L Round 28 Sample	Round 28 Duplicate	Round 29 Sample	Round 29 Duplicate	Units	Reporting Limit Round 28	Reporting Limit Round 29	95th UTLV[a]
2,4-Dinitrophenol	<5	<6	<5	<5	µg/L	5	5	<RL
2,4-Dinitrotoluene	<5	<5	<5	<5	µg/L	5	5	<RL
2-Methylphenol	<5	<5	<5	<5	µg/L	5	5	<RL
3-Methylphenol/ 4-Methylphenol	<5	<5	<5	<5	µg/L	5	5	<RL
Hexachlorobenzene	<5	<5	<5	<5	µg/L	5	5	<RL
Hexachloroethane	<5	<5	<5	<5	µg/L	5	5	<RL
Nitrobenzene	<5	<5	<5	<5	µg/L	5	5	<RL
Pentachlorophenol	<5	<5	<5	<5	µg/L	5	5	<RL
Pyridine	<5	<5	<5	<5	µg/L	5	5	<RL
Isobutanol	<5	<5	<5	<5	mg/L	5	5	<RL
Alkalinity	103	102	102	103	mg/L	20	20	113
Chloride	349	350	347	341	mg/L	20	5.0	6,723
Density	0.997	0.995	0.997	0.997	g/ml	N/A[c]	N/A[c]	1.01
Nitrate (as N)	5.93	5.93	5.32	6.40	mg/L	1.0	1.1	12.2
pH	7.44	7.44	7.50	7.60	SU[d]	N/A[c]	N/A[c]	6.8 - 8.0
Specific conductance	3,880	3,870	3,440	3,530	µmhos/cm	N/A[c]	N/A[c]	5,192
Sulfate	2,100	2,130	2,090	2,060	mg/L	20	25	2,543
Total dissolved solids	3,450	2.940	3,640	3,640	mg/L	20	100	11,000
Total organic carbon	<0.5	<0.5	<1.0	<1.0	mg/L	0.5	1.0	15.45
Total organic halogen	<0.06	<0.06	<0.06	<0.06	mg/L	0.06	0.06	0.19
Total suspended solids	<10	7 J[e]	<10	<10	mg/L	10	10	91.0
Antimony	<0.010	<0.010	<0.010	<0.010	mg/L	0.010	0.010	0.480
Arsenic	<0.010	<0.010	<0.010	<0.010	mg/L	0.010	0.010	<0.5
Barium	<0.010	<0.010	<0.010	<0.010	mg/L	0.010	0.010	<0.1
Beryllium	<0.010	<0.010	<0.010	<0.010	mg/L	0.010	0.010	<0.01
Cadmium	<0.010	<0.010	<0.010	<0.010	mg/L	0.010	0.010	<0.05
Calcium	609	623	574	576	mg/L	100	10	733
Chromium	<0.025	<0.025	<0.025	<0.025	mg/L	0.025	0.025	<0.5
Iron	<0.50	<0.50	<0.05	<0.05	mg/L	0.5	0.05	0.505
Lead	<0.02	<0.02	<0.005	<0.005	mg/L	0.02	0.005	<0.05
Magnesium	152	154	153	152	mg/L	5.0	5.0	188
Mercury	<0.0002	<0.0002	<0.0002	<0.0002	mg/L	0.0002	0.0002	<0.002
Nickel	0.040	0.040	0.010	0.011	mg/L	0.010	0.010	0.284
Potassium	3.86	3.85	4.50	4.51	mg/L	5.0	1.0	10.1
Selenium	<0.010	<0.010	<0.010	<0.010	mg/L	0.010	0.010	0.220
Silver	<0.013	<0.013	<0.005	<0.005	mg/L	0.013	0.005	<0.5
Sodium	214	221	217	214	mg/L	100	5.0	369
Thallium	<0.010	<0.010	<0.010	<0.010	mg/L	0.010	0.010	<0.058
Vanadium	0.046	0.045	0.049 J[e]	0.049 J[e]	mg/L	0.05	0.05	<0.5

[a] 95th Upper tolerance limit value, equivalent to 95% confidence limit. 95th percentile for nitrate, TOC, TOX, TSS, and trace metals.
[b] Reporting limit. Value corresponds to method reporting limit (MRL) except method detection limit (MDL) used for nitrate.
[c] Standard unit
[d] Not applicable
J[e] Estimated concentration below method reporting limit.

Appendix F – Groundwater Data Tables

Table F.8 – WIPP Well Inventory for 2009

Sorted by Active Wells at Year-End				Sorted by Formation for Wells Measured at Least Once in 2009			
Count	**Well Number**	**Zone**	**Notes**	**Count**	**Well Number**	**Zone**	**Reason Not Assessed for Long-Term Water Level Trend in Culebra**
1	AEC-7	CUL		1	CB-1(PIP)	B/C	
2	C-2505	SR/DL		2	DOE-2	B/C	
3	C-2506	SR/DL		3	AEC-7	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-04b	CUL	Plugged in July 2009
8	DOE-2	B/C		8	H-04bR	CUL	New in July, replaces H-4b
9	ERDA-9	CUL		9	H-05b	CUL	
10	H-02b1	MAG		10	H-06bR	CUL	
11	H-02b2	CUL		11	H-07b	CUL	
12	H-03b1	MAG		12	H-10c	CUL	
13	H-03b2	CUL		13	H-11b4	CUL	
14	H-03d	SR/DL	Dry; not measured in 2009	14	H-12	CUL	
15	H-04bR	CUL		15	H-17	CUL	
16	H-04c	MAG		16	H-19b0	CUL	
17	H-05b	CUL		17	H-19b2	CUL	Redundant to H19B0
18	H-06bR	CUL		18	H-19b3	CUL	Redundant to H19B0
19	H-06c	MAG		19	H-19b4	CUL	Redundant to H19B0
20	H-07b1	CUL		20	H-19b5	CUL	Redundant to H19B0
21	H-08a	MAG		21	H-19b6	CUL	Redundant to H19B0
22	H-09c	MAG/CUL		22	H-19b7	CUL	Redundant to H19B0
23	H-10a	MAG		23	I-461	CUL	
24	H-10c	CUL		24	SNL-1	CUL	
25	H-11b2	MAG		25	SNL-2	CUL	
26	H-11b4	CUL		26	SNL-3	CUL	
27	H-12	CUL		27	SNL-5	CUL	
28	H-14	MAG		28	SNL-6	CUL	Depressed from projected equilibrium
29	H-15R	CUL		29	SNL-8	CUL	
30	H-15	MAG		30	SNL-9	CUL	
31	H-16	CUL		31	H-15R	CUL	
32	H-17	CUL		32	SNL-10	CUL	
33	H-18	MAG		33	H-16	CUL	
34	H-19b0	CUL		34	SNL-12	CUL	
35	H-19b2	CUL		35	SNL-13	CUL	
36	H-19b3	CUL		36	SNL-14	CUL	
37	H-19b4	CUL		37	SNL-15	CUL	Depressed from projected equilibrium
38	H-19b5	CUL		38	SNL-16	CUL	
39	H-19b6	CUL		39	SNL-17	CUL	
40	H-19b7	CUL		40	SNL-18	CUL	
41	I-461	CUL		41	SNL-19	CUL	
42	SNL-01	CUL		42	WIPP-11	CUL	
43	SNL-02	CUL		43	WIPP-13	CUL	
44	SNL-03	CUL		44	WIPP-19	CUL	
45	SNL-05	CUL		45	WQSP-1	CUL	

Appendix F – Groundwater Data Tables

Table F.8 – WIPP Well Inventory for 2009

Sorted by Active Wells at Year-End				Sorted by Formation for Wells Measured at Least Once in 2009			
Count	**Well Number**	**Zone**	**Notes**	**Count**	**Well Number**	**Zone**	**Reason Not Assessed for Long-Term Water Level Trend in Culebra**
46	SNL-06	CUL		46	WQSP-2	CUL	
47	SNL-08	CUL		47	WQSP-3	CUL	
48	SNL-09	CUL		48	WQSP-4	CUL	
49	SNL-10	CUL		49	WQSP-5	CUL	
50	SNL-12	CUL		50	WQSP-6	CUL	
51	SNL-13	CUL		51	WQSP-6A	DL	
52	SNL-14	CUL		52	H-02b1	MAG	
53	SNL-15	CUL		53	H-03b1	MAG	
54	SNL-16	CUL		54	H-04c	MAG	
55	SNL-17	CUL		55	H-06c	MAG	
56	SNL-18	CUL		56	H-08a	MAG	
57	SNL-19	CUL		57	H-10a	MAG	
58	PZ-01	SR/DL		58	H-11b2	MAG	
59	PZ-02	SR/DL		59	H-14	MAG	
60	PZ-03	SR/DL		60	H-18	MAG	
61	PZ-04	SR/DL		61	WIPP-18	MAG	
62	PZ-05	SR/DL		62	H-15	MAG	
63	PZ-06	SR/DL		63	H-09c	MAG/CUL	
64	PZ-07	SR/DL		64	C-2737	MAG/CUL	
65	PZ-08	SR/DL		65	WIPP-25	MAG/CUL	Plugged in July 2009
66	PZ-09	SR/DL		66	C-2505	SR/DL	
67	PZ-10	SR/DL		67	C-2506	SR/DL	
68	PZ-11	SR/DL		68	C-2507	SR/DL	
69	PZ-12	SR/DL		69	C-2811	SR/DL	
70	PZ-13	SR/DL		70	PZ-01	SR/DL	
71	PZ-14	SR/DL		71	PZ-02	SR/DL	
72	PZ-15	SR/DL		72	PZ-03	SR/DL	
73	WIPP-11	CUL		73	PZ-04	SR/DL	
74	WIPP-13	CUL		74	PZ-05	SR/DL	
75	WIPP-18	MAG		75	PZ-06	SR/DL	
76	WIPP-19	CUL		76	PZ-07	SR/DL	
77	WQSP-1	CUL		77	PZ-08	SR/DL	
78	WQSP-2	CUL		78	PZ-09	SR/DL	
79	WQSP-3	CUL		79	PZ-10	SR/DL	
80	WQSP-4	CUL		80	PZ-11	SR/DL	
81	WQSP-5	CUL		81	PZ-12	SR/DL	
82	WQSP-6	CUL		82	PZ-13	SR/DL	
83	WQSP-6A	DL		83	PZ-14	SR/DL	
				84	PZ-15	SR/DL	

Appendix F – Groundwater Data Tables

Table F.9 – Water Levels							
Well Number	Zone	Date	Adjusted Depth Top of Casing (ft)	Adjusted Depth Meters	Water Level Elevation (ft amsl)	Elevation in Meters (amsl)	Adjusted Freshwater Head (ft amsl)
AEC-7	CUL	01/13/09	614.13	187.19	3,044.21	927.88	3,064.46
AEC-7	CUL	02/09/09	614.19	187.21	3,044.15	927.86	3,064.39
AEC-7	CUL	03/24/09	612.73	186.76	3,044.33	927.91	3,064.59
AEC-7	CUL	04/21/09	612.75	186.77	3,044.31	927.91	3,064.57
AEC-7	CUL	05/19/09	612.74	186.76	3,044.32	927.91	3,064.58
AEC-7	CUL	06/09/09	612.73	186.76	3,044.33	927.91	3,064.59
AEC-7	CUL	07/14/09	612.81	186.78	3,044.25	927.89	3,064.50
AEC-7	CUL	08/10/09	612.79	186.78	3,044.27	927.89	3,064.52
AEC-7	CUL	09/22/09	612.87	186.80	3,044.19	927.87	3,064.44
AEC-7	CUL	10/19/09	612.89	186.81	3,044.17	927.86	3,064.42
AEC-7	CUL	11/09/09	612.97	186.83	3,044.09	927.84	3,064.33
AEC-7	CUL	12/08/09	612.83	186.79	3,044.23	927.88	3,064.48
C-2737 (PIP)	CUL	01/20/09	386.13	117.69	3,014.63	918.86	3,024.08
C-2737 (PIP)	CUL	02/12/09	385.97	117.64	3,014.79	918.91	3,024.25
C-2737 (PIP)	CUL	03/26/09	386.08	117.68	3,014.68	918.87	3,024.13
C-2737 (PIP)	CUL	04/23/09	386.43	117.78	3,014.33	918.77	3,023.16
C-2737 (PIP)	CUL	05/21/09	386.40	117.77	3,014.36	918.78	3,023.20
C-2737 (PIP)	CUL	06/11/09	386.28	117.74	3,014.48	918.81	3,023.32
C-2737 (PIP)	CUL	07/16/09	386.44	117.79	3,014.32	918.76	3,023.15
C-2737 (PIP)	CUL	08/13/09	386.36	117.76	3,014.40	918.79	3,023.24
C-2737 (PIP)	CUL	09/23/09	386.29	117.74	3,014.47	918.81	3,023.31
C-2737 (PIP)	CUL	10/22/09	386.64	117.85	3,014.12	918.70	3,022.95
C-2737 (PIP)	CUL	11/11/09	386.82	117.90	3,013.94	918.65	3,022.76
C-2737 (PIP)	CUL	12/10/09	386.42	117.78	3,014.34	918.77	3,023.17
ERDA-9	CUL	01/20/09	398.00	121.31	3,012.17	918.11	3,033.55
ERDA-9	CUL	02/12/09	397.88	121.27	3,012.29	918.15	3,033.68
ERDA-9	CUL	03/26/09	397.83	121.26	3,012.34	918.16	3,033.74
ERDA-9	CUL	04/23/09	398.11	121.34	3,012.06	918.08	3,033.44
ERDA-9	CUL	05/20/09	398.13	121.35	3,012.04	918.07	3,033.42
ERDA-9	CUL	06/11/09	397.97	121.30	3,012.20	918.12	3,033.59
ERDA-9	CUL	07/16/09	398.03	121.32	3,012.14	918.10	3,033.52
ERDA-9	CUL	08/12/09	398.02	121.32	3,012.15	918.10	3,033.53
ERDA-9	CUL	09/23/09	398.06	121.33	3,012.11	918.09	3,033.49
ERDA-9	CUL	10/19/09	398.30	121.40	3,011.87	918.02	3,033.23
ERDA-9	CUL	11/11/09	398.47	121.45	3,011.70	917.97	3,033.05
ERDA-9	CUL	12/10/09	398.39	121.43	3,011.78	917.99	3,033.14
H-02b2	CUL	03/26/09	335.42	102.24	3,042.94	927.49	3,042.94
H-02b2	CUL	04/23/09	335.32	102.21	3,043.04	927.52	3,043.04
H-02b2	CUL	05/21/09	335.32	102.21	3,043.04	927.52	3,043.04
H-02b2	CUL	06/10/09	335.27	102.19	3,043.09	927.53	3,043.09
H-02b2	CUL	07/15/09	335.38	102.22	3,042.98	927.50	3,042.98
H-02b2	CUL	08/13/09	335.43	102.24	3,042.93	927.49	3,042.93
H-02b2	CUL	09/23/09	335.50	102.26	3,042.86	927.46	3,042.86
H-02b2	CUL	10/20/09	335.32	102.21	3,043.04	927.52	3,043.04
H-02b2	CUL	11/11/09	335.72	102.33	3,042.64	927.40	3,042.64
H-02b2	CUL	12/10/09	335.59	102.29	3,042.77	927.44	3,042.77

Appendix F – Groundwater Data Tables

Table F.9 – Water Levels							
Well Number	Zone	Date	Adjusted Depth Top of Casing (ft)	Adjusted Depth Meters	Water Level Elevation (ft amsl)	Elevation in Meters (amsl)	Adjusted Freshwater Head (ft amsl)
H-03b2	CUL	01/20/09	387.41	118.08	3,002.50	915.16	3,013.91
H-03b2	CUL	02/12/09	387.22	118.02	3,002.69	915.22	3,014.11
H-03b2	CUL	03/26/09	387.78	118.20	3,002.13	915.05	3,013.53
H-03b2	CUL	04/23/09	387.98	118.26	3,001.93	914.99	3,013.32
H-03b2	CUL	05/20/09	387.85	118.22	3,002.06	915.03	3,013.45
H-03b2	CUL	06/11/09	387.62	118.15	3,002.29	915.10	3,013.69
H-03b2	CUL	07/16/09	387.68	118.16	3,002.23	915.08	3,013.63
H-03b2	CUL	08/12/09	387.77	118.19	3,002.14	915.05	3,013.54
H-03b2	CUL	09/23/09	387.68	118.16	3,002.23	915.08	3,013.63
H-03b2	CUL	10/21/09	388.16	118.31	3,001.75	914.93	3,013.13
H-03b2	CUL	11/10/09	388.18	118.32	3,001.73	914.93	3,013.11
H-03b2	CUL	12/10/09	387.76	118.19	3,002.15	915.06	3,013.55
H-04b	CUL	01/14/09	329.36	100.39	3,004.22	915.69	3,006.49
H-04b	CUL	02/11/09	329.47	100.42	3,004.11	915.65	3,006.38
H-04b	CUL	03/26/09	329.41	100.40	3,004.17	915.67	3,006.44
H-04b	CUL	04/22/09	329.72	100.50	3,003.86	915.58	3,006.13
H-04b	CUL	05/20/09	329.90	100.55	3,003.68	915.52	3,005.94
H-04b	CUL	06/09/09	329.87	100.54	3,003.71	915.53	3,005.97
H-04bR	CUL	07/15/09	330.40	100.71	3,004.24	938.68	3,007.04
H-04bR	CUL	11/10/09	330.41	100.71	3,004.23	938.68	3,007.03
H-04bR	CUL	12/09/09	330.08	100.61	3,004.56	938.78	3,007.36
H-05b	CUL	01/13/09	466.71	142.25	3,040.07	926.61	3,081.32
H-05b	CUL	02/09/09	466.51	142.19	3,040.27	926.67	3,081.54
H-05b	CUL	03/24/09	466.48	142.18	3,040.30	926.68	3,081.57
H-05b	CUL	04/21/09	466.69	142.25	3,040.09	926.62	3,081.34
H-05b	CUL	05/19/09	466.79	142.28	3,039.99	926.59	3,081.23
H-05b	CUL	06/09/09	466.64	142.23	3,040.14	926.63	3,081.40
H-05b	CUL	07/14/09	466.85	142.30	3,039.93	926.57	3,081.17
H-05b	CUL	08/10/09	466.86	142.30	3,039.92	926.57	3,081.16
H-05b	CUL	09/21/09	466.97	142.33	3,039.81	926.53	3,081.04
H-05b	CUL	10/19/09	467.12	142.38	3,039.66	926.49	3,080.87
H-05b	CUL	11/09/09	467.10	142.37	3,039.68	926.49	3,080.90
H-05b	CUL	12/08/09	467.01	142.34	3,039.77	926.52	3,080.99
H-06bR	CUL	03/24/09	288.77	88.02	3,060.45	932.83	3,071.29
H-06bR	CUL	04/22/09	288.94	88.07	3,060.28	932.77	3,071.12
H-06bR	CUL	05/19/09	289.31	88.18	3,059.91	932.66	3,070.73
H-06bR	CUL	06/08/09	289.26	88.17	3,059.96	932.68	3,070.79
H-06bR	CUL	07/13/09	289.53	88.25	3,059.69	932.59	3,070.51
H-06bR	CUL	08/11/09	289.39	88.21	3,059.83	932.64	3,070.65
H-06bR	CUL	09/21/09	289.30	88.18	3,059.92	932.66	3,070.74
H-06bR	CUL	10/19/09	289.42	88.22	3,059.80	932.63	3,070.62
H-06bR	CUL	11/11/09	289.88	88.36	3,059.34	932.49	3,070.15
H-06bR	CUL	12/10/09	289.85	88.35	3,059.37	932.50	3,070.18
H-07b1	CUL	01/14/09	164.97	50.28	2,998.75	914.02	2,998.75
H-07b1	CUL	02/10/09	164.82	50.24	2,998.90	914.06	2,998.90
H-07b1	CUL	03/24/09	165.19	50.35	2,998.53	913.95	2,998.53

Appendix F – Groundwater Data Tables

Table F.9 – Water Levels							
Well Number	Zone	Date	Adjusted Depth Top of Casing (ft)	Adjusted Depth Meters	Water Level Elevation (ft amsl)	Elevation in Meters (amsl)	Adjusted Freshwater Head (ft amsl)
H-07b1	CUL	04/21/09	165.26	50.37	2,998.46	913.93	2,998.46
H-07b1	CUL	05/18/09	165.50	50.44	2,998.22	913.86	2,998.22
H-07b1	CUL	06/08/09	165.37	50.40	2,998.35	913.90	2,998.35
H-07b1	CUL	07/13/09	165.65	50.49	2,998.07	913.81	2,998.07
H-07b1	CUL	08/10/09	165.69	50.50	2,998.03	913.80	2,998.03
H-07b1	CUL	09/22/09	166.02	50.60	2,997.70	913.70	2,997.70
H-07b1	CUL	10/19/09	165.74	50.52	2,997.98	913.78	2,997.98
H-07b1	CUL	11/10/09	166.03	50.61	2,997.69	913.70	2,997.69
H-07b1	CUL	12/08/09	165.29	50.38	2,998.43	913.92	2,998.43
H-09c (PIP)	CUL	01/13/09	411.23	125.34	2,995.82	913.13	2,996.58
H-09c (PIP)	CUL	02/10/09	411.17	125.32	2,995.88	913.14	2,996.64
H-09c (PIP)	CUL	03/25/09	411.62	125.46	2,995.43	913.01	2,996.19
H-09c (PIP)	CUL	04/21/09	411.93	125.56	2,995.12	912.91	2,995.87
H-09c (PIP)	CUL	05/18/09	411.82	125.52	2,995.23	912.95	2,995.99
H-09c (PIP)	CUL	06/09/09	411.54	125.44	2,995.51	913.03	2,996.27
H-09c (PIP)	CUL	07/14/09	411.23	125.34	2,995.82	913.13	2,996.58
H-09c (PIP)	CUL	08/10/09	411.24	125.35	2,995.81	913.12	2,996.57
H-09c (PIP)	CUL	09/22/09	411.03	125.28	2,996.02	913.19	2,996.78
H-09c (PIP)	CUL	10/20/09	411.24	125.35	2,995.81	913.12	2,996.57
H-09c (PIP)	CUL	11/10/09	410.89	125.24	2,996.16	913.23	2,996.92
H-09c (PIP)	CUL	12/08/09	410.14	125.01	2,996.91	913.46	2,997.67
H-10c	CUL	01/13/09	664.97	202.68	3,023.43	921.54	3,024.14
H-10c	CUL	02/09/09	664.71	202.60	3,023.69	921.62	3,024.40
H-10c	CUL	03/25/09	664.75	202.62	3,023.65	921.61	3,024.36
H-10c	CUL	04/21/09	664.97	202.68	3,023.43	921.54	3,024.14
H-10c	CUL	05/19/09	665.02	202.70	3,023.38	921.53	3,024.09
H-10c	CUL	06/09/09	664.88	202.66	3,023.52	921.57	3,024.23
H-10c	CUL	08/10/09	723.60	220.55	2,964.80	903.67	3,022.52
H-10c	CUL	09/22/09	720.75	219.68	2,967.65	904.54	3,025.62
H-10c	CUL	10/20/09	721.70	219.97	2,966.70	904.25	3,024.59
H-10c	CUL	11/09/09	720.13	219.50	2,968.27	904.73	3,026.30
H-10c	CUL	12/08/09	719.74	219.38	2,968.66	904.85	3,026.72
H-11b4	CUL	01/13/09	422.83	128.88	2,987.96	910.73	3,007.39
H-11b4	CUL	02/11/09	422.89	128.90	2,987.90	910.71	3,007.32
H-11b4	CUL	03/25/09	422.89	128.90	2,987.90	910.71	3,007.32
H-11b4	CUL	04/22/09	423.21	128.99	2,987.58	910.61	3,006.98
H-11b4	CUL	05/20/09	423.30	129.02	2,987.49	910.59	3,006.89
H-11b4	CUL	06/09/09	423.25	129.01	2,987.54	910.60	3,006.94
H-11b4	CUL	07/14/09	423.05	128.95	2,987.74	910.66	3,007.15
H-11b4	CUL	08/11/09	423.16	128.98	2,987.63	910.63	3,007.04
H-11b4	CUL	09/23/09	423.19	128.99	2,987.60	910.62	3,007.01
H-11b4	CUL	10/19/09	423.16	128.98	2,987.63	910.63	3,007.04
H-11b4	CUL	11/09/09	423.33	129.03	2,987.46	910.58	3,006.86
H-11b4	CUL	12/09/09	423.00	128.93	2,987.79	910.68	3,007.21
H-12	CUL	01/13/09	456.70	139.20	2,970.63	905.45	3,007.28
H-12	CUL	02/09/09	456.62	139.18	2,970.71	905.47	3,007.36

Appendix F – Groundwater Data Tables

Table F.9 – Water Levels							
Well Number	Zone	Date	Adjusted Depth Top of Casing (ft)	Adjusted Depth Meters	Water Level Elevation (ft amsl)	Elevation in Meters (amsl)	Adjusted Freshwater Head (ft amsl)
H-12	CUL	03/25/09	456.55	139.16	2,970.78	905.49	3,007.44
H-12	CUL	04/21/09	456.66	139.19	2,970.67	905.46	3,007.32
H-12	CUL	05/19/09	456.70	139.20	2,970.63	905.45	3,007.28
H-12	CUL	06/09/09	456.64	139.18	2,970.69	905.47	3,007.34
H-12	CUL	07/14/09	456.75	139.22	2,970.58	905.43	3,007.22
H-12	CUL	08/10/09	456.79	139.23	2,970.54	905.42	3,007.18
H-12	CUL	09/22/09	456.83	139.24	2,970.50	905.41	3,007.13
H-12	CUL	10/20/09	456.74	139.21	2,970.59	905.44	3,007.23
H-12	CUL	11/09/09	456.81	139.24	2,970.52	905.41	3,007.16
H-12	CUL	12/08/09	456.59	139.17	2,970.74	905.48	3,007.40
H-15R	CUL	04/23/09	507.51	154.69	2,974.51	906.63	3,021.99
H-15R	CUL	05/20/09	507.46	154.67	2,974.56	906.65	3,022.04
H-15R	CUL	06/10/09	507.30	154.63	2,974.72	906.69	3,022.22
H-15R	CUL	07/15/09	507.34	154.64	2,974.68	906.68	3,022.18
H-15R	CUL	08/12/09	507.34	154.64	2,974.68	906.68	3,022.18
H-15R	CUL	09/23/09	507.32	154.63	2,974.70	906.69	3,022.20
H-15R	CUL	10/22/09	507.20	154.59	2,974.82	906.73	3,022.34
H-15R	CUL	11/10/09	507.42	154.66	2,974.60	906.66	3,022.09
H-15R	CUL	12/10/09	507.19	154.59	2,974.83	906.73	3,022.35
H-16	CUL	01/20/09	373.85	113.95	3,036.21	925.44	3,049.49
H-16	CUL	02/13/09	373.67	113.89	3,036.39	925.49	3,049.68
H-16	CUL	03/26/09	373.27	113.77	3,036.79	925.61	3,050.10
H-16	CUL	04/23/09	373.45	113.83	3,036.61	925.56	3,049.91
H-16	CUL	05/21/09	373.41	113.82	3,036.65	925.57	3,049.95
H-16	CUL	06/11/09	373.36	113.80	3,036.70	925.59	3,050.00
H-16	CUL	07/16/09	373.44	113.82	3,036.62	925.56	3,049.92
H-16	CUL	08/13/09	373.51	113.85	3,036.55	925.54	3,049.85
H-16	CUL	09/24/09	373.77	113.93	3,036.29	925.46	3,049.58
H-16	CUL	10/22/09	373.73	113.91	3,036.33	925.47	3,049.62
H-16	CUL	11/11/09	373.94	113.98	3,036.12	925.41	3,049.40
H-16	CUL	12/14/09	374.78	114.23	3,035.28	925.15	3,048.53
H-17	CUL	01/13/09	417.90	127.38	2,967.34	904.45	3,003.64
H-17	CUL	02/11/09	417.72	127.32	2,967.52	904.50	3,003.85
H-17	CUL	03/24/09	417.76	127.33	2,967.48	904.49	3,003.80
H-17	CUL	04/22/09	417.97	127.40	2,967.27	904.42	3,003.57
H-17	CUL	05/20/09	418.09	127.43	2,967.15	904.39	3,003.43
H-17	CUL	06/09/09	417.98	127.40	2,967.26	904.42	3,003.56
H-17	CUL	07/14/09	418.03	127.42	2,967.21	904.41	3,003.50
H-17	CUL	08/11/09	418.02	127.41	2,967.22	904.41	3,003.51
H-17	CUL	09/23/09	418.02	127.41	2,967.22	904.41	3,003.51
H-17	CUL	10/19/09	418.00	127.41	2,967.24	904.41	3,003.53
H-17	CUL	11/09/09	418.00	127.41	2,967.24	904.41	3,003.53
H-17	CUL	12/09/09	417.79	127.34	2,967.45	904.48	3,003.77
H-19b0	CUL	01/14/09	424.92	129.52	2,993.41	912.39	3,018.09
H-19b0	CUL	02/12/09	424.88	129.50	2,993.45	912.40	3,018.13
H-19b0	CUL	03/26/09	425.08	129.56	2,993.25	912.34	3,017.91

Appendix F – Groundwater Data Tables

Table F.9 – Water Levels							
Well Number	Zone	Date	Adjusted Depth Top of Casing (ft)	Adjusted Depth Meters	Water Level Elevation (ft amsl)	Elevation in Meters (amsl)	Adjusted Freshwater Head (ft amsl)
H-19b0	CUL	04/22/09	425.72	129.76	2,992.61	912.15	3,017.23
H-19b0	CUL	05/20/09	425.42	129.67	2,992.91	912.24	3,017.55
H-19b0	CUL	06/11/09	425.25	129.62	2,993.08	912.29	3,017.73
H-19b0	CUL	07/15/09	425.33	129.64	2,993.00	912.27	3,017.65
H-19b0	CUL	08/12/09	425.32	129.64	2,993.01	912.27	3,017.66
H-19b0	CUL	09/23/09	425.36	129.65	2,992.97	912.26	3,017.61
H-19b0	CUL	10/19/09	425.80	129.78	2,992.53	912.12	3,017.14
H-19b0	CUL	11/11/09	425.77	129.77	2,992.56	912.13	3,017.17
H-19b0	CUL	12/10/09	425.38	129.66	2,992.95	912.25	3,017.59
H-19b2	CUL	03/26/09	426.42	129.97	2,992.51	912.12	3,013.61
H-19b2	CUL	06/11/09	426.60	130.03	2,992.33	912.06	3,013.41
H-19b2	CUL	09/23/09	426.71	130.06	2,992.22	912.03	3,013.30
H-19b2	CUL	12/07/09	426.84	130.10	2,992.09	911.99	3,013.16
H-19b3	CUL	03/26/09	426.65	130.04	2,992.37	912.07	3,013.36
H-19b3	CUL	06/11/09	426.84	130.10	2,992.18	912.02	3,013.16
H-19b3	CUL	09/23/09	426.94	130.13	2,992.08	911.99	3,013.05
H-19b3	CUL	12/07/09	427.10	130.18	2,991.92	911.94	3,012.88
H-19b4	CUL	03/26/09	425.91	129.82	2,993.07	912.29	3,012.46
H-19b4	CUL	06/11/09	426.08	129.87	2,992.90	912.24	3,012.28
H-19b4	CUL	09/23/09	426.16	129.89	2,992.82	912.21	3,012.20
H-19b4	CUL	12/08/09	426.05	129.86	2,992.93	912.25	3,012.31
H-19b5	CUL	03/26/09	425.90	129.81	2,992.68	912.17	3,013.69
H-19b5	CUL	06/11/09	426.08	129.87	2,992.50	912.11	3,013.50
H-19b5	CUL	09/23/09	426.41	129.97	2,992.17	912.01	3,013.15
H-19b5	CUL	12/08/09	426.99	130.15	2,991.59	911.84	3,012.53
H-19b6	CUL	03/26/09	426.59	130.02	2,992.43	912.09	3,013.75
H-19b6	CUL	06/11/09	426.74	130.07	2,992.28	912.05	3,013.59
H-19b6	CUL	09/23/09	426.84	130.10	2,992.18	912.02	3,013.49
H-19b6	CUL	12/07/09	427.03	130.16	2,991.99	911.96	3,013.28
H-19b7	CUL	03/26/09	426.60	130.03	2,992.34	912.07	3,013.66
H-19b7	CUL	06/11/09	426.78	130.08	2,992.16	912.01	3,013.46
H-19b7	CUL	09/23/09	426.88	130.11	2,992.06	911.98	3,013.36
H-19b7	CUL	12/08/09	426.69	130.06	2,992.25	912.04	3,013.56
I-461	CUL	01/12/09	238.04	72.55	3,045.57	928.29	3,048.20
I-461	CUL	02/11/09	238.34	72.65	3,045.27	928.20	3,047.90
I-461	CUL	03/24/09	238.54	72.71	3,045.07	928.14	3,047.69
I-461	CUL	04/21/09	238.73	72.76	3,044.88	928.08	3,047.50
I-461	CUL	05/18/09	239.04	72.86	3,044.57	927.98	3,047.18
I-461	CUL	06/08/09	239.15	72.89	3,044.46	927.95	3,047.07
I-461	CUL	07/13/09	239.22	72.91	3,044.39	927.93	3,047.00
I-461	CUL	08/10/09	238.44	72.68	3,045.17	928.17	3,047.79
I-461	CUL	09/21/09	238.56	72.71	3,045.05	928.13	3,047.67
I-461	CUL	10/20/09	238.71	72.76	3,044.90	928.09	3,047.52
I-461	CUL	11/10/09	239.22	72.91	3,044.39	927.93	3,047.00
I-461	CUL	12/08/09	239.07	72.87	3,044.54	927.98	3,047.15
SNL-01	CUL	01/12/09	432.94	131.96	3,079.90	938.75	3,085.66

Appendix F – Groundwater Data Tables

Table F.9 – Water Levels							
Well Number	Zone	Date	Adjusted Depth Top of Casing (ft)	Adjusted Depth Meters	Water Level Elevation (ft amsl)	Elevation in Meters (amsl)	Adjusted Freshwater Head (ft amsl)
SNL-01	CUL	02/11/09	433.08	132.00	3,079.76	938.71	3,085.51
SNL-01	CUL	03/25/09	433.29	132.07	3,079.55	938.65	3,085.30
SNL-01	CUL	04/22/09	433.59	132.16	3,079.25	938.56	3,084.99
SNL-01	CUL	05/19/09	434.03	132.29	3,078.81	938.42	3,084.53
SNL-01	CUL	06/08/09	433.95	132.27	3,078.89	938.45	3,084.61
SNL-01	CUL	07/13/09	434.32	132.38	3,078.52	938.33	3,084.23
SNL-01	CUL	08/12/09	434.53	132.44	3,078.31	938.27	3,084.02
SNL-01	CUL	09/21/09	434.21	132.35	3,078.63	938.37	3,084.35
SNL-01	CUL	10/21/09	434.07	132.30	3,078.77	938.41	3,084.49
SNL-01	CUL	11/09/09	434.39	132.40	3,078.45	938.31	3,084.16
SNL-01	CUL	12/09/09	434.32	132.38	3,078.52	938.33	3,084.23
SNL-02	CUL	01/12/09	250.64	76.40	3,072.42	936.47	3,075.72
SNL-02	CUL	02/11/09	251.03	76.51	3,072.03	936.35	3,075.33
SNL-02	CUL	03/24/09	251.29	76.59	3,071.77	936.28	3,075.06
SNL-02	CUL	04/21/09	251.36	76.61	3,071.70	936.25	3,074.99
SNL-02	CUL	05/18/09	251.68	76.71	3,071.38	936.16	3,074.67
SNL-02	CUL	06/08/09	251.98	76.80	3,071.08	936.07	3,074.36
SNL-02	CUL	07/13/09	252.53	76.97	3,070.53	935.90	3,073.80
SNL-02	CUL	08/10/09	251.70	76.72	3,071.36	936.15	3,074.65
SNL-02	CUL	09/21/09	251.63	76.70	3,071.43	936.17	3,074.72
SNL-02	CUL	10/20/09	251.93	76.79	3,071.13	936.08	3,074.41
SNL-02	CUL	11/09/09	252.47	76.95	3,070.59	935.92	3,073.86
SNL-02	CUL	12/9/09	252.73	77.03	3,070.33	935.84	3,073.60
SNL-03	CUL	01/12/09	417.25	127.18	3,073.10	936.68	3,083.23
SNL-03	CUL	02/11/09	417.40	127.22	3,072.95	936.64	3,083.08
SNL-03	CUL	03/25/09	417.50	127.25	3,072.85	936.60	3,082.97
SNL-03	CUL	04/21/09	417.77	127.34	3,072.58	936.52	3,082.69
SNL-03	CUL	05/20/09	418.11	127.44	3,072.24	936.42	3,082.34
SNL-03	CUL	06/08/09	418.16	127.46	3,072.19	936.40	3,082.29
SNL-03	CUL	07/13/09	418.44	127.54	3,071.91	936.32	3,082.01
SNL-03	CUL	08/11/09	418.56	127.58	3,071.79	936.28	3,081.88
SNL-03	CUL	09/21/09	418.46	127.55	3,071.89	936.31	3,081.98
SNL-03	CUL	10/21/09	418.38	127.52	3,071.97	936.34	3,082.07
SNL-03	CUL	11/10/09	418.88	127.67	3,071.47	936.18	3,081.55
SNL-03	CUL	12/9/09	418.68	127.61	3,071.67	936.25	3,081.76
SNL-05	CUL	01/12/09	305.57	93.14	3,074.41	937.08	3,078.53
SNL-05	CUL	02/11/09	305.86	93.23	3,074.12	936.99	3,078.24
SNL-05	CUL	03/24/09	306.15	93.31	3,073.83	936.90	3,077.94
SNL-05	CUL	04/21/09	306.41	93.39	3,073.57	936.82	3,077.68
SNL-05	CUL	05/18/09	306.83	93.52	3,073.15	936.70	3,077.26
SNL-05	CUL	06/08/09	306.96	93.56	3,073.02	936.66	3,077.12
SNL-05	CUL	07/13/09	307.15	93.62	3,072.83	936.60	3,076.93
SNL-05	CUL	08/11/09	307.25	93.65	3,072.73	936.57	3,076.83
SNL-05	CUL	09/21/09	307.05	93.59	3,072.93	936.63	3,077.03
SNL-05	CUL	10/20/09	307.09	93.60	3,072.89	936.62	3,076.99
SNL-05	CUL	11/09/09	307.40	93.70	3,072.58	936.52	3,076.68

Appendix F – Groundwater Data Tables

Table F.9 – Water Levels							
Well Number	Zone	Date	Adjusted Depth Top of Casing (ft)	Adjusted Depth Meters	Water Level Elevation (ft amsl)	Elevation in Meters (amsl)	Adjusted Freshwater Head (ft amsl)
SNL-05	CUL	12/9/09	307.45	93.71	3,072.53	936.51	3,076.63
SNL-06	CUL	01/13/09	842.17	256.69	2,803.94	854.64	2,929.44
SNL-06	CUL	02/09/09	835.96	254.80	2,810.15	856.53	2,937.22
SNL-06	CUL	03/24/09	826.30	251.86	2,819.81	859.48	2,949.32
SNL-06	CUL	04/21/09	819.48	249.78	2,826.63	861.56	2,957.87
SNL-06	CUL	05/19/09	813.43	247.93	2,832.68	863.40	2,965.45
SNL-06	CUL	06/10/09	808.74	246.50	2,837.37	864.83	2,971.33
SNL-06	CUL	07/16/09	801.31	244.24	2,844.80	867.10	2,980.64
SNL-06	CUL	08/10/09	796.14	242.66	2,849.97	868.67	2,987.11
SNL-06	CUL	09/22/09	787.47	240.02	2,858.64	871.31	2,997.98
SNL-06	CUL	10/19/09	782.06	238.37	2,864.05	872.96	3,004.76
SNL-06	CUL	11/09/09	778.75	237.36	2,867.36	873.97	3,008.90
SNL-06	CUL	12/8/09	772.28	235.39	2,873.83	875.94	3,017.01
SNL-08	CUL	01/13/09	544.53	165.97	3,011.20	917.81	3,055.42
SNL-08	CUL	02/09/09	544.23	165.88	3,011.50	917.91	3,055.75
SNL-08	CUL	03/24/09	544.30	165.90	3,011.43	917.88	3,055.67
SNL-08	CUL	04/21/09	544.50	165.96	3,011.23	917.82	3,055.45
SNL-08	CUL	05/19/09	544.57	165.98	3,011.16	917.80	3,055.38
SNL-08	CUL	06/09/09	544.34	165.91	3,011.39	917.87	3,055.63
SNL-08	CUL	07/14/09	544.42	165.94	3,011.31	917.85	3,055.54
SNL-08	CUL	08/10/09	544.45	165.95	3,011.28	917.84	3,055.51
SNL-08	CUL	09/21/09	544.44	165.95	3,011.29	917.84	3,055.52
SNL-08	CUL	10/19/09	544.48	165.96	3,011.25	917.83	3,055.48
SNL-08	CUL	11/09/09	544.44	165.95	3,011.29	917.84	3,055.52
SNL-08	CUL	12/8/09	544.25	165.89	3,011.48	917.90	3,055.73
SNL-09	CUL	01/12/09	309.49	94.33	3,051.47	930.09	3,058.17
SNL-09	CUL	02/09/09	309.44	94.32	3,051.52	930.10	3,058.22
SNL-09	CUL	03/24/09	309.86	94.45	3,051.10	929.98	3,057.79
SNL-09	CUL	04/22/09	310.08	94.51	3,050.88	929.91	3,057.56
SNL-09	CUL	05/18/09	310.38	94.60	3,050.58	929.82	3,057.26
SNL-09	CUL	06/08/09	310.26	94.57	3,050.70	929.85	3,057.38
SNL-09	CUL	07/13/09	310.57	94.66	3,050.39	929.76	3,057.06
SNL-09	CUL	08/11/09	310.37	94.60	3,050.59	929.82	3,057.27
SNL-09	CUL	09/21/09	310.28	94.57	3,050.68	929.85	3,057.36
SNL-09	CUL	10/19/09	310.46	94.63	3,050.50	929.79	3,057.17
SNL-09	CUL	11/10/09	310.83	94.74	3,050.13	929.68	3,056.79
SNL-09	CUL	12/9/09	310.79	94.73	3,050.17	929.69	3,056.84
SNL-10	CUL	01/14/09	324.55	98.92	3,053.04	930.57	3,056.80
SNL-10	CUL	02/11/09	324.53	98.92	3,053.06	930.57	3,056.82
SNL-10	CUL	03/26/09	324.61	98.94	3,052.98	930.55	3,056.74
SNL-10	CUL	04/22/09	324.94	99.04	3,052.65	930.45	3,056.40
SNL-10	CUL	05/19/09	325.13	99.10	3,052.46	930.39	3,056.21
SNL-10	CUL	06/08/09	325.05	99.08	3,052.54	930.41	3,056.29
SNL-10	CUL	07/13/09	325.36	99.17	3,052.23	930.32	3,055.98
SNL-10	CUL	08/11/09	325.48	99.21	3,052.11	930.28	3,055.85
SNL-10	CUL	09/22/09	325.46	99.20	3,052.13	930.29	3,055.87

Appendix F – Groundwater Data Tables

Table F.9 – Water Levels							
Well Number	Zone	Date	Adjusted Depth Top of Casing (ft)	Adjusted Depth Meters	Water Level Elevation (ft amsl)	Elevation in Meters (amsl)	Adjusted Freshwater Head (ft amsl)
SNL-10	CUL	10/19/09	325.40	99.18	3,052.19	930.31	3,055.94
SNL-10	CUL	11/10/09	325.69	99.27	3,051.90	930.22	3,055.64
SNL-10	CUL	12/8/09	325.38	99.18	3,052.21	930.31	3,055.96
SNL-12	CUL	01/13/09	337.25	102.79	3,002.21	915.07	3,004.78
SNL-12	CUL	02/10/09	337.20	102.78	3,002.26	915.09	3,004.83
SNL-12	CUL	03/25/09	337.52	102.88	3,001.94	914.99	3,004.51
SNL-12	CUL	04/21/09	337.81	102.96	3,001.65	914.90	3,004.21
SNL-12	CUL	05/18/09	337.97	103.01	3,001.49	914.85	3,004.05
SNL-12	CUL	06/09/09	337.80	102.96	3,001.66	914.91	3,004.22
SNL-12	CUL	07/14/09	337.70	102.93	3,001.76	914.94	3,004.32
SNL-12	CUL	08/10/09	337.68	102.92	3,001.78	914.94	3,004.34
SNL-12	CUL	09/22/09	337.78	102.96	3,001.68	914.91	3,004.24
SNL-12	CUL	10/20/09	337.55	102.89	3,001.91	914.98	3,004.48
SNL-12	CUL	11/10/09	338.03	103.03	3,001.43	914.84	3,003.99
SNL-12	CUL	12/8/09	337.22	102.78	3,002.24	915.08	3,004.81
SNL-13	CUL	01/13/09	284.84	86.82	3,009.38	917.26	3,012.64
SNL-13	CUL	02/11/09	284.70	86.78	3,009.52	917.30	3,012.78
SNL-13	CUL	03/24/09	284.56	86.73	3,009.66	917.34	3,012.92
SNL-13	CUL	04/21/09	284.71	86.78	3,009.51	917.30	3,012.77
SNL-13	CUL	05/19/09	284.88	86.83	3,009.34	917.25	3,012.59
SNL-13	CUL	06/08/09	284.73	86.79	3,009.49	917.29	3,012.75
SNL-13	CUL	07/14/09	284.89	86.83	3,009.33	917.24	3,012.58
SNL-13	CUL	08/12/09	285.06	86.89	3,009.16	917.19	3,012.41
SNL-13	CUL	09/23/09	285.21	86.93	3,009.01	917.15	3,012.26
SNL-13	CUL	10/20/09	284.97	86.86	3,009.25	917.22	3,012.50
SNL-13	CUL	11/10/09	285.36	86.98	3,008.86	917.10	3,012.10
SNL-13	CUL	12/9/09	285.08	86.89	3,009.14	917.19	3,012.39
SNL-14	CUL	01/13/09	376.40	114.73	2,992.01	911.96	3,006.08
SNL-14	CUL	02/11/09	376.50	114.76	2,991.91	911.93	3,005.97
SNL-14	CUL	03/24/09	376.49	114.75	2,991.92	911.94	3,005.98
SNL-14	CUL	04/21/09	376.79	114.85	2,991.62	911.85	3,005.67
SNL-14	CUL	05/20/09	376.94	114.89	2,991.47	911.80	3,005.51
SNL-14	CUL	06/09/09	376.90	114.88	2,991.51	911.81	3,005.56
SNL-14	CUL	07/14/09	376.72	114.82	2,991.69	911.87	3,005.74
SNL-14	CUL	08/11/09	376.79	114.85	2,991.62	911.85	3,005.67
SNL-14	CUL	09/23/09	376.83	114.86	2,991.58	911.83	3,005.63
SNL-14	CUL	10/19/09	376.76	114.84	2,991.65	911.85	3,005.70
SNL-14	CUL	11/09/09	376.97	114.90	2,991.44	911.79	3,005.48
SNL-14	CUL	12/09/09	376.63	114.80	2,991.78	911.89	3,005.84
SNL-15	CUL	01/13/09	625.15	190.55	2,854.78	870.14	2,923.84
SNL-15	CUL	02/09/09	622.99	189.89	2,856.94	870.80	2,926.50
SNL-15	CUL	03/25/09	619.51	188.83	2,860.42	871.86	2,930.79
SNL-15	CUL	04/21/09	617.48	188.21	2,862.45	872.47	2,933.29
SNL-15	CUL	05/19/09	615.39	187.57	2,864.54	873.11	2,935.87
SNL-15	CUL	06/09/09	613.87	187.11	2,866.06	873.58	2,937.74
SNL-15	CUL	07/15/09	611.39	186.35	2,868.54	874.33	2,940.79

Appendix F – Groundwater Data Tables

Table F.9 – Water Levels							
Well Number	Zone	Date	Adjusted Depth Top of Casing (ft)	Adjusted Depth Meters	Water Level Elevation (ft amsl)	Elevation in Meters (amsl)	Adjusted Freshwater Head (ft amsl)
SNL-15	CUL	08/11/09	609.43	185.75	2,870.50	874.93	2,943.21
SNL-15	CUL	09/23/09	606.42	184.84	2,873.51	875.85	2,946.92
SNL-15	CUL	10/19/09	604.75	184.33	2,875.18	876.35	2,948.97
SNL-15	CUL	11/09/09	604.24	184.17	2,875.69	876.51	2,949.60
SNL-15	CUL	12/08/09	601.36	183.29	2,878.57	877.39	2,953.15
SNL-16	CUL	01/14/09	123.40	37.61	3,009.60	917.33	3,011.51
SNL-16	CUL	02/10/09	123.31	37.58	3,009.69	917.35	3,011.60
SNL-16	CUL	03/24/09	123.65	37.69	3,009.35	917.25	3,011.25
SNL-16	CUL	04/21/09	123.77	37.73	3,009.23	917.21	3,011.13
SNL-16	CUL	05/18/09	124.11	37.83	3,008.89	917.11	3,010.78
SNL-16	CUL	06/08/09	124.06	37.81	3,008.94	917.12	3,010.83
SNL-16	CUL	07/13/09	124.09	37.82	3,008.91	917.12	3,010.80
SNL-16	CUL	08/11/09	123.75	37.72	3,009.25	917.22	3,011.15
SNL-16	CUL	09/22/09	124.08	37.82	3,008.92	917.12	3,010.81
SNL-16	CUL	10/19/09	123.91	37.77	3,009.09	917.17	3,010.98
SNL-16	CUL	11/10/09	124.27	37.88	3,008.73	917.06	3,010.62
SNL-16	CUL	12/08/09	123.56	37.66	3,009.44	917.28	3,011.34
SNL-17	CUL	01/14/09	231.55	70.58	3,006.51	916.38	3,007.34
SNL-17	CUL	02/10/09	231.45	70.55	3,006.61	916.41	3,007.44
SNL-17	CUL	03/24/09	231.74	70.63	3,006.32	916.33	3,007.14
SNL-17	CUL	04/21/09	231.85	70.67	3,006.21	916.29	3,007.03
SNL-17	CUL	05/18/09	232.04	70.73	3,006.02	916.23	3,006.84
SNL-17	CUL	06/09/09	232.01	70.72	3,006.05	916.24	3,006.87
SNL-17	CUL	07/14/09	232.05	70.73	3,006.01	916.23	3,006.83
SNL-17	CUL	08/10/09	232.13	70.75	3,005.93	916.21	3,006.75
SNL-17	CUL	09/22/09	232.33	70.81	3,005.73	916.15	3,006.55
SNL-17	CUL	10/20/09	232.10	70.74	3,005.96	916.22	3,006.78
SNL-17	CUL	11/10/09	232.50	70.87	3,005.56	916.09	3,006.38
SNL-17	CUL	12/08/09	231.89	70.68	3,006.17	916.28	3,006.99
SNL-18	CUL	01/12/09	299.70	91.35	3,075.74	937.49	3,078.76
SNL-18	CUL	02/11/09	299.99	91.44	3,075.45	937.40	3,078.47
SNL-18	CUL	03/25/09	300.30	91.53	3,075.14	937.30	3,078.15
SNL-18	CUL	04/22/09	300.57	91.61	3,074.87	937.22	3,077.63
SNL-18	CUL	05/19/09	301.01	91.75	3,074.43	937.09	3,077.18
SNL-18	CUL	06/08/09	301.03	91.75	3,074.41	937.08	3,077.16
SNL-18	CUL	07/13/09	301.17	91.80	3,074.27	937.04	3,077.02
SNL-18	CUL	08/12/09	301.25	91.82	3,074.19	937.01	3,076.94
SNL-18	CUL	09/21/09	301.00	91.74	3,074.44	937.09	3,077.19
SNL-18	CUL	10/20/09	301.03	91.75	3,074.41	937.08	3,077.16
SNL-18	CUL	11/09/09	301.27	91.83	3,074.17	937.01	3,076.92
SNL-18	CUL	12/09/09	301.31	91.84	3,074.13	936.99	3,076.88
SNL-19	CUL	01/12/09	149.56	45.59	3,073.09	936.68	3,074.73
SNL-19	CUL	02/11/09	149.89	45.69	3,072.76	936.58	3,074.40
SNL-19	CUL	03/24/09	150.23	45.79	3,072.42	936.47	3,074.06
SNL-19	CUL	04/21/09	150.35	45.83	3,072.30	936.44	3,073.94
SNL-19	CUL	05/18/09	150.67	45.92	3,071.98	936.34	3,073.62

Appendix F – Groundwater Data Tables

Table F.9 – Water Levels							
Well Number	Zone	Date	Adjusted Depth Top of Casing (ft)	Adjusted Depth Meters	Water Level Elevation (ft amsl)	Elevation in Meters (amsl)	Adjusted Freshwater Head (ft amsl)
SNL-19	CUL	06/08/09	150.98	46.02	3,071.67	936.25	3,073.30
SNL-19	CUL	07/13/09	151.29	46.11	3,071.36	936.15	3,072.99
SNL-19	CUL	08/10/09	150.58	45.90	3,072.07	936.37	3,073.71
SNL-19	CUL	09/21/09	150.51	45.88	3,072.14	936.39	3,073.78
SNL-19	CUL	10/20/09	150.83	45.97	3,071.82	936.29	3,073.45
SNL-19	CUL	11/09/09	151.24	46.10	3,071.41	936.17	3,073.04
SNL-19	CUL	12/09/09	151.48	46.17	3,071.17	936.09	3,072.80
WIPP-11	CUL	01/12/09	361.91	110.31	3,065.87	934.48	3,083.23
WIPP-11	CUL	02/11/09	362.07	110.36	3,065.71	934.43	3,083.06
WIPP-11	CUL	03/24/09	362.26	110.42	3,065.52	934.37	3,082.86
WIPP-11	CUL	04/21/09	362.40	110.46	3,065.38	934.33	3,082.72
WIPP-11	CUL	05/18/09	362.87	110.60	3,064.91	934.18	3,082.23
WIPP-11	CUL	06/10/09	362.80	110.58	3,064.98	934.21	3,082.30
WIPP-11	CUL	07/13/09	363.14	110.69	3,064.64	934.10	3,081.95
WIPP-11	CUL	08/11/09	363.30	110.73	3,064.48	934.05	3,081.79
WIPP-11	CUL	09/21/09	363.11	110.68	3,064.67	934.11	3,081.98
WIPP-11	CUL	10/21/09	363.09	110.67	3,064.69	934.12	3,082.00
WIPP-11	CUL	11/09/09	363.43	110.77	3,064.35	934.01	3,081.65
WIPP-11	CUL	12/09/09	363.37	110.76	3,064.41	934.03	3,081.71
WIPP-13	CUL	01/20/09	343.92	104.83	3,061.75	933.22	3,082.18
WIPP-13	CUL	02/11/09	343.85	104.81	3,061.82	933.24	3,082.25
WIPP-13	CUL	03/26/09	343.82	104.80	3,061.85	933.25	3,082.29
WIPP-13	CUL	04/22/09	344.25	104.93	3,061.42	933.12	3,081.83
WIPP-13	CUL	05/19/09	344.71	105.07	3,060.96	932.98	3,081.35
WIPP-13	CUL	06/10/09	344.66	105.05	3,061.01	933.00	3,081.40
WIPP-13	CUL	07/16/09	344.94	105.14	3,060.73	932.91	3,081.10
WIPP-13	CUL	08/11/09	344.80	105.10	3,060.87	932.95	3,081.25
WIPP-13	CUL	09/21/09	344.65	105.05	3,061.02	933.00	3,081.41
WIPP-13	CUL	10/21/09	344.52	105.01	3,061.15	933.04	3,081.55
WIPP-13	CUL	11/11/09	345.04	105.17	3,060.63	932.88	3,081.00
WIPP-13	CUL	12/10/09	344.83	105.10	3,060.84	932.94	3,081.22
WIPP-19	CUL	01/14/09	388.91	118.54	3,046.20	928.48	3,063.35
WIPP-19	CUL	02/12/09	388.90	118.54	3,046.21	928.48	3,063.36
WIPP-19	CUL	03/26/09	388.83	118.52	3,046.28	928.51	3,063.44
WIPP-19	CUL	04/23/09	389.07	118.59	3,046.04	928.43	3,063.57
WIPP-19	CUL	05/20/09	389.45	118.70	3,045.66	928.32	3,063.17
WIPP-19	CUL	06/09/09	389.38	118.68	3,045.73	928.34	3,063.24
WIPP-19	CUL	07/15/09	389.58	118.74	3,045.53	928.28	3,063.03
WIPP-19	CUL	08/12/09	389.80	118.81	3,045.31	928.21	3,062.80
WIPP-19	CUL	09/21/09	389.65	118.77	3,045.46	928.26	3,062.96
WIPP-19	CUL	10/22/09	389.78	118.80	3,045.33	928.22	3,062.83
WIPP-19	CUL	11/11/09	390.10	118.90	3,045.01	928.12	3,062.49
WIPP-19	CUL	12/10/09	389.99	118.87	3,045.12	928.15	3,062.61
WIPP-25 (PIP)	CUL	01/12/09	147.69	45.02	3,066.55	934.68	3,069.69
WIPP-25 (PIP)	CUL	02/11/09	148.02	45.12	3,066.22	934.58	3,069.36
WIPP-25 (PIP)	CUL	03/24/09	148.25	45.19	3,065.99	934.51	3,069.13

Appendix F – Groundwater Data Tables

Table F.9 – Water Levels							
Well Number	Zone	Date	Adjusted Depth Top of Casing (ft)	Adjusted Depth Meters	Water Level Elevation (ft amsl)	Elevation in Meters (amsl)	Adjusted Freshwater Head (ft amsl)
WIPP-25 (PIP)	CUL	04/21/09	148.43	45.24	3,065.81	934.46	3,068.95
WIPP-25 (PIP)	CUL	05/18/09	148.70	45.32	3,065.54	934.38	3,068.67
WIPP-25 (PIP)	CUL	06/11/09	148.85	45.37	3,065.39	934.33	3,068.52
WQSP-1	CUL	01/20/09	358.43	109.25	3,060.82	932.94	3,077.87
WQSP-1	CUL	02/12/09	358.30	109.21	3,060.95	932.98	3,078.01
WQSP-1	CUL	03/26/09	358.30	109.21	3,060.95	932.98	3,078.01
WQSP-1	CUL	04/23/09	358.70	109.33	3,060.55	932.86	3,077.59
WQSP-1	CUL	05/18/09	359.20	109.48	3,060.05	932.70	3,077.06
WQSP-1	CUL	06/10/09	359.10	109.45	3,060.15	932.73	3,077.17
WQSP-1	CUL	07/16/09	359.51	109.58	3,059.74	932.61	3,076.74
WQSP-1	CUL	08/12/09	359.51	109.58	3,059.74	932.61	3,076.74
WQSP-1	CUL	09/21/09	359.31	109.52	3,059.94	932.67	3,076.95
WQSP-1	CUL	10/22/09	359.50	109.58	3,059.75	932.61	3,076.75
WQSP-1	CUL	11/10/09	359.96	109.72	3,059.29	932.47	3,076.27
WQSP-1	CUL	12/16/09	359.92	109.70	3,059.33	932.48	3,076.31
WQSP-2	CUL	01/14/09	397.84	121.26	3,066.03	934.53	3,086.54
WQSP-2	CUL	02/12/09	397.93	121.29	3,065.94	934.50	3,086.44
WQSP-2	CUL	03/26/09	397.95	121.30	3,065.92	934.49	3,086.42
WQSP-2	CUL	04/23/09	398.34	121.41	3,065.53	934.37	3,086.01
WQSP-2	CUL	05/20/09	398.74	121.54	3,065.13	934.25	3,085.59
WQSP-2	CUL	06/10/09	398.76	121.54	3,065.11	934.25	3,085.57
WQSP-2	CUL	07/15/09	399.00	121.62	3,064.87	934.17	3,085.32
WQSP-2	CUL	08/12/09	399.20	121.68	3,064.67	934.11	3,085.11
WQSP-2	CUL	09/21/09	399.01	121.62	3,064.86	934.17	3,085.31
WQSP-2	CUL	10/21/09	398.97	121.61	3,064.90	934.18	3,085.35
WQSP-2	CUL	11/11/09	399.54	121.78	3,064.33	934.01	3,084.76
WQSP-2	CUL	12/10/09	399.42	121.74	3,064.45	934.04	3,084.88
WQSP-3	CUL	01/14/09	462.61	141.00	3,017.53	919.74	3,074.73
WQSP-3	CUL	02/12/09	462.47	140.96	3,017.67	919.79	3,074.89
WQSP-3	CUL	03/26/09	462.26	140.90	3,017.88	919.85	3,075.13
WQSP-3	CUL	04/23/09	462.43	140.95	3,017.71	919.80	3,074.94
WQSP-3	CUL	05/20/09	464.04	141.44	3,016.10	919.31	3,073.10
WQSP-3	CUL	06/09/09	463.43	141.25	3,016.71	919.49	3,073.79
WQSP-3	CUL	07/15/09	463.39	141.24	3,016.75	919.51	3,073.84
WQSP-3	CUL	08/12/09	463.46	141.26	3,016.68	919.48	3,073.76
WQSP-3	CUL	09/21/09	463.31	141.22	3,016.83	919.53	3,073.93
WQSP-3	CUL	10/21/09	466.32	142.13	3,013.82	918.61	3,070.49
WQSP-3	CUL	11/11/09	464.56	141.60	3,015.58	919.15	3,072.50
WQSP-3	CUL	12/10/09	463.94	141.41	3,016.20	919.34	3,073.21
WQSP-4	CUL	01/14/09	442.20	134.78	2,990.89	911.62	3,015.95
WQSP-4	CUL	02/12/09	442.17	134.77	2,990.92	911.63	3,015.99
WQSP-4	CUL	03/26/09	442.35	134.83	2,990.74	911.58	3,015.79
WQSP-4	CUL	04/22/09	442.97	135.02	2,990.12	911.39	3,015.13
WQSP-4	CUL	05/20/09	442.62	134.91	2,990.47	911.50	3,015.50
WQSP-4	CUL	06/10/09	442.55	134.89	2,990.54	911.52	3,015.58
WQSP-4	CUL	07/15/09	442.56	134.89	2,990.53	911.51	3,015.57

Appendix F – Groundwater Data Tables

Table F.9 – Water Levels							
Well Number	Zone	Date	Adjusted Depth Top of Casing (ft)	Adjusted Depth Meters	Water Level Elevation (ft amsl)	Elevation in Meters (amsl)	Adjusted Freshwater Head (ft amsl)
WQSP-4	CUL	08/12/09	442.57	134.90	2,990.52	911.51	3,015.56
WQSP-4	CUL	09/23/09	442.60	134.90	2,990.49	911.50	3,015.52
WQSP-4	CUL	10/21/09	442.82	134.97	2,990.27	911.43	3,015.29
WQSP-4	CUL	11/11/09	443.03	135.04	2,990.06	911.37	3,015.06
WQSP-4	CUL	12/10/09	442.63	134.91	2,990.46	911.49	3,015.49
WQSP-5	CUL	01/14/09	377.64	115.10	3,006.74	916.45	3,013.77
WQSP-5	CUL	02/11/09	377.62	115.10	3,006.76	916.46	3,013.79
WQSP-5	CUL	03/26/09	378.48	115.36	3,005.90	916.20	3,012.91
WQSP-5	CUL	04/22/09	378.25	115.29	3,006.13	916.27	3,013.14
WQSP-5	CUL	05/20/09	378.10	115.24	3,006.28	916.31	3,013.29
WQSP-5	CUL	06/10/09	377.94	115.20	3,006.44	916.36	3,013.46
WQSP-5	CUL	07/15/09	377.95	115.20	3,006.43	916.36	3,013.45
WQSP-5	CUL	08/12/09	377.99	115.21	3,006.39	916.35	3,013.41
WQSP-5	CUL	09/22/09	377.98	115.21	3,006.40	916.35	3,013.42
WQSP-5	CUL	10/21/09	378.41	115.34	3,005.97	916.22	3,012.98
WQSP-5	CUL	11/11/09	378.56	115.39	3,005.82	916.17	3,012.82
WQSP-5	CUL	12/10/09	378.14	115.26	3,006.24	916.30	3,013.25
WQSP-6	CUL	01/14/09	342.70	104.45	3,022.02	921.11	3,025.84
WQSP-6	CUL	02/11/09	342.65	104.44	3,022.07	921.13	3,025.89
WQSP-6	CUL	03/26/09	343.76	104.78	3,020.96	920.79	3,024.76
WQSP-6	CUL	04/22/09	343.20	104.61	3,021.52	920.96	3,025.33
WQSP-6	CUL	05/20/09	343.13	104.59	3,021.59	920.98	3,025.40
WQSP-6	CUL	06/10/09	342.92	104.52	3,021.80	921.04	3,025.61
WQSP-6	CUL	07/14/09	342.96	104.53	3,021.76	921.03	3,025.57
WQSP-6	CUL	08/12/09	343.02	104.55	3,021.70	921.01	3,025.51
WQSP-6	CUL	09/22/09	346.01	105.46	3,018.71	920.10	3,022.48
WQSP-6	CUL	10/19/09	343.50	104.70	3,021.22	920.87	3,025.02
WQSP-6	CUL	11/11/09	343.53	104.71	3,021.19	920.86	3,024.99
WQSP-6	CUL	12/10/09	343.21	104.61	3,021.51	920.96	3,025.32
C-2737 (ANNULUS)	MAG	01/20/09	256.83	78.28	3,143.93	958.27	
C-2737 (ANNULUS)	MAG	02/12/09	256.68	78.24	3,144.08	958.32	
C-2737 (ANNULUS)	MAG	03/26/09	256.47	78.17	3,144.29	958.38	
C-2737 (ANNULUS)	MAG	04/23/09	256.79	78.27	3,143.97	958.28	
C-2737 (ANNULUS)	MAG	05/21/09	256.92	78.31	3,143.84	958.24	
C-2737 (ANNULUS)	MAG	06/11/09	257.01	78.34	3,143.75	958.22	
C-2737 (ANNULUS)	MAG	07/16/09	257.34	78.44	3,143.42	958.11	
C-2737 (ANNULUS)	MAG	08/13/09	258.38	78.75	3,142.38	957.80	
C-2737 (ANNULUS)	MAG	09/23/09	258.30	78.73	3,142.46	957.82	
C-2737 (ANNULUS)	MAG	10/22/09	257.83	78.59	3,142.93	957.97	
C-2737 (ANNULUS)	MAG	11/11/09	257.94	78.62	3,142.82	957.93	
C-2737 (ANNULUS)	MAG	12/10/09	257.53	78.50	3,143.23	958.06	
H-02b1	MAG	01/20/09	235.05	71.64	3,143.44	958.12	
H-02b1	MAG	02/12/09	235.03	71.64	3,143.46	958.13	
H-02b1	MAG	03/26/09	234.97	71.62	3,143.52	958.14	
H-02b1	MAG	04/23/09	234.22	71.39	3,144.27	958.37	
H-02b1	MAG	05/21/09	234.43	71.45	3,144.06	958.31	

Appendix F – Groundwater Data Tables

Table F.9 – Water Levels							
Well Number	**Zone**	**Date**	**Adjusted Depth Top of Casing (ft)**	**Adjusted Depth Meters**	**Water Level Elevation (ft amsl)**	**Elevation in Meters (amsl)**	**Adjusted Freshwater Head (ft amsl)**
H-02b1	MAG	06/10/09	234.50	71.48	3,143.99	958.29	
H-02b1	MAG	07/15/09	234.60	71.51	3,143.89	958.26	
H-02b1	MAG	08/13/09	234.70	71.54	3,143.79	958.23	
H-02b1	MAG	09/23/09	234.72	71.54	3,143.77	958.22	
H-02b1	MAG	10/20/09	234.79	71.56	3,143.70	958.20	
H-02b1	MAG	11/11/09	234.68	71.53	3,143.81	958.23	
H-02b1	MAG	12/10/09	234.66	71.52	3,143.83	958.24	
H-03b1	MAG	01/20/09	244.32	74.47	3,146.40	959.02	
H-03b1	MAG	02/12/09	244.07	74.39	3,146.65	959.10	
H-03b1	MAG	03/26/09	244.00	74.37	3,146.72	959.12	
H-03b1	MAG	11/10/09	248.71	75.81	3,142.01	957.68	
H-03b1	MAG	12/10/09	245.74	74.90	3,144.98	958.59	
H-04c	MAG	01/14/09	186.86	56.95	3,147.42	959.33	
H-04c	MAG	02/11/09	186.76	56.92	3,147.52	959.36	
H-04c	MAG	03/26/09	186.67	56.90	3,147.61	959.39	
H-04c	MAG	04/22/09	186.75	56.92	3,147.53	959.37	
H-04c	MAG	05/19/09	186.75	56.92	3,147.53	959.37	
H-04c	MAG	06/09/09	186.65	56.89	3,147.63	959.40	
H-04c	MAG	07/14/09	186.22	56.76	3,148.06	959.53	
H-04c	MAG	08/11/09	185.35	56.49	3,148.93	959.79	
H-04c	MAG	09/22/09	186.32	56.79	3,147.96	959.50	
H-04c	MAG	10/19/09	186.48	56.84	3,147.80	959.45	
H-04c	MAG	11/10/09	186.44	56.83	3,147.84	959.46	
H-04c	MAG	12/09/09	186.36	56.80	3,147.92	959.49	
H-06c	MAG	01/14/09	279.00	85.04	3,069.69	935.64	
H-06c	MAG	02/09/09	278.75	84.96	3,069.94	935.72	
H-06c	MAG	03/24/09	278.66	84.94	3,070.03	935.75	
H-06c	MAG	04/22/09	278.69	84.94	3,070.00	935.74	
H-06c	MAG	05/19/09	278.75	84.96	3,069.94	935.72	
H-06c	MAG	06/08/09	278.55	84.90	3,070.14	935.78	
H-06c	MAG	07/13/09	278.60	84.92	3,070.09	935.76	
H-06c	MAG	08/11/09	278.56	84.91	3,070.13	935.78	
H-06c	MAG	09/21/09	278.42	84.86	3,070.27	935.82	
H-06c	MAG	10/19/09	278.49	84.88	3,070.20	935.80	
H-08a	MAG	01/14/09	405.95	123.73	3,027.33	922.73	
H-08a	MAG	02/10/09	405.96	123.74	3,027.32	922.73	
H-08a	MAG	03/25/09	405.96	123.74	3,027.32	922.73	
H-08a	MAG	04/21/09	405.89	123.72	3,027.39	922.75	
H-08a	MAG	05/18/09	405.90	123.72	3,027.38	922.75	
H-08a	MAG	06/09/09	405.88	123.71	3,027.40	922.75	
H-08a	MAG	07/14/09	405.92	123.72	3,027.36	922.74	
H-08a	MAG	08/10/09	405.89	123.72	3,027.39	922.75	
H-08a	MAG	09/22/09	405.90	123.72	3,027.38	922.75	
H-08a	MAG	10/20/09	405.80	123.69	3,027.48	922.78	
H-09c (ANNULUS)	MAG	01/13/09	269.15	82.04	3,137.90	956.43	
H-09c (ANNULUS)	MAG	02/10/09	268.77	81.92	3,138.28	956.55	

Appendix F – Groundwater Data Tables

Table F.9 – Water Levels							
Well Number	**Zone**	**Date**	**Adjusted Depth Top of Casing (ft)**	**Adjusted Depth Meters**	**Water Level Elevation (ft amsl)**	**Elevation in Meters (amsl)**	**Adjusted Freshwater Head (ft amsl)**
H-09c (ANNULUS)	MAG	03/25/09	268.83	81.94	3,138.22	956.53	
H-09c (ANNULUS)	MAG	04/21/09	268.99	81.99	3,138.06	956.48	
H-09c (ANNULUS)	MAG	05/18/09	269.06	82.01	3,137.99	956.46	
H-09c (ANNULUS)	MAG	06/09/09	268.84	81.94	3,138.21	956.53	
H-09c (ANNULUS)	MAG	07/14/09	268.83	81.94	3,138.22	956.53	
H-09c (ANNULUS)	MAG	08/10/09	268.82	81.94	3,138.23	956.53	
H-09c (ANNULUS)	MAG	09/22/09	268.84	81.94	3,138.21	956.53	
H-09c (ANNULUS)	MAG	10/20/09	268.59	81.87	3,138.46	956.60	
H-09c (ANNULUS)	MAG	11/10/09	268.79	81.93	3,138.26	956.54	
H-09c (ANNULUS)	MAG	12/08/09	268.33	81.79	3,138.72	956.68	
H-10a	MAG	01/13/09	466.14	142.08	3,222.31	982.16	
H-10a	MAG	02/09/09	466.19	142.09	3,222.26	982.14	
H-10a	MAG	03/25/09	466.22	142.10	3,222.23	982.14	
H-10a	MAG	04/21/09	466.28	142.12	3,222.17	982.12	
H-10a	MAG	05/19/09	466.35	142.14	3,222.10	982.10	
H-10a	MAG	06/09/09	466.40	142.16	3,222.05	982.08	
H-10a	MAG	07/14/09	466.54	142.20	3,221.91	982.04	
H-10a	MAG	08/10/09	466.59	142.22	3,221.86	982.02	
H-10a	MAG	09/22/09	466.75	142.27	3,221.70	981.97	
H-10a	MAG	10/20/09	466.81	142.28	3,221.64	981.96	
H-10a	MAG	11/09/09	466.83	142.29	3,221.62	981.95	
H-10a	MAG	12/08/09	466.84	142.29	3,221.61	981.95	
H-11b2	MAG	01/13/09	273.86	83.47	3,138.00	956.46	
H-11b2	MAG	02/11/09	273.60	83.39	3,138.26	956.54	
H-11b2	MAG	03/25/09	273.45	83.35	3,138.41	956.59	
H-11b2	MAG	04/22/09	273.51	83.37	3,138.35	956.57	
H-11b2	MAG	05/20/09	273.49	83.36	3,138.37	956.58	
H-11b2	MAG	06/09/09	273.35	83.32	3,138.51	956.62	
H-11b2	MAG	07/14/09	273.34	83.31	3,138.52	956.62	
H-11b2	MAG	08/11/09	273.32	83.31	3,138.54	956.63	
H-11b2	MAG	09/23/09	273.35	83.32	3,138.51	956.62	
H-11b2	MAG	10/19/09	273.32	83.31	3,138.54	956.63	
H-11b2	MAG	11/09/09	273.25	83.29	3,138.61	956.65	
H-11b2	MAG	12/09/09	273.10	83.24	3,138.76	956.69	
H-14	MAG	08/11/09	277.67	84.63	3,069.41	935.56	
H-14	MAG	09/22/09	260.39	79.37	3,086.69	940.82	
H-14	MAG	10/20/09	252.35	76.92	3,094.73	943.27	
H-14	MAG	11/11/09	246.92	75.26	3,100.16	944.93	
H-14	MAG	12/10/09	240.89	73.42	3,106.19	946.77	
H-15	MAG	01/14/09	356.35	108.62	3,127.15	953.16	
H-15	MAG	02/12/09	355.78	108.44	3,127.72	953.33	
H-15	MAG	03/26/09	354.90	108.17	3,128.60	953.60	
H-15	MAG	04/23/09	354.56	108.07	3,129.88	953.99	
H-15	MAG	05/20/09	354.27	107.98	3,129.23	953.79	
H-15	MAG	06/10/09	353.97	107.89	3,129.53	953.88	
H-15	MAG	07/16/09	353.66	107.80	3,129.84	953.98	

Appendix F – Groundwater Data Tables

Table F.9 – Water Levels							
Well Number	Zone	Date	Adjusted Depth Top of Casing (ft)	Adjusted Depth Meters	Water Level Elevation (ft amsl)	Elevation in Meters (amsl)	Adjusted Freshwater Head (ft amsl)
H-15	MAG	08/12/09	353.43	107.73	3,130.07	954.05	
H-15	MAG	09/23/09	352.98	107.59	3,130.52	954.18	
H-15	MAG	10/22/09	352.58	107.47	3,130.92	954.30	
H-15	MAG	11/10/09	352.38	107.41	3,131.12	954.37	
H-15	MAG	12/10/09	351.77	107.22	3,131.73	954.55	
H-18	MAG	01/20/09	263.82	80.41	3,150.39	960.24	
H-18	MAG	02/09/09	263.36	80.27	3,150.85	960.38	
H-18	MAG	07/14/09	269.27	82.07	3,144.94	958.58	
H-18	MAG	08/11/09	267.62	81.57	3,146.59	959.08	
H-18	MAG	09/23/09	266.13	81.12	3,148.08	959.53	
H-18	MAG	10/22/09	265.14	80.81	3,149.07	959.84	
H-18	MAG	11/10/09	265.07	80.79	3,149.14	959.86	
H-18	MAG	12/10/09	264.33	80.57	3,149.88	960.08	
WIPP-18	MAG	01/14/09	307.84	93.83	3,149.73	960.04	
WIPP-18	MAG	02/12/09	307.74	93.80	3,149.83	960.07	
WIPP-18	MAG	03/26/09	307.64	93.77	3,149.93	960.10	
WIPP-18	MAG	04/23/09	307.70	93.79	3,149.87	960.08	
WIPP-18	MAG	05/20/09	307.76	93.81	3,149.81	960.06	
WIPP-18	MAG	06/09/09	307.65	93.77	3,149.92	960.10	
WIPP-25 (ANNULUS)	MAG	01/12/09	147.86	45.07	3,066.38	934.63	
WIPP-25 (ANNULUS)	MAG	02/11/09	148.17	45.16	3,066.07	934.54	
WIPP-25 (ANNULUS)	MAG	03/24/09	148.42	45.24	3,065.82	934.46	
WIPP-25 (ANNULUS)	MAG	04/21/09	148.61	45.30	3,065.63	934.40	
WIPP-25 (ANNULUS)	MAG	05/18/09	148.86	45.37	3,065.38	934.33	
WIPP-25 (ANNULUS)	MAG	06/11/09	149.02	45.42	3,065.22	934.28	
WQSP-6A	DL	01/14/09	167.03	50.91	3,196.77	974.38	
WQSP-6A	DL	02/11/09	167.07	50.92	3,196.73	974.36	
WQSP-6A	DL	07/14/09	166.97	50.89	3,196.83	974.39	
WQSP-6A	DL	08/12/09	167.13	50.94	3,196.92	974.42	
WQSP-6A	DL	09/22/09	167.23	50.97	3,196.82	974.39	
WQSP-6A	DL	10/19/09	166.99	50.90	3,197.06	974.46	
WQSP-6A	DL	11/11/09	167.22	50.97	3,196.83	974.39	
WQSP-6A	DL	12/10/09	167.08	50.93	3,196.97	974.44	
CB-1	B/C	01/13/09	324.18	98.81	3,004.94	915.91	
CB-1	B/C	02/11/09	323.45	98.59	3,005.67	916.13	
CB-1	B/C	03/24/09	322.63	98.34	3,006.49	916.38	
CB-1	B/C	04/22/09	322.21	98.21	3,006.91	916.51	
CB-1	B/C	05/20/09	321.89	98.11	3,007.23	916.60	
CB-1	B/C	06/09/09	321.53	98.00	3,007.59	916.71	
CB-1	B/C	07/14/09	321.08	97.87	3,008.04	916.85	
CB-1	B/C	08/11/09	320.81	97.78	3,008.31	916.93	
CB-1	B/C	09/23/09	320.40	97.66	3,008.72	917.06	
CB-1	B/C	10/19/09	320.00	97.54	3,009.12	917.18	
CB-1	B/C	11/09/09	319.90	97.51	3,009.22	917.21	
CB-1	B/C	12/09/09	319.43	97.36	3,009.69	917.35	
DOE-2	B/C	01/20/09	353.45	107.73	3,065.73	934.43	

Appendix F – Groundwater Data Tables

Table F.9 – Water Levels							
Well Number	Zone	Date	Adjusted Depth Top of Casing (ft)	Adjusted Depth Meters	Water Level Elevation (ft amsl)	Elevation in Meters (amsl)	Adjusted Freshwater Head (ft amsl)
DOE-2	B/C	02/11/09	353.11	107.63	3,066.07	934.54	
DOE-2	B/C	03/26/09	352.95	107.58	3,066.23	934.59	
DOE-2	B/C	04/22/09	353.01	107.60	3,066.17	934.57	
DOE-2	B/C	05/20/09	352.95	107.58	3,066.23	934.59	
DOE-2	B/C	06/10/09	352.85	107.55	3,066.33	934.62	
DOE-2	B/C	07/16/09	352.87	107.55	3,066.31	934.61	
DOE-2	B/C	08/11/09	352.78	107.53	3,066.40	934.64	
DOE-2	B/C	09/23/09	352.79	107.53	3,066.39	934.64	
DOE-2	B/C	10/21/09	352.65	107.49	3,066.53	934.68	
DOE-2	B/C	11/11/09	352.75	107.52	3,066.43	934.65	
DOE-2	B/C	12/10/09	352.53	107.45	3,066.65	934.71	
C-2505	SR/D	03/26/09	43.97	13.40	3,368.96	1,026.86	
C-2505	SR/D	06/11/09	44.44	13.55	3,368.49	1,026.72	
C-2505	SR/D	09/24/09	45.05	13.73	3,367.88	1,026.53	
C-2505	SR/D	12/14/09	45.27	13.80	3,367.66	1,026.46	
C-2506	SR/D	03/26/09	43.35	13.21	3,369.49	1,027.02	
C-2506	SR/D	06/11/09	43.82	13.36	3,369.02	1,026.88	
C-2506	SR/D	09/24/09	44.44	13.55	3,368.40	1,026.69	
C-2506	SR/D	12/14/09	44.65	13.61	3,368.19	1,026.62	
C-2507	SR/D	03/26/09	43.86	13.37	3,366.05	1,025.97	
C-2507	SR/D	06/11/09	44.34	13.51	3,365.57	1,025.82	
C-2507	SR/D	09/24/09	44.91	13.69	3,365.00	1,025.65	
C-2507	SR/D	12/14/09	45.13	13.76	3,364.78	1,025.58	
C-2811	SR/D	03/26/09	51.60	15.73	3,347.24	1,020.24	
C-2811	SR/D	06/11/09	52.06	15.87	3,346.78	1,020.10	
C-2811	SR/D	09/23/09	52.69	16.06	3,346.15	1,019.90	
C-2811	SR/D	12/14/09	52.78	16.09	3,346.06	1,019.88	
PZ-01	SR/D	03/26/09	40.89	12.46	3,372.39	1,027.90	
PZ-01	SR/D	06/11/09	41.24	12.57	3,372.04	1,027.80	
PZ-01	SR/D	09/24/09	41.67	12.70	3,371.61	1,027.67	
PZ-01	SR/D	12/14/09	41.89	12.77	3,371.39	1,027.60	
PZ-02	SR/D	03/26/09	40.97	12.49	3,372.39	1,027.90	
PZ-02	SR/D	06/11/09	41.53	12.66	3,371.83	1,027.73	
PZ-02	SR/D	09/23/09	42.16	12.85	3,371.20	1,027.54	
PZ-02	SR/D	12/14/09	42.33	12.90	3,371.03	1,027.49	
PZ-03	SR/D	03/26/09	42.44	12.94	3,373.68	1,028.30	
PZ-03	SR/D	06/11/09	42.92	13.08	3,373.20	1,028.15	
PZ-03	SR/D	09/24/09	43.50	13.26	3,372.62	1,027.98	
PZ-03	SR/D	12/14/09	43.61	13.29	3,372.51	1,027.94	
PZ-04	SR/D	03/26/09	44.45	13.55	3,367.56	1,026.43	
PZ-04	SR/D	06/11/09	45.03	13.73	3,366.98	1,026.26	
PZ-04	SR/D	09/24/09	45.70	13.93	3,366.31	1,026.05	
PZ-04	SR/D	12/14/09	46.03	14.03	3,365.98	1,025.95	
PZ-05	SR/D	03/26/09	40.92	12.47	3,374.32	1,028.49	
PZ-05	SR/D	06/11/09	41.46	12.64	3,373.78	1,028.33	
PZ-05	SR/D	09/24/09	42.05	12.82	3,373.19	1,028.15	

Appendix F – Groundwater Data Tables

Table F.9 – Water Levels							
Well Number	Zone	Date	Adjusted Depth Top of Casing (ft)	Adjusted Depth Meters	Water Level Elevation (ft amsl)	Elevation in Meters (amsl)	Adjusted Freshwater Head (ft amsl)
PZ-05	SR/D	12/14/09	42.25	12.88	3,372.99	1,028.09	
PZ-06	SR/D	03/26/09	42.17	12.85	3,371.16	1,027.53	
PZ-06	SR/D	06/11/09	42.67	13.01	3,370.66	1,027.38	
PZ-06	SR/D	09/24/09	43.15	13.15	3,370.18	1,027.23	
PZ-06	SR/D	12/14/09	43.37	13.22	3,369.96	1,027.16	
PZ-07	SR/D	03/26/09	35.70	10.88	3,378.14	1,029.66	
PZ-07	SR/D	06/11/09	36.25	11.05	3,377.59	1,029.49	
PZ-07	SR/D	09/24/09	36.81	11.22	3,377.03	1,029.32	
PZ-07	SR/D	12/14/09	36.78	11.21	3,377.06	1,029.33	
PZ-08	SR/D	03/26/09	62.46	19.04	3,355.73	1,022.83	
PZ-08	SR/D	06/11/09	62.33	19.00	3,355.86	1,022.87	
PZ-08	SR/D	09/23/09	62.48	19.04	3,355.71	1,022.82	
PZ-08	SR/D	12/14/09	62.39	19.02	3,355.80	1,022.85	
PZ-09	SR/D	03/26/09	56.12	17.11	3,364.97	1,025.64	
PZ-09	SR/D	06/11/09	56.52	17.23	3,364.57	1,025.52	
PZ-09	SR/D	09/24/09	56.94	17.36	3,364.15	1,025.39	
PZ-09	SR/D	12/14/09	56.88	17.34	3,364.21	1,025.41	
PZ-10	SR/D	03/26/09	35.94	10.95	3,369.79	1,027.11	
PZ-10	SR/D	06/11/09	36.60	11.16	3,369.13	1,026.91	
PZ-10	SR/D	09/24/09	37.35	11.38	3,368.38	1,026.68	
PZ-10	SR/D	12/14/09	37.61	11.46	3,368.12	1,026.60	
PZ-11	SR/D	03/26/09	43.28	13.19	3,375.50	1,028.85	
PZ-11	SR/D	06/11/09	43.76	13.34	3,375.02	1,028.71	
PZ-11	SR/D	09/24/09	44.47	13.55	3,374.31	1,028.49	
PZ-11	SR/D	12/14/09	44.42	13.54	3,374.36	1,028.50	
PZ-12	SR/D	03/26/09	49.90	15.21	3,359.02	1,023.83	
PZ-12	SR/D	06/11/09	50.67	15.44	3,358.25	1,023.59	
PZ-12	SR/D	09/24/09	51.50	15.70	3,357.42	1,023.34	
PZ-12	SR/D	12/14/09	51.62	15.73	3,357.30	1,023.30	
PZ-13	SR/D	03/26/09	64.55	19.67	3,357.69	1,023.42	
PZ-13	SR/D	06/11/09	64.89	19.78	3,357.35	1,023.32	
PZ-13	SR/D	09/23/09	65.24	19.89	3,357.00	1,023.21	
PZ-13	SR/D	12/14/09	65.25	19.89	3,356.99	1,023.21	
PZ-14	SR/D	03/26/09	66.45	20.25	3,354.13	1,022.34	
PZ-14	SR/D	06/11/09	66.72	20.34	3,353.86	1,022.26	
PZ-14	SR/D	09/23/09	67.03	20.43	3,353.55	1,022.16	
PZ-14	SR/D	12/14/09	66.96	20.41	3,353.62	1,022.18	
PZ-15	SR/D	03/26/09	46.19	14.08	3,384.67	1,031.65	
PZ-15	SR/D	06/11/09	46.55	14.19	3,384.31	1,031.54	
PZ-15	SR/D	09/23/09	46.79	14.26	3,384.07	1,031.46	
PZ-15	SR/D	12/14/09	46.91	14.30	3,383.95	1,031.43	

Appendix G – Air Sampling Data: Concentrations of Radionuclides in Air Filter Composites

Appendix G – Air Sampling Data: Concentrations of Radionuclides in Air Filter Composites

Table G.1 – Radionuclide Concentrations (Bq/m^3) in Quarterly Composite Air Filters Collected from Locations Surrounding the WIPP Site. See Appendix C for sampling location codes.

Location	Quarter	[RN][a]	2 x TPU[b]	MDC	[RN][a]	2 x TPU[b]	MDC[c]	[RN][a]	2 x TPU[b]	MDC[c]
			^{241}Am			^{238}Pu			$^{239/240}$Pu	
CBD	1 (Avg)	-1.00E-04	6.09E-04	2.49E-03	-9.01E-05	5.46E-04	1.75E-03	-9.04E-04	6.27E-04	2.70E-03
	2	3.40E-04	4.40E-04	8.66E-03	-2.31E-04	2.31E-04	7.04E-08	7.00E-06	2.55E-04	3.71E-03
	3	-4.00E-04	4.98E-04	6.97E-04	1.22E-05	4.02E-04	3.40E-04	-4.38E-04	3.05E-04	4.01E-04
	4	-2.20E-04	4.22E-04	4.97E-04	-8.71E-05	3.50E-04	3.77E-04	-6.19E-05	3.31E-04	4.62E-04
MLR	1	9.13E-05	6.55E-04	2.46E-03	-9.63E-05	5.58E-04	1.76E-03	-1.30E-03	4.22E-04	2.71E-03
	2	3.67E-05	2.32E-04	8.66E-03	-1.24E-04	3.50E-04	8.65E-08	-1.32E-04	2.35E-04	3.71E-03
	3	-2.00E-04	7.41E-04	8.10E-04	-1.48E-04	4.56E-04	4.38E-04	-1.36E-04	5.91E-04	4.98E-04
	4	3.72E-04	6.78E-04	5.27E-04	1.56E-04	5.45E-04	4.04E-04	-6.02E-05	3.57E-04	4.88E-04
SEC	1	-5.86E-05	6.01E-04	2.46E-03	5.78E-04	9.12E-04	1.80E-03	-5.47E-04	7.82E-04	2.75E-03
	2	1.46E-04	3.30E-04	8.66E-03	-1.80E-05	3.84E-04	7.81E-08	3.67E-05	2.62E-04	3.71E-03
	3	-2.32E-04	7.07E-04	7.74E-04	-1.28E-04	3.79E-04	3.75E-04	-3.04E-04	4.24E-04	4.35E-04
	4	-1.11E-04	4.58E-04	4.79E-04	5.34E-05	5.71E-04	4.82E-04	-1.92E-04	2.61E-04	5.66E-04
SMR	1	1.66E-04	6.17E-04	2.42E-03	-8.16E-05	4.63E-04	1.70E-03	-8.33E-04	5.48E-04	2.65E-03
	2 (Avg)	9.18E-05	2.98E-04	8.66E-03	-1.54E-04	2.44E-04	6.99E-08	1.81E-05	2.42E-04	3.71E-03
	3	-1.92E-04	6.11E-04	7.23E-04	2.18E-04	3.99E-04	3.29E-04	-3.37E-04	3.76E-04	3.89E-04
	4	3.16E-04	6.83E-04	5.21E-04	2.74E-04	4.40E-04	3.80E-04	1.90E-04	4.82E-04	4.64E-04
WEE	1	-4.79E-05	5.73E-04	2.45E-03	-7.06E-05	5.07E-04	1.73E-03	-1.10E-03	4.57E-04	2.68E-03
	2	-2.98E-05	1.47E-04	8.66E-03	-1.74E-04	1.56E-04	5.38E-08	-4.88E-05	1.05E-04	3.71E-03
	3	-1.06E-04	6.43E-04	6.67E-04	4.33E-04	7.55E-04	4.90E-04	-5.33E-04	2.07E-04	5.50E-04
	4 (Avg)	5.77E-05	5.00E-04	4.67E-04	-1.53E-04	3.30E-04	4.11E-04	-7.12E-06	3.23E-04	4.95E-04
WFF	1	-1.30E-04	5.92E-04	2.50E-03	3.57E-04	8.46E-04	1.85E-03	-7.27E-04	8.31E-04	2.81E-03
	2	2.17E-04	3.27E-04	8.66E-03	-2.26E-04	2.56E-04	8.93E-08	3.68E-04	5.29E-04	3.71E-03
	3 (Avg)	-1.71E-04	7.32E-04	8.03E-04	-8.43E-05	3.83E-04	3.39E-04	-2.59E-04	4.10E-04	4.00E-04
	4	3.59E-04	6.32E-04	4.75E-04	-9.90E-06	4.68E-04	3.87E-04	-1.73E-04	2.11E-04	4.71E-04
WSS	1	-3.47E-04	4.71E-04	2.45E-03	-1.39E-04	5.39E-04	1.73E-03	-1.02E-03	5.68E-04	2.68E-03
	2	1.91E-04	4.06E-04	8.66E-03	-1.36E-04	3.20E-04	7.61E-08	-1.67E-05	2.92E-04	3.71E-03
	3	2.90E-03	1.86E-03	9.37E-04	-2.73E-05	7.52E-04	5.85E-04	1.99E-03	1.40E-03	6.50E-04
	4	-3.16E-04	3.28E-04	4.96E-04	-8.30E-05	3.80E-04	4.10E-04	2.77E-04	4.92E-04	4.94E-04
	Mean	9.37E-05	5.64E-04	3.10E-03	-6.41E-06	4.62E-04	6.45E-04	-2.23E-04	4.40E-04	1.85E-03
	Minimum	-4.00E-04	4.98E-04	6.97E-04	-2.31E-04	3.30E-04	4.11E-04	-1.30E-03	2.07E-04	5.50E-04
	Maximum	2.90E-03	1.86E-03	9.37E-04	5.78E-04	7.55E-04	4.90E-04	1.99E-03	1.40E-03	6.50E-04
WAB	1	1.62E-04	8.24E-04	2.61E-03	-1.97E-04	3.81E-04	1.71E-03	-1.41E-03	2.36E-04	2.66E-03
(Blank)	2	2.60E-04	6.25E-04	9.09E-03	-1.76E-04	4.83E-04	4.73E-04	2.01E-04	5.63E-04	4.18E-03
	3	-3.69E-04	5.30E-04	7.47E-04	-4.76E-05	3.15E-04	3.69E-04	-3.94E-04	3.00E-04	4.29E-04
	4	1.65E-04	2.45E-04	3.17E-04	4.15E-05	1.90E-04	2.54E-04	-4.14E-05	1.12E-04	3.39E-04

Location	Quarter	[RN][a]	2 x TPU[b]	MDC	[RN][a]	2 x TPU[b]	MDC[c]	[RN][a]	2 x TPU[b]	MDC[c]
			$^{233/234}$U			^{235}U			^{238}U	
CBD	1 (Avg)	1.27E-02	2.77E-03	6.84E-03	1.47E-03	1.02E-03	1.98E-03	1.58E-02	2.99E-03	5.74E-03
	2	3.56E-03	2.08E-03	9.76E-02	5.93E-04	6.23E-04	1.10E-02	3.19E-03	1.95E-03	8.32E-02
	3	4.90E-03	1.93E-03	1.14E-03	3.54E-04	6.17E-04	5.42E-04	4.57E-03	1.79E-03	9.62E-04
	4	4.74E-03	2.45E-03	1.17E-03	2.76E-04	6.07E-04	4.55E-04	6.01E-03	2.60E-03	8.06E-04
MLR	1	1.20E-02	2.68E-03	6.83E-03	2.22E-03	1.27E-03	1.97E-03	9.93E-03	2.36E-03	5.73E-03
	2	3.67E-03	2.13E-03	9.76E-02	2.53E-04	4.39E-04	1.10E-02	2.27E-03	1.55E-03	8.32E-02
	3	8.18E-03	2.83E-03	1.20E-03	4.91E-04	6.82E-04	6.15E-04	5.71E-03	2.22E-03	1.02E-03
	4	3.71E-03	2.27E-03	1.16E-03	7.41E-04	7.51E-04	4.46E-04	3.86E-03	2.26E-03	7.99E-04
SEC	1	1.33E-02	2.65E-03	6.79E-03	5.11E-04	6.16E-04	1.92E-03	1.32E-02	2.56E-03	5.69E-03
	2	1.96E-03	1.50E-03	9.76E-02	3.46E-04	5.09E-04	1.10E-02	2.66E-03	1.91E-03	8.32E-02
	3	4.71E-03	1.87E-03	1.14E-03	2.03E-05	4.04E-04	5.41E-04	6.43E-03	2.19E-03	9.62E-04
	4	2.92E-03	2.29E-03	1.20E-03	-1.01E-04	3.39E-04	4.89E-04	2.70E-03	2.22E-03	8.34E-04
			$^{233/234}$U			^{235}U			^{238}U	

Appendix G – Air Sampling Data: Concentrations of Radionuclides in Air Filter Composites

Table G.1 – Radionuclide Concentrations (Bq/m^3) in Quarterly Composite Air Filters Collected from Locations Surrounding the WIPP Site. See Appendix C for sampling location codes.

Location	Quarter	[RN][a]	2 x TPU[b]	MDC	[RN][a]	2 x TPU[b]	MDC[c]	[RN][a]	2 x TPU[b]	MDC[c]
SMR	1	1.23E-02	2.55E-03	6.79E-03	1.25E-03	9.10E-04	1.92E-03	9.85E-03	2.20E-03	5.69E-03
	2 (Avg)	3.24E-03	1.91E-03	9.76E-02	1.65E-04	3.49E-04	1.10E-02	2.39E-03	1.59E-03	8.32E-02
	3	7.38E-03	2.39E-03	1.14E-03	1.89E-05	3.97E-04	5.33E-04	6.73E-03	2.22E-03	9.55E-04
	4	7.06E-04	1.99E-03	1.19E-03	1.87E-04	5.57E-04	4.83E-04	3.00E-03	2.26E-03	8.29E-04
WEE	1	9.78E-03	2.31E-03	6.80E-03	6.78E-04	6.88E-04	1.93E-03	1.15E-02	2.40E-03	5.69E-03
	2	3.99E-03	1.60E-03	9.76E-02	1.47E-04	2.63E-04	1.10E-02	1.72E-03	9.72E-04	8.32E-02
	3	8.11E-03	2.50E-03	1.14E-03	5.33E-04	6.82E-04	5.36E-04	6.47E-03	2.16E-03	9.58E-04
	4 (Avg)	1.77E-03	2.02E-03	1.16E-03	2.42E-04	5.30E-04	4.46E-04	3.70E-03	2.24E-03	7.99E-04
WFF	1	1.06E-02	2.44E-03	6.81E-03	1.46E-03	1.00E-03	1.94E-03	9.40E-03	2.20E-03	5.70E-03
	2	2.80E-03	1.80E-03	9.76E-02	1.66E-04	5.02E-04	1.10E-02	1.81E-03	1.43E-03	8.32E-02
	3	4.46E-03	1.74E-03	1.11E-03	9.03E-05	3.63E-04	5.05E-04	6.01E-03	2.00E-03	9.33E-04
	4	2.47E-03	2.07E-03	1.15E-03	-1.55E-04	3.21E-04	4.27E-04	4.96E-03	2.33E-03	7.84E-04
WSS	1	1.06E-02	2.40E-03	6.80E-03	9.88E-04	8.06E-04	1.93E-03	1.07E-02	2.31E-03	5.69E-03
	2 (Avg)	4.24E-03	2.66E-03	9.76E-02	3.15E-04	5.04E-04	1.10E-02	1.99E-03	1.60E-03	8.32E-02
	3	6.92E-03	2.08E-03	1.09E-03	2.97E-04	5.22E-04	4.75E-04	4.79E-03	1.66E-03	9.08E-04
	4	1.70E-03	1.97E-03	1.14E-03	1.11E-04	4.88E-04	4.24E-04	8.78E-04	1.84E-03	7.81E-04
	Mean	5.98E-03	2.21E-03	2.67E-02	4.88E-04	5.99E-04	3.48E-03	5.79E-03	2.07E-03	2.27E-02
	Minimum	7.06E-04	1.99E-03	1.19E-03	-1.55E-04	3.21E-04	4.27E-04	8.78E-04	1.84E-03	7.81E-04
	Maximum	1.33E-02	2.65E-03	6.79E-03	2.22E-03	1.27E-03	1.97E-03	1.58E-02	2.99E-03	5.74E-03
WAB	1	7.68E-03	2.57E-03	6.98E-03	3.49E-04	6.97E-04	2.15E-03	7.23E-03	2.36E-03	5.87E-03
(Blank)	2	2.74E-03	2.04E-03	9.81E-02	3.95E-05	5.09E-04	1.16E-02	8.45E-05	1.32E-03	8.36E-02
	3	3.42E-03	1.66E-03	1.18E-03	3.94E-05	4.31E-04	5.82E-04	4.85E-03	1.94E-03	9.95E-04
	4	3.64E-03	9.89E-04	9.93E-04	1.14E-04	1.94E-04	2.39E-04	3.47E-03	9.58E-04	6.32E-04

Location	Quarter	[RN][a]	2 x TPU[b]	MDC	[RN][a]	2 x TPU[b]	MDC[c]	[RN][a]	2 x TPU[b]	MDC[c]
			^{40}K			^{60}Co			^{137}C	
CBD	1 (Avg)	3.37E+00	1.51E+01	1.70E+01	-1.35E-02	1.57E+00	1.74E+00	-2.65E-01	1.81E+00	1.95E+00
	2	5.74E+00	5.66E+00	1.85E-03	-2.34E-01	6.56E-01	1.87E-04	4.55E-03	7.04E-01	2.14E-04
	3	-1.64E+00	7.96E+00	9.06E+00	7.24E-01	8.54E-01	9.68E-01	-1.38E-02	8.75E-01	9.76E-01
	4	4.50E+00	9.55E+00	1.16E+01	3.84E-01	1.04E+00	1.25E+00	3.86E-01	1.26E+00	1.42E+00
MLR	1	1.43E+01	1.69E+01	1.99E+01	-4.39E-01	1.79E+00	1.92E+00	-1.74E+00	2.34E+00	2.38E+00
	2	3.70E+00	5.55E+00	1.82E-03	-1.65E-01	6.14E-01	1.79E-04	-4.51E-02	6.88E-01	2.09E-04
	3	-8.14E+00	1.34E+01	1.40E+01	2.06E-01	1.36E+00	1.62E+00	-1.37E+00	1.85E+00	1.88E+00
	4	1.08E+01	1.24E+01	1.48E+01	-1.46E+00	1.54E+00	1.52E+00	-7.60E-01	1.65E+00	1.80E+00
SEC	1	1.90E+01	1.14E+01	1.43E+01	8.11E-01	1.13E+00	1.35E+00	-1.40E+00	1.54E+00	1.59E+00
	2	2.48E+00	3.73E+00	1.27E-03	-2.87E-01	4.85E-01	1.33E-04	2.04E-01	4.47E-01	1.38E-04
	3	3.07E+00	7.85E+00	9.31E+00	-5.44E-01	9.26E-01	9.35E-01	-9.08E-01	9.36E-01	9.62E-01
	4	-5.17E+00	8.28E+00	9.00E+00	3.14E-01	8.10E-01	9.05E-01	6.62E-01	8.39E-01	9.62E-01
SMR	1	5.06E+00	1.66E+01	1.86E+01	-1.43E-01	1.86E+00	2.05E+00	5.90E-01	2.22E+00	2.42E+00
	2 (Avg)	1.77E+00	5.10E+00	1.59E-03	1.11E-01	5.13E-01	1.59E-04	2.42E-03	5.78E-01	1.76E-04
	3	2.44E+00	1.10E+01	1.31E+01	1.01E+00	1.17E+00	1.44E+00	1.04E+00	1.33E+00	1.49E+00
	4	1.15E+01	1.17E+01	1.43E+01	-2.56E-01	1.31E+00	1.43E+00	-1.32E+00	1.58E+00	1.66E+00
WEE	1	6.26E+00	1.72E+01	1.94E+01	2.21E-01	1.86E+00	2.08E+00	-5.35E-01	2.33E+00	2.49E+00
	2	2.99E+00	5.94E+00	1.86E-03	1.45E-01	5.94E-01	1.83E-04	-9.02E-01	7.61E-01	2.04E-04
	3	6.61E+00	8.58E+00	1.09E+01	3.90E-01	9.93E-01	1.19E+00	1.02E+00	1.14E+00	1.31E+00
	4 (Avg)	4.80E+00	7.26E+00	5.45E+00	2.68E-01	7.94E-01	5.97E-01	5.88E-02	9.52E-01	6.55E-01
WFF	1	5.37E+00	1.22E+01	1.41E+01	5.37E-01	1.15E+00	1.35E+00	-9.76E-01	1.49E+00	1.58E+00
	2	4.35E+00	3.81E+00	1.38E-03	-9.10E-02	4.58E-01	1.37E-04	-7.29E-01	5.65E-01	1.43E-04
	3 (Avg)	4.64E+00	1.12E+01	1.30E+01	6.75E-01	1.15E+00	1.37E+00	-6.42E-01	1.40E+00	1.48E+00
	4	5.09E+00	8.91E+00	1.10E+01	1.05E+00	9.58E-01	1.24E+00	3.84E-01	1.11E+00	1.26E+00
			^{40}K			^{60}Co			^{137}C	
WSS	1	-1.23E+00	1.01E+01	1.16E+01	4.56E-01	1.08E+00	1.28E+00	-1.34E+00	1.31E+00	1.28E+00

Appendix G – Air Sampling Data: Concentrations of Radionuclides in Air Filter Composites

Table G.1 – Radionuclide Concentrations (Bq/m³) in Quarterly Composite Air Filters Collected from Locations Surrounding the WIPP Site. See Appendix C for sampling location codes.

Location	Quarter	[RN][a]	2 x TPU[b]	MDC	[RN][a]	2 x TPU[b]	MDC[c]	[RN][a]	2 x TPU[b]	MDC[c]
	2	-1.55E-01	4.42E+00	1.36E-03	1.24E-01	4.58E-01	1.49E-04	-1.96E-01	4.92E-01	1.41E-04
	3	1.48E+01	1.24E+01	1.51E+01	3.52E-01	1.37E+00	1.57E+00	-2.00E+00	1.72E+00	1.74E+00
	4	4.19E+00	8.94E+00	1.10E+01	2.96E-01	9.62E-01	1.11E+00	1.83E-01	1.14E+00	1.28E+00
	Mean	4.66E+00	9.76E+00	9.88E+00	1.58E-01	1.05E+00	1.03E+00	-3.79E-01	1.25E+00	1.16E+00
	Minimum	-8.14E+00	1.34E+01	1.40E+01	-1.46E+00	1.54E+00	1.52E+00	-2.00E+00	1.72E+00	1.74E+00
	Maximum	1.48E+01	1.24E+01	1.51E+01	1.05E+00	9.58E-01	1.24E+00	1.04E+00	1.33E+00	1.49E+00
WAB	1	3.04E+00	1.02E+01	1.24E+01	-1.16E+00	1.31E+00	1.20E+00	-1.63E+00	1.29E+00	1.22E+00
(Blank)	2	3.03E+00	1.17E+01	1.34E+01	7.13E-02	1.20E+00	1.35E+00	-1.50E-01	1.43E+00	1.60E+00
	3	9.93E+00	1.21E+01	1.44E+01	8.54E-01	1.27E+00	1.50E+00	-1.83E+00	1.68E+00	1.70E+00
	4	5.80E+00	7.70E+00	9.34E+00	-1.06E-01	8.72E-01	9.31E-01	-2.82E-01	8.57E-01	9.34E-01

Location	Quarter	[RN][a]	2 x TPU[b]	MDC[c]
			^{90}Sr	
CBD	1 (Avg)	-1.64E-02	3.79E-02	1.09E-02
	2	-9.14E-03	1.98E-02	4.06E-02
	3	-4.64E-03	2.01E-02	1.99E-03
	4	-2.28E-02	4.49E-02	3.13E-03
MLR	1	-1.97E-02	3.95E-02	1.12E-02
	2	-2.05E-02	1.87E-02	4.06E-02
	3	1.80E-03	2.05E-02	2.12E-03
	4	-2.40E-02	4.63E-02	3.27E-03
SEC	1	-3.57E-02	3.78E-02	1.09E-02
	2	-1.30E-02	2.06E-02	4.06E-02
	3	-1.16E-02	2.06E-02	2.08E-03
	4	-3.90E-02	4.37E-02	2.96E-03
SMR	1	-1.41E-02	3.86E-02	1.09E-02
	2 (Avg)	-1.65E-02	1.98E-02	4.06E-02
	3	-1.59E-02	1.97E-02	1.97E-03
	4	-2.44E-02	4.58E-02	3.20E-03
WEE	1	-6.33E-03	4.02E-02	1.11E-02
	2	-1.75E-02	1.99E-02	4.06E-02
	3	-8.77E-03	1.94E-02	2.00E-03
	4	-1.31E-02	1.96E-02	2.13E-02
WFF	1	-1.37E-02	3.99E-02	1.11E-02
	2	-1.16E-02	2.07E-02	4.06E-02
	3 (Avg)	-1.27E-02	3.03E-02	2.58E-02
	4	-2.22E-02	4.73E-02	3.23E-03
			^{90}Sr	
WSS	1	-2.38E-02	4.00E-02	1.11E-02
	2	-1.29E-02	1.99E-02	4.06E-02
	3	-1.84E-02	1.98E-02	2.01E-03
	4	-1.35E-02	4.82E-02	3.36E-03
	Mean	-1.64E-02	3.07E-02	1.57E-02
	Minimum	-3.90E-02	4.37E-02	2.96E-03
	Maximum	1.80E-03	2.05E-02	2.12E-03

[a] Radionuclide concentration
[b] Total propagated uncertainty
[c] Minimum detectable concentration

Appendix G – Air Sampling Data: Concentrations of Radionuclides in Air Filter Composites

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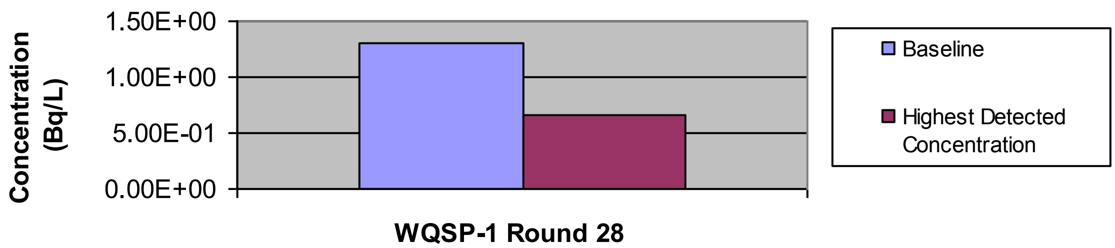
Appendix G – Air Sampling Data: Concentrations of Radionuclides in Air Filter Composites

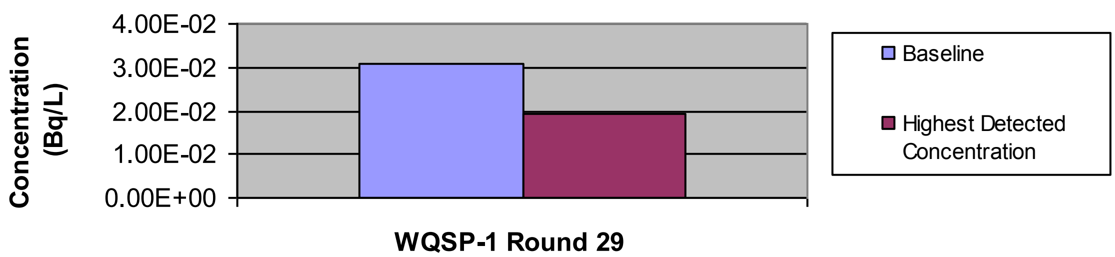
Appendix H – Comparison of Detected Radionuclides to the Radiological Baseline

The figures in this appendix show the highest detected radionuclides from 2009 environmental monitoring sample analysis results compared to the 99 percent confidence interval radiological baseline values established for these isotopes (DOE/WIPP-92-037). Figures address air filter composite, groundwater, surface water, sediment, soil, and vegetation results. Note: all results with the exception of vegetation were compared to the baseline upper 99 percentile probability value. The baseline did not include probability distributions for vegetation; therefore, vegetation sample results are compared to the baseline mean values. A detailed discussion of environmental monitoring radionuclide sample results is presented in Chapter 4.

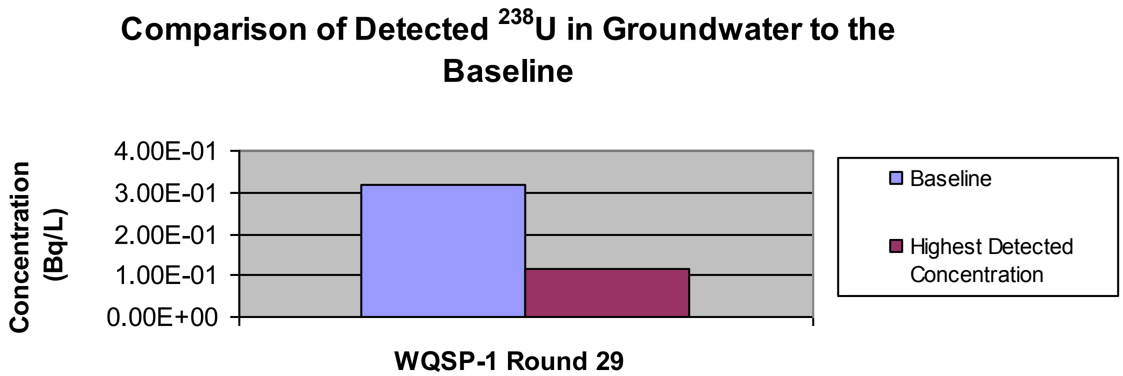
Comparison of Detected $^{233/234}U$ in Groundwater to the Baseline

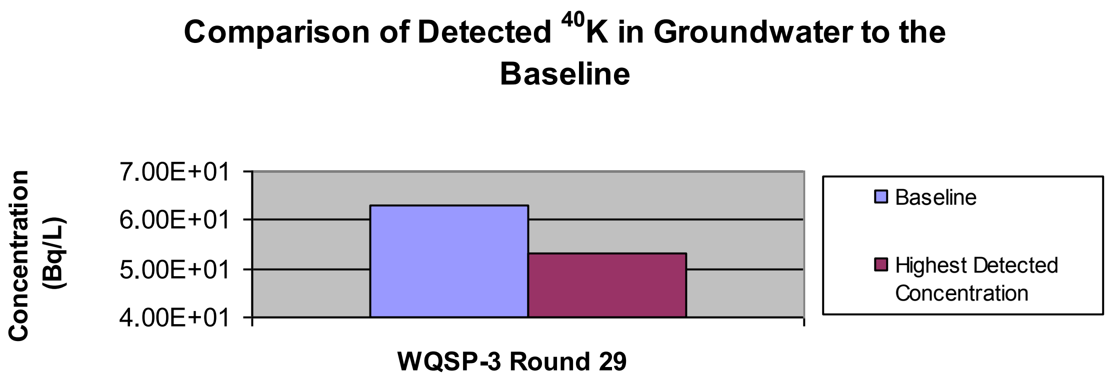


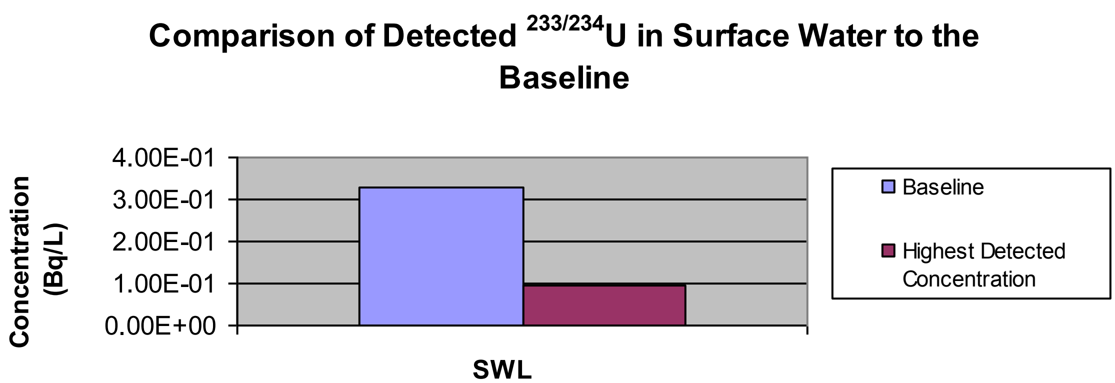
Comparison of Detected ^{235}U in Groundwater to the Baseline



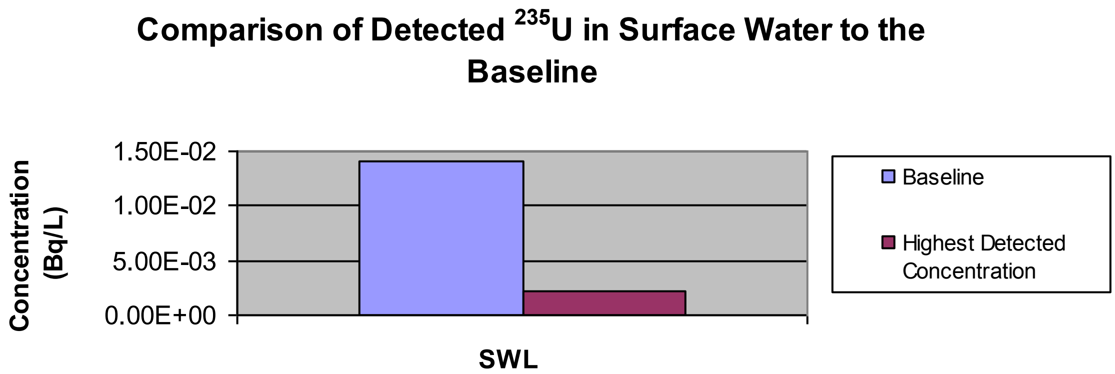
Appendix G – Air Sampling Data: Concentrations of Radionuclides in Air Filter Composites

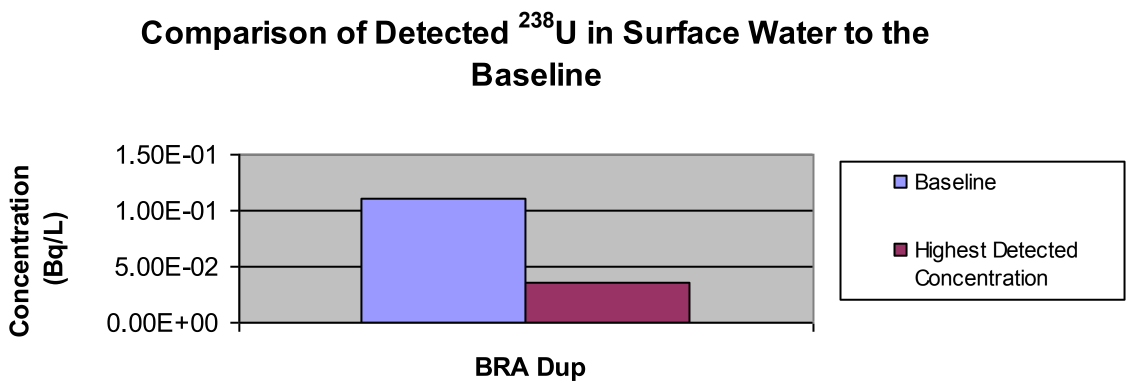


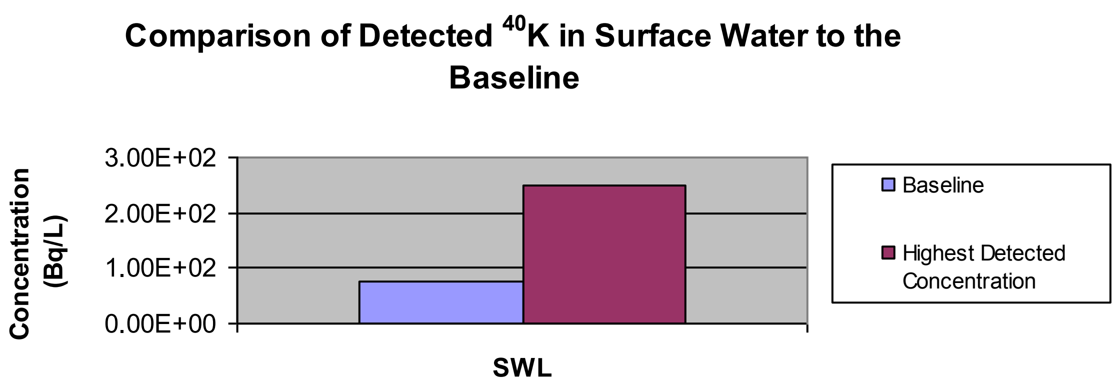




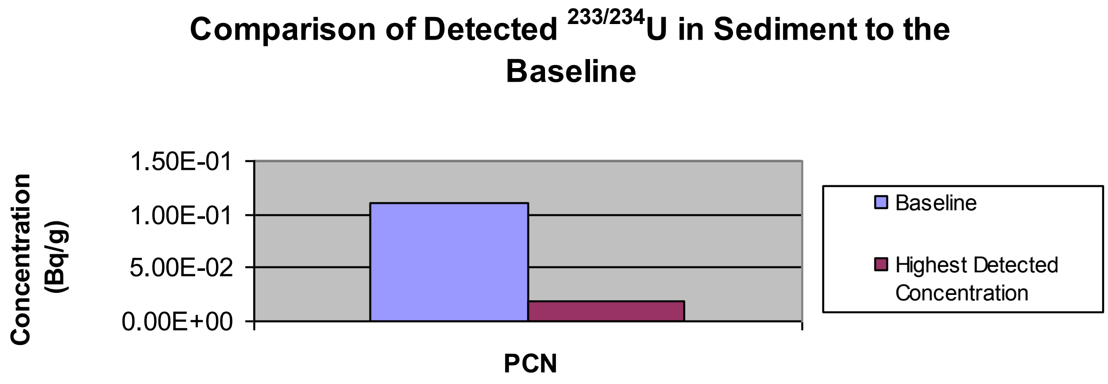
Appendix G – Air Sampling Data: Concentrations of Radionuclides in Air Filter Composites

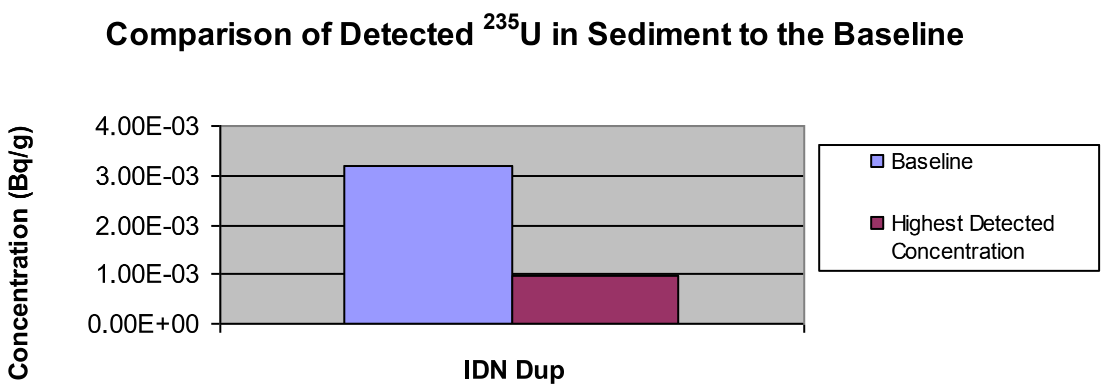


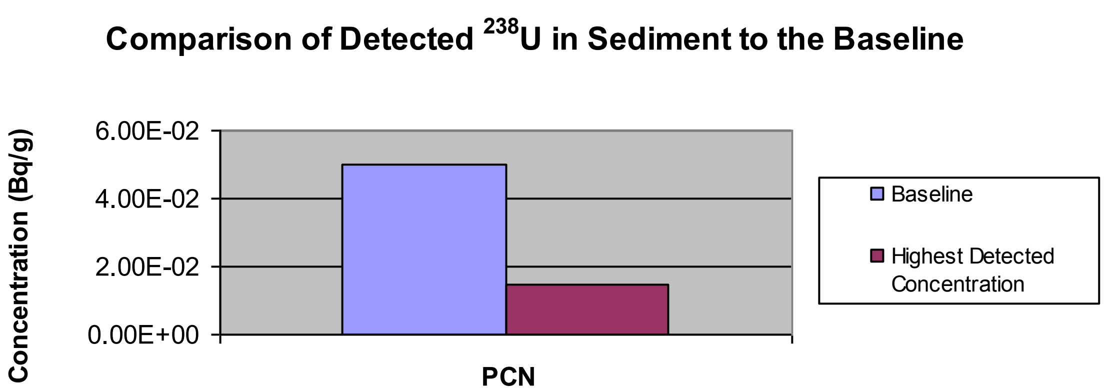




Appendix G – Air Sampling Data: Concentrations of Radionuclides in Air Filter Composites

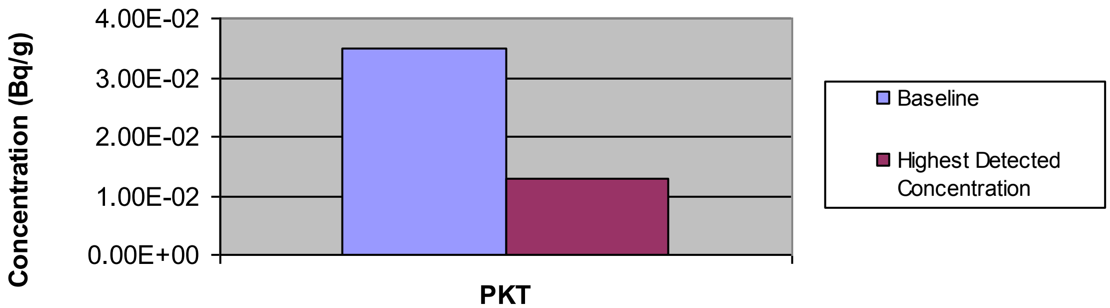




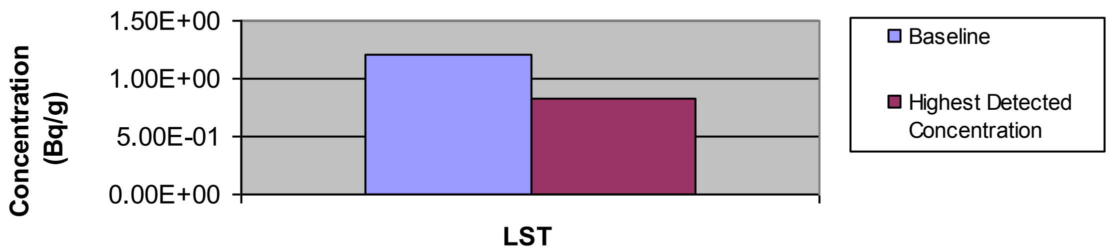


Appendix G – Air Sampling Data: Concentrations of Radionuclides in Air Filter Composites

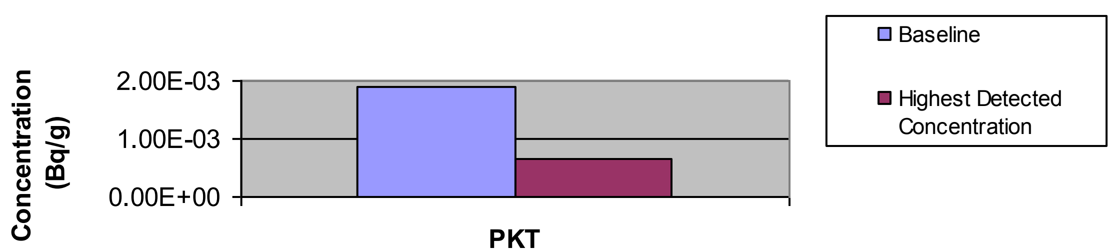
Comparison of Detected ^{137}Cs in Sediment to the Baseline



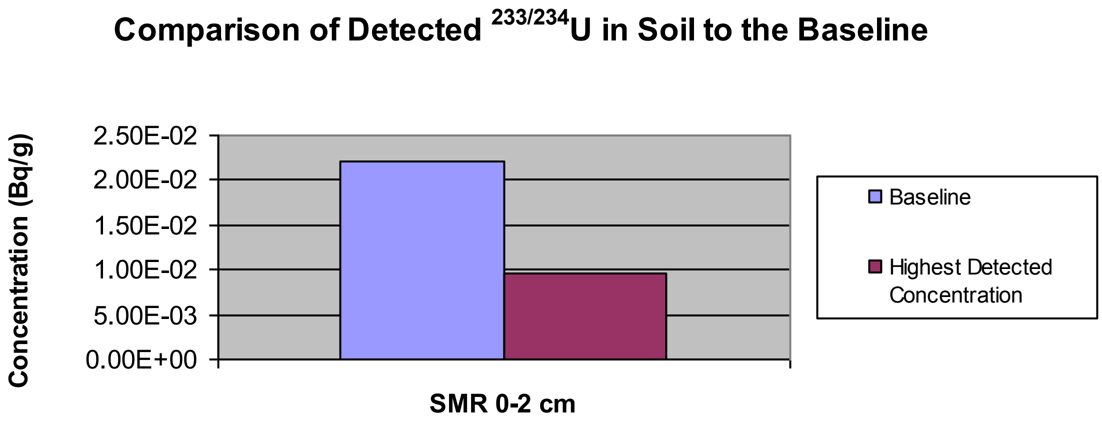
Comparison of Detected ^{40}K in Sediment to the Baseline

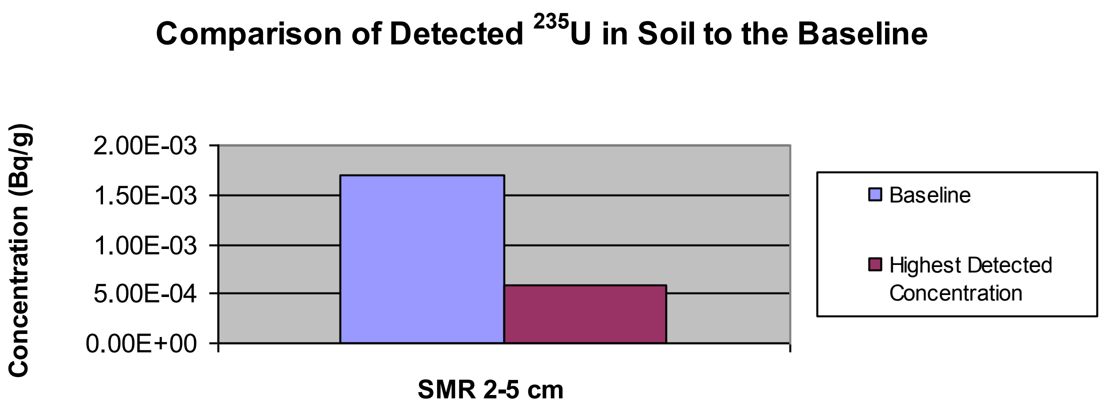


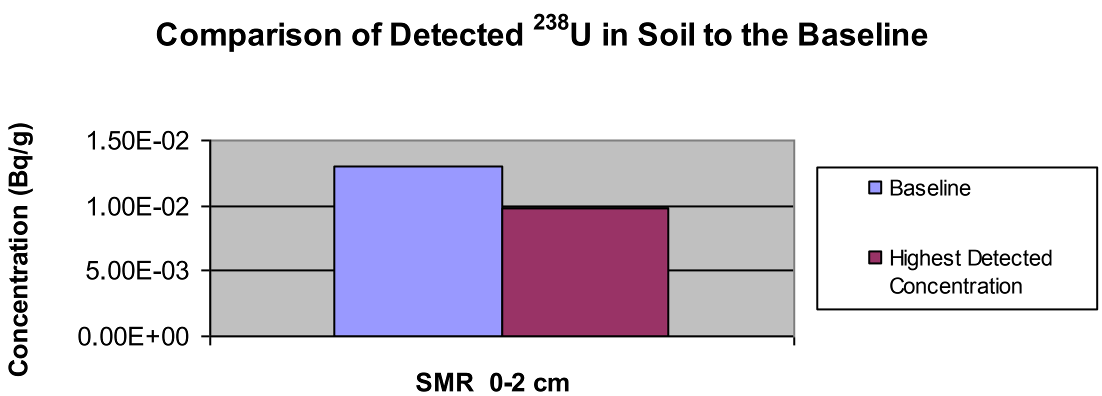
Comparison of Detected $^{239/240}$Pu in Sediment to the Baseline



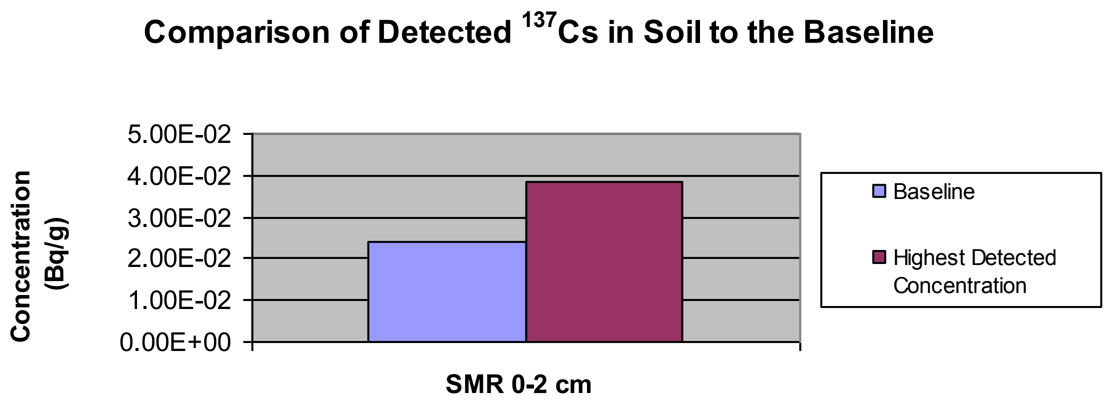
Appendix G – Air Sampling Data: Concentrations of Radionuclides in Air Filter Composites

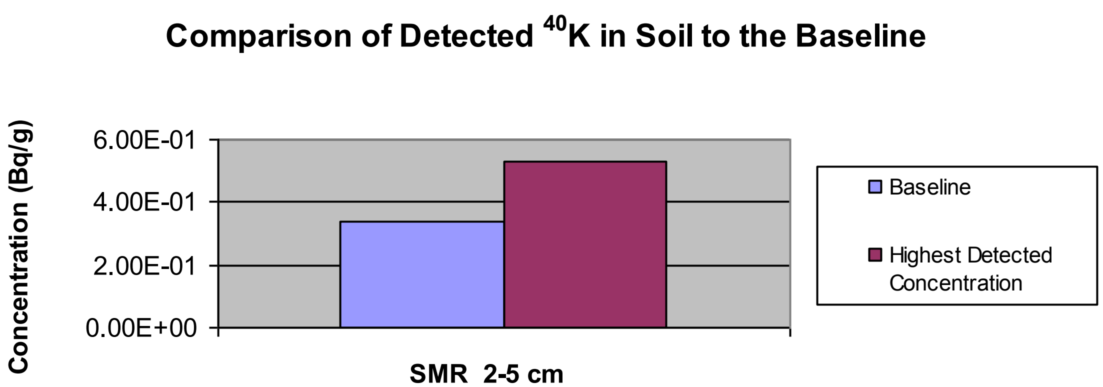


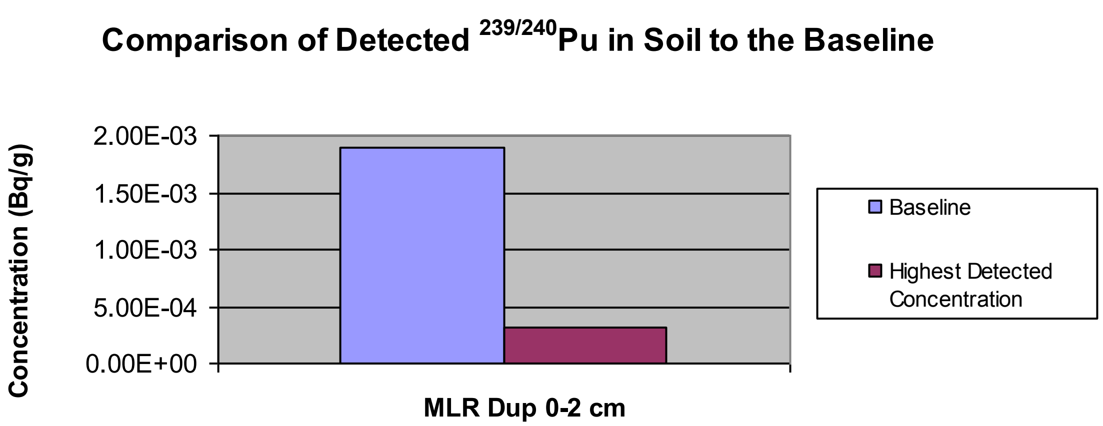




Appendix G – Air Sampling Data: Concentrations of Radionuclides in Air Filter Composites







Appendix G – Air Sampling Data: Concentrations of Radionuclides in Air Filter Composites

Comparison of Detected ^{40}K in Vegetation to the Baseline