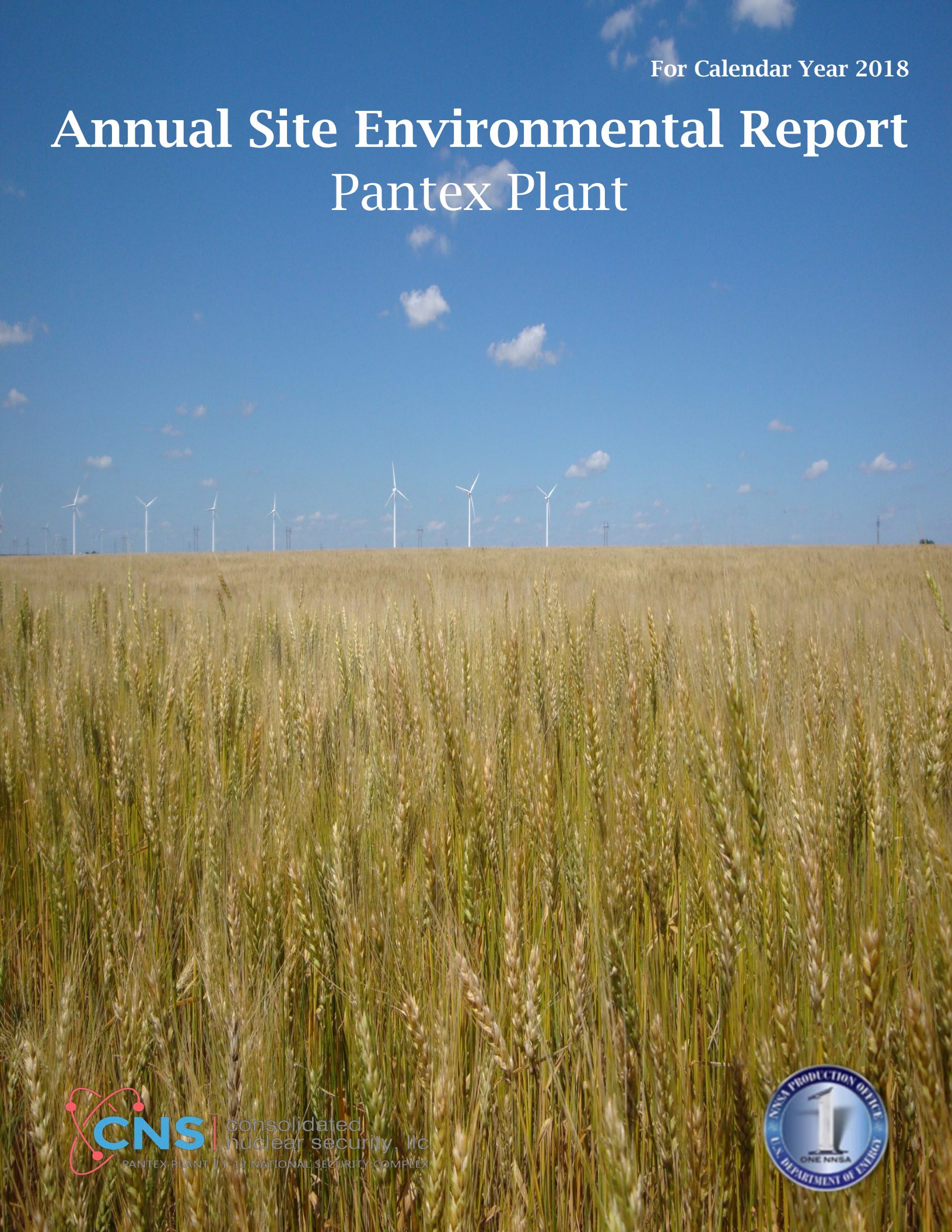


For Calendar Year 2018

# Annual Site Environmental Report Pantex Plant



It is the CNS environmental policy to protect the environment, prevent pollution, comply with applicable requirements, and continually take actions to conserve and improve our natural environment within which we perform our missions. The CNS Environmental Management System:

- Implements appropriate controls and actions to minimize environmental impacts caused by our activities, products, and services;
- Seeks continual improvement in protection of the environment through sustainability, pollution prevention/source reduction, recycling/reuse, and housekeeping excellence;
- Advances strict compliance with relevant environmental laws, regulations and other requirements;
- Provides the framework for setting and reviewing environmental objectives and targets; and
- Documents conformance to each element of the International Organization for Standardization (ISO), *Environmental Management Systems – Requirements with Guidance for Use (ISO 14001)*.

Morgan N. Smith  
Chief Executive Officer



**On the cover: On October 6, 2003, the Texas Commission on Environmental Quality (TCEQ) issued Pantex a Texas Land Application Permit (TLAP) that authorizes the beneficial reuse of treated wastewater for the purpose of agricultural irrigation. The wheat crop shown on the front cover is just one of the many crops that are grown at Pantex utilizing treated wastewater.**

# Site Environmental Report Pantex Plant 2018

## **Prepared for**

U.S. Department of Energy/National Nuclear Security Administration Production  
Office

## Prepared by

Environmental Compliance Department  
Waste Operations Department  
and the Environmental Projects Department

Consolidated Nuclear Security, LLC  
(CNS Pantex) Amarillo, Texas 79120-0020

<https://pantex.energy.gov>

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**Help Us Make This Site Environmental Report More Useful For You!**

We want this summary to be easy to read and useful. To help continue this effort, please take a few minutes to let us know if this annual report meets your needs. Please tear out this page and mail or fax it to:

CNS Pantex Plant  
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**1. How do you use the information in this summary? Please circle.**

- To become more familiar with Pantex Plant monitoring
- To help me make a decision about moving to the Texas Panhandle
- To send to others outside the Texas Panhandle
- To prepare for public meetings
- Other (please explain)

**2. What parts of the summary do you use? Please circle.**

- Pantex Plant overview/mission
- Site management
- Environmental compliance
- Environmental monitoring
- Quality assurance
- Regulatory oversight
- Current issues and actions

**3. Does this guide contain?**

Enough detail                      Too much detail                      Too little detail

Comments:

**4. If you could change this report to make it more readable and useful to you, what would you change?**

What is your affiliation? Please circle.

- |                                  |                      |
|----------------------------------|----------------------|
| Pantex contractor                | DOE                  |
| State agency                     | Federal agency       |
| Public interest group            | Member of the public |
| Member of Native American Nation | Local government     |
| University                       | Industry             |

Other Comments:

Thank you!

**Annual Site Environmental Report for Pantex Plant**

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## Abbreviations and Acronyms

AEC	Atomic Energy Commission
AFV	Alternative Fuel Vehicle
ALARA	As Low As Reasonably Achievable
AQMR	Air Quality Management Requirement
ARPA	Archaeological Resource Protection Act
B&W	Babcock & Wilcox
BOD	Biochemical Oxygen Demand
CAA	Clean Air Act
CAP	Corrective Action Plan
CAR	Corrective Action Report
CCL	Contaminant Candidate List
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CNS	Consolidated Nuclear Security
COC	Chain of Custody
COC	Contaminants of Concern
COD	Chemical Oxygen Demand
CoE	Center of Excellence
CP	Compliance Plan
CRM	Cultural Resource Management
CWA	Clean Water Act
CY	Calendar Year
D&Z	Day & Zimmerman
DBP	Disinfectant By-Product
DCS	Derived Concentration Standard
DOE	U.S. Department of Energy
DOECAP	DOE Consolidated Audit Program
DOT	Department of Transportation
DPS	Department of Public Safety
DQO	Data Quality Objective
EA	Environmental Assessment
ECD	Environmental Compliance Department
EIS	Environmental Impact Statement
EMCS	Energy Management Control System
EMS	Environmental Management System
EO	Executive Order
EPA	U.S. Environmental Protection Agency
ERA	Ecological Risk Assessment
ERDA	Energy Research and Development Administration
ESA	Endangered Species Act
FGZ	Fine Grained Zone
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FM	Farm-to-Market Road
GHG	Greenhouse Gas
GPS	Global Positioning Satellite
GWPS	Groundwater Protection Standard
HAP	Hazardous Air Pollutant
HE	High Explosives
HEPA	High-Efficiency Particulate Air
HEPF	High Explosives Pressing Facility

## Abbreviations and Acronyms

HPFL	High Pressure Fire Loop
HRO	High Reliability Organization
HVAC	Heating-Ventilation Air Conditioning
HWTPF	Hazardous Waste Treatment & Processing Facility
IAG	Interagency Agreement
ICRP	International Commission of Radiological Protection
IEDB	Integrated Environmental Database
ISB	In-Situ Bioremediation
ISM	Integrated Safety Management
ISO	International Organization for Standardization
IWQP	Inland Water Quality Parameter
LCR	Lead & Copper Rule
LQAP	Laboratory Quality Assurance Program
LTM	Long-Term Monitoring
LTS	Long-Term Stewardship
M&E	Material and Equipment
MAPEP	Mixed Analyte Performance Evaluation Program
MCL	Maximum Contaminant Level
MDL	Method Detection Limit
MEI	Maximally Exposed Individual
MHC	Mason and Hanger Corporation
MOU	Memorandum of Understanding
MSGP	Multi-Sector General Permit
NCR	Non-conformance Report
NELAC	National Environmental Laboratory Accreditation Conference
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NIST	National Institute of Standards and Technology
NNSA	National Nuclear Security Administration
NPL	National Priorities List
NPO	National Nuclear Security Administration Production Office
NPS	National Park Service
NRF	NEPA Review Form
NWS	National Weather Service
O&M	Operation and Maintenance
OSSF	On-Site Sewage Facility
P1PTS	Playa 1 Pump & Treat System
P2	Pollution Prevention
PA/CRMP	Programmatic Agreement/Cultural Resources Management Plan
PBR	Permits-By-Rule
PCB	Polychlorinated Biphenols
PE	Performance Evaluation
PER	Problem Evaluation Report
PIDAS	Perimeter Intrusion Detection and Surveillance
PM	Particulate Matter
PMU	Playa Management Unit
PPOA	Pollution Prevention Opportunity Assessment
PQL	Practical Quantitation Limit
PRB	Permeable Reactive Barrier
PREP	Pantex Renewable Energy Project
PST	Petroleum Storage Tank
PTE	Potential to Emit
PTT	Platform Transmitter Terminal



## Abbreviations and Acronyms

PWS	Public Water System
QA	Quality Assurance
QC	Quality Control
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RER	Replicate Error Ratio
ROD	Record of Decision
RRS	Risk Reduction Standard
RSD	Radiation Safety Department
SA	Supplement Analysis
SAP	Sampling & Analysis Plan
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SDS	Safety Data Sheets
SDZ	Surface Danger Zone
SEISB	Southeast In-Situ Bioremediation
SEPTS	Southeast Pump and Treat System
SHPO	State Historic Preservation Office
SOC	Synthetic Organic Chemicals
SMP	Site Management Plan
SOP	Standard Operating Procedures
SOW	Statement of Work
STEM	Science, Technology, Engineering, and Math
SVE	Soil Vapor Extraction
SVOC	Semi-Volatile Organic Compound
SWEIS	Site-wide Environmental Impact Statement
SWMU	Solid Waste Management Unit
TAC	Texas Administrative Code
TCAA	Texas Clean Air Act
TCEQ	Texas Commission on Environmental Quality
TDSHS	Texas Department of State Health Services
THM	Total Trihalomethanes
TLAP	Texas Land Application Permit
TLD	Thermoluminescent Dosimeter
TNI	The NELAC Institute
TPDES	Texas Pollutant Discharge Elimination System
TPWD	Texas Parks and Wildlife Department
TPY	Tons per Year
TRI	Toxic Chemical Release Inventory
TSCA	Toxic Substances Control Act
TSS	Total Suspended Solids
TTRF	Texas Tech Research Farm
TTU	Texas Tech University
TWQP	Texas Water Quality Permit
TYSP	Ten Year Site Plan
UCL	Upper Confidence Limit
UIC	Underground Injection Control
USACE	U.S. Army Corps of Engineers
VOC	Volatile Organic Compound
VMF	Vehicle Maintenance Facility
WWTF	Wastewater Treatment Facility

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## Acknowledgments

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The results presented in this report are from samples collected by the Environment, Safety & Health Division's Environmental Projects Department. Many other staff members in the Environmental Departments worked on validating data, conducting quality checks, and making the data available electronically. The *2018 Annual Site Environmental Report for Pantex Plant* was reviewed for classification issues and it was determined to be unclassified.

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## Glossary

**Activity** - The rate of disintegration or transformation of radioactive material, generally expressed in units of Curies (Ci). The official SI unit is the Becquerel (Bq). One Bq (one disintegration or transformation per second) is equivalent to  $2.7 \times 10^{-11}$  Ci.

**ALARA** - An acronym and phrase, "As Low As Reasonably Achievable," used to describe an approach to radiation exposures and emission control or management whereby the exposures and resulting doses to the public are maintained as far below the specified limits as economic, technical, and practical considerations will permit. ALARA is not a dose limit.

**Aliquot** - Contained an exact number of times in something else - used of a divisor or part.

**Alpha particle** - Type of particulate radiation (identical to the nucleus of the helium atom) consisting of two protons and two neutrons.

**Ammonium nitrate** - A colorless crystalline salt ( $\text{NH}_4\text{NO}_3$ ) used in explosives, fertilizers, and veterinary medicine.

**Anion** - A negatively charged ion that migrates to an anode, as in electrolysis.

**ANSI** - American National Standards Institute, a voluntary standards organization; Administrator, U.S. Technical Advisory Group to the International Organization for Standardization (ISO).

**Aquifer** - Rock or sediment in a formation, group of formations, or part of a formation that is saturated and sufficiently permeable to transmit economic quantities of water to wells and springs.

**Archeology** - The scientific discipline responsible for recovering, analyzing, interpreting, and explaining the unwritten portion of the prehistoric and historic past.

**Archival** - Relating to, held in, or constituting archives, which are places where public records or historic documents are preserved.

**Artifact** - Any object manufactured or modified by human beings.

**Asbestos** - Group of naturally occurring minerals that separate into fibers. The asbestos family includes actinolite, anthophyllite, chrysotile, crocidolite, and tremolite.

**Assembly** - The process of putting together a nuclear weapon or nuclear weapon component. This process takes place at the Pantex Plant.

**Background or control samples** - Samples obtained from a background sampling location for comparison with samples obtained at or near Pantex. Background or control samples are not expected to be affected by Pantex operations. The U.S. Department of Agriculture Research Station and the Texas Agri-Life Bush Research Farm at Bushland, Texas, have often been used as a control or background location.

**Background radiation** - Ionizing radiation which is in the natural environment, including cosmic rays and radiation from the naturally radioactive elements, both outside and inside the bodies of humans and animals.

**Becquerel (Bq)** - The Système International d'Unités (SI units) unit of radioactivity is the becquerel, defined as one nuclear disintegration per second; therefore, one Curie (Ci) is equivalent to  $3.7 \times 10^{10}$  Bq.

**Best Management Practices** - Practices that are not required by law, regulation, or permit, but are designed to help ensure that the Pantex Plant produces the highest quality services and products.

**Beta particle** - Type of particulate radiation emitted from the nucleus of an atom that has a mass and charge equal in magnitude to that of the electron.

**Biomass** - Literally, “living weight,” refers to mass having its origin as living organisms.

**Biome** - Recognizable community units formed by the interaction of regional climate, regional biota, and substrate, e.g., the same biome units generally can be found on different continents at the same latitudes with approximately the same weather conditions and where topography is similar. Biomes are the largest land community units recognized.

**Biota** - Living organisms.

**Biota Concentration Guide** – The limiting concentration of a radionuclide in soil, sediment, or water that would not cause dose limits for protection of aquatic and terrestrial biota to be exceeded. An analogue to the Derived Concentration Guide (DCG) used for human exposure.

**Blackwater Draw Formation** - Quaternary formation consisting primarily of pedogenically modified eolian sands and silts interbedded with numerous caliche layers. The Blackwater Draw Formation overlies the Tertiary Ogallala Formation at Pantex.

**Burning Ground** - The Pantex Plant location where thermal processing (burning) of high explosives (HE) is conducted.

**Calibration** - The adjustment of a measurement system and the determination of its accuracy using known sources and instrument measurements. Adjustment of flow, temperature, humidity, or pressure gauges and the determination of system accuracy should be conducted using standard operating procedures and sources that are traceable to the National Institute of Standards and Technology.

**Categorical Exclusion** – Categorical exclusions are categories of actions under the National Environmental Policy Act (NEPA) that DOE has determined, by regulation, do not individually or cumulatively have a significant effect on the human environment and for which; therefore, neither an environmental assessment nor an

environmental impact statement normally is required.

**Cation** – A positively charged ion that in an electrolyte moves toward a negative electrode.

**Cell** - (1) This is the smallest unit capable of independent functioning. (2) A structure at Pantex in which certain nuclear explosive assembly or disassembly operations are conducted.

**Central flyway** - A major migratory route used by large numbers of migrating birds in fall and spring that crosses the central portion of North America from Canada to Mexico.

**Centripetal drainage** - The flow of water in a basin toward a central drain or sink, such as a pond or lake.

**Code of Federal Regulations (CFR)** - Final federal regulations in force: published in codified form.

**Composite samples** – Samples that contain a certain number of subsamples.

**Council on Environmental Quality (CEQ)** - Created, in the Executive Office of the President, by the National Environmental Policy Act (NEPA), such that its members are exceptionally well qualified to analyze and interpret environmental trends and information of all kinds; to appraise programs and activities of the federal government in the light of the policy set forth in Title I of NEPA; to be conscious of and responsive to the scientific, economic, social, aesthetic, and cultural needs and interests of the Nation; and to formulate and recommend national policies to promote the improvement of the quality of the environment.

**Cultural Resources** - Districts, sites, structures, and objects and evidence of some importance to a culture, a subculture, or a community for scientific, traditional, religious, and other reasons. These resources and relevant environmental data are important for describing and reconstructing past lifeways, for interpreting

human behavior, and for predicting future courses of cultural development.

**Depleted uranium** - Uranium for which the content of the isotope of <sup>235</sup>uranium is smaller than 0.7 percent; the level found in naturally occurring uranium (and thus generally synonymous with isotope <sup>238</sup>uranium).

**Derived Concentration Guide** - The concentration of the radionuclide in air or water that, under conditions of continuous exposure for one year by one exposure mode (for example, ingestion of water or breathing the air) would result in an effective dose equivalent of 100 mrem (0.1 rem or 1 mSv). Values for these concentrations are tabulated in DOE STD 1196 2011; Derived Concentration Technical Standard.

**Dismantlement** - The disassembly of a nuclear weapon no longer required by the DOD. This process takes place at the Pantex Plant.

**Dockum Group** - Triassic sedimentary rocks that underlie the Ogallala Formation at the Pantex Plant. The Dockum Group rocks consist of shale, clayey siltstone, and sandstone.

**Dose** - The quantity of ionizing radiation received. Often used in the sense of exposure dose (a measure of the total amount of ionization that the radiation could produce in air, measured in roentgens [R]). This should be distinguished from the absorbed dose (measured in rads) that represents the energy absorbed from the radiation per gram of any material. Furthermore, dose equivalent (or biological dose), given in rem, is a term used to express the amount of effective radiation when modifying factors such as quality factors have been considered. It is therefore a measure of the biological damage to living tissue from the radiation exposure.

**Duplicate sample** - A sample that is taken at the same location and the same site; it may be taken simultaneously or consecutively. This sample may be collected for the purpose of evaluating the performance of a measurement system or of the homogeneity of a sample population; i.e., to

determine whether the sample results are representative or an anomaly. The duplicates are supposed to be similar in terms of the population sampled.

**Ecosystem** - Living organisms and their nonliving (abiotic) environment functioning together as a community.

**Effective Dose Equivalent (EDE)** - The sum of the products of the exposures to individual organs and tissues and appropriate weighting factors representing the risk relative to that for an equal dose to the whole body.

**Effects Screening Levels (ESL)** - Guideline concentrations established by the TCEQ to evaluate the potential impacts of air pollutant emissions including acute and chronic health effects, odor nuisance potential, vegetation effects or corrosion effects. ESLs are set to provide a margin of safety below levels at which adverse effects are reported in scientific literature. This margin of safety is added to protect sensitive sub-populations, such as children, the elderly, and persons with pre-existing illnesses.

**Effluent** - A fluid discharged into the environment; an outflow of waste. Its monitoring is conducted at the point of release.

**Emission** - A substance discharged to the air.

**Emissions standards** - Legally enforceable limits on the quantities and/or kinds of air contaminants that can be emitted into the atmosphere.

**Encephalitis** - Inflammation of the brain. In the U.S., this is an acute, often fatal, viral disease of the central nervous system that is transmitted to humans by mosquitoes (arthropods) after a blood meal from infected horses or mules.

**Environmental Assessment** - A concise public document that a Federal agency prepares under NEPA to provide sufficient evidence and analysis to determine whether a proposed agency action would require preparation of an environmental

impact statement or a finding of no significant impact.

**Environmental Impact Statement** – The detailed written statement that is required by Section 102(2)(C) of NEPA for a proposed major federal action significantly affecting the quality of the human environment.

**Environmental Monitoring** - Sample collection and analysis of environmental media, i.e., air, water, soil, foodstuff, and biota for the purpose of assessing effects of operations at that site on the local environment. It consists of effluent monitoring and environmental surveillance.

**Environmental Protection Agency (EPA)** - Federal agency created to protect the nation's water, land, and air from pollution or environmental damage.

**Environmental Restoration (ER) Program** - Program at Pantex responsible for investigation and remediation of Solid Waste Management Units.

**Environmental Surveillance** - The collection and analysis of samples, or direct measurements of air, water, soil, foodstuff, and other media for the purpose of determining compliance with applicable standards and permit requirements, assessing radiation exposures of members of the public, and assessing the effects, if any, on the local environment.

**Ephemeral** - Lasting only a short period of time. Used in this document to describe water bodies that often does not have water year round. Typically, these water bodies have water following the wet seasons and then are dry during the dry seasons.

**Evapotranspiration** - The sum of evaporation, the process by which water passes from the liquid to the vapor state, and transpiration, the process by which plants give off water vapor through their leaves.

**Extirpate** – To destroy completely.

**Fauna** - Animal life, or animals as a whole, especially those that are characteristic of a region.

**Fecal coliform bacteria** - Simple organisms associated with the intestine of warm-blooded animals that are commonly used to indicate the presence of fecal material and the potential presence of organisms capable of causing human disease.

**Flora** - Plant life or plants as a whole, especially those that are characteristic of a region.

**Gamma ray (gamma radiation)** – High-energy, short wavelength electromagnetic radiation (a packet of energy) emitted from the nucleus. (Gamma radiation frequently accompanies alpha and beta emissions and always accompanies fission.) Gamma rays are very penetrating and can be stopped or shielded against by dense materials such as lead or uranium. Gamma rays are similar to X-rays, but are usually more energetic.

**Grab sample** - A single sample, collected at one time and place.

**Greenhouse Gases (GHGs)** – Chemical compounds found in the earth's atmosphere which absorb infrared radiation (heat) from the reflection of sunlight striking the earth's surface and cause rising temperatures. Some occur in nature (e.g., carbon dioxide, methane, and nitrous oxide), and others such as hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride are anthropogenic (man-made). For Federal agencies emissions of greenhouse gases are further classified as:

**Scope 1:** direct GHG emissions from sources that are owned or controlled by the Federal agency;

**Scope 2:** direct GHG emissions resulting from the consumption of purchased or acquired electricity, heat, or steam purchased by a Federal agency; and

**Scope 3:** GHG emissions from sources not owned or directly controlled by a Federal agency



but related to agency activities such as vendor supply chains, delivery services, and employee travel and commuting.

**Hantavirus Pulmonary Syndrome** - The Hantavirus is found in saliva, urine, or feces of various rodent species and is transmitted to humans by inhalation. It causes rapidly progressive pulmonary symptoms that result in serious illness. Human-to-human transmission has not been demonstrated.

**Hazardous material** - A material, including a hazardous substance, as defined by 49 CFR 171.8 that poses a risk to health, safety, and property when handled or transported.

**Hazardous waste** - Defined by 40 CFR Part 261, as any material that a) is a solid waste, and b) is a listed hazardous waste (Subpart D), or c) exhibits any of the characteristics of ignitability, corrosivity, reactivity or toxicity (Subpart C).

**Hemoglobin** - A protein found in red blood cells that transports oxygen.

**Herpesvirus** - Any virus belonging to the family Herpesviridae. It is basically a wildlife disease, and offers possible implications to research on human viruses.

**Herbicide** - A substance (usually chemical) used to destroy undesirable plants.

**Herpetofauna** - Reptiles (snakes, turtles, lizards, etc.) and amphibians (frogs, toads, salamanders).

**High explosives (HE)** - Any chemical compound or mechanical mixture which, when subjected to heat, impact, friction, shock, or other suitable initiation stimulus undergoes a very rapid chemical change with the evolution of large volumes of highly heated gases that exert pressure in the surrounding medium.

**Histopathology** - The science or study of dealing with the structure of abnormal or diseased tissue; examination of the tissue changes that accompany a disease.

**Historic** - Of, relating to, or existing in times postdating the development of written records. Historic cultural resources are all evidences of human occupations that date to recorded periods in history. Historic resources also may be considered to be archeological resources when archeological work is involved in their identification and interpretation.

**Industrial solid waste** - Solid waste resulting from or incidental to any process of industry or manufacturing, or mining or agricultural operations.

**Infrastructure** - The basic services, facilities and equipment needed for the functioning and growth of an area.

**Insecticide** - A substance used to destroy undesirable insects.

**Interim Stabilization Measure (ISM)** - Action taken to control or abate threats to human health and/or the environment from releases and/or to prevent or minimize the further spread of contamination while long-term remedies are pursued.

**International System of Units** - An internationally accepted coherent system of physical units, derived from the Meter, Kilogram, Second, Ampere (MKSA) System, using the meter, kilogram, second, ampere, kelvin, mole, and candela as the basic units (SI units) of the fundamental quantities length, mass, time, electric current, temperature, and luminous intensity. Abbr.: SI from the French "Système International d'Unités."

**Invertebrate** - Animals characterized by not having a backbone or spinal column, including a wide variety of organisms such as insects, spiders, worms, clams, crayfish, etc.

**Isotope** - Any of two or more species of atoms of a chemical element with the same atomic number and position in the periodic table and nearly identical chemical behavior but with different numbers of neutrons in their nuclei, and thus

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differing atomic mass number and different physical properties.

**Lacustrine** - Pertaining to, produced by, or inhabiting a lake or lakes.

**Lagomorph** - Any of the various gnawing mammals in the order Lagomorpha, including rabbits, hares, and pikas.

**Less than 55-gallon Hazardous Waste Accumulation Sites** - Temporary hazardous or mixed waste accumulation points located at or near the point of generation to collect no more than a total of 55 gallons of hazardous waste or no more than 1 quart of acutely hazardous waste. This area must be under the control of the operator of the process generating the waste.

**Less than 90-Day Hazardous Waste Accumulation Sites** - These are temporary accumulation areas used to collect hazardous wastes for 90 days or less before transfer to an interim status or permitted hazardous waste processing or storage facility.

**Llano Estacado** - Spanish for “staked plains”, used to refer to the Southern High Plains.

**Low-level radioactive waste** - Waste containing radioactivity not classified as high-level, transuranic waste, spent nuclear fuel, or special by-product material.

**Mammal** - Animals in the class Mammalia that are distinguished by having self-regulating body temperature, hair, and in females, milk-producing mammary glands to feed their young.

**Matrix spike duplicates** - Used to evaluate the precision of a specific analysis.

**Maximum Contaminant Levels (MCLs)** - The maximum permissible level of a contaminant in water that is delivered to the free flowing outlet of the ultimate user of a public water system. MCLs are enforceable standards.

**Method Detection Limit** - A measure of instrument sensitivity using solutions that have

been subjected to all sample preparation steps for the method.

**Metric System** - See International System of Units.

**Mitigation** - The alleviation of adverse impacts on resources by avoidance through project redesign or project relocation.

**Mixed waste** - Waste containing both radionuclides as defined by the Atomic Energy Act, and hazardous constituents as defined by 42 USC 6901 et seq. and 40 CFR 261.

**Mortuary remains** - Human physical remains and associated artifacts that exist in prehistoric and historic temporal contexts.

**National Ambient Air Quality Standards (NAAQS)** - Standards developed, under the authority of the Clean Air Act by the Environmental Protection Agency, to protect the quality of the air we breathe. Standards are set for six pollutants: sulfur dioxide, particulate matter with a mean aerodynamic diameter of 10 microns or less, carbon monoxide, ozone, nitrogen dioxide, and lead.

**National Environmental Policy Act (NEPA)** - Federal statute promulgated under 40 CFR part 1500 through 1508; requires Federal facility actions be evaluated for environmental impacts, usually in the form of Environmental Impact Statements or Environmental Assessments. 10 CFR 1021 is DOE's Implementing Procedures for NEPA.

**National Pollutant Discharge Elimination System (NPDES)** - U.S. Federal Regulation (40 CFR, Parts 122 and 125) that requires permits for the discharge of pollutants from any point source into the waters of the United States.

**National Register of Historic Places (NRHP)** - A national list of districts, sites, buildings, structures, and objects significant in American history, architecture, archeology, engineering, and culture.

**Native American** - A tribe, people, or culture that is indigenous to the United States.

**Necropsy** - Autopsy, postmortem examination.

**Nuclear weapon** - Any weapon with a nuclear device designed specifically to produce a large release of energy (nuclear explosion) from the fission and/or fusion of atomic nuclei.

**Off-Normal Event** - Abnormal or unplanned events or conditions that adversely affect, potentially affect, or are indicative of degradation in, the safety, security, environmental or health protection performance or operation of a facility.

**Off-site** - Outside the Pantex Plant site boundary.

**On-site** - Within the Pantex Plant site boundary.

**Ogallala Formation** - Tertiary formation consisting of gravel, sand, silt, and clay. This is the principal geologic unit in the High Plains Aquifer. Comprises the Ogallala Aquifer in the Panhandle of Texas, the primary source of groundwater in the region. The top of the Ogallala Formation in large areas of Texas and New Mexico consists of a resistant caliche layer. The Ogallala Formation at Pantex overlies the Triassic Dockum Group strata and underlies the Quaternary Blackwater Draw Formation.

**Outfall** - The outlet of a body of water. In the surface water permitting program, the term outfall refers to the effluent monitoring location identified by the permit. An outfall may be “internal” (associated with a building) or “final” (the last monitoring point at Pantex.)

**Perched aquifer** - Groundwater separated from the underlying main body of groundwater, or aquifer, by unsaturated rock.

**Permian** - The last period of the Paleozoic era (after the Pennsylvanian) thought to have covered the span of time between 280 and 225 million years ago (Ma); also, the corresponding system of rocks. It is named after the province of Perm, Russia, where rocks of this age were first studied.

**Plague** - An acute infection caused by the bacterium *Yersinia pestis*. It is transmitted from rodent to humans by the bite of an infected flea. It is less commonly transmitted by direct contact with infected animals or airborne droplets. This disease is also manifested by an acute onset of fever followed by shock, multiple organ failure, and death; caught early, it is treatable with antibiotics.

**Playa** - A natural depression acting as a detention basin receiving surface runoff within a watershed area; an ephemeral lake.

**Plume** - An elongated pattern of contaminated air or water originating at a point source, such as a smoke stack or a hazardous waste disposal site.

**Plutonium** - A heavy, radioactive, manmade metallic element with atomic number 94. Its most important isotope is fissile <sup>239</sup>plutonium, which is produced by neutron irradiation of <sup>238</sup>uranium. The nuclei of all atoms of this isotope contain 94 protons and 145 neutrons.

**Pollution prevention** – The process of reducing and/or eliminating the generation of waste materials through source reduction, process modification, and recycling/reuse to minimize environmental or health hazards associated with hazardous wastes, pollutants or contaminants.

**Potable** - Suitable for drinking.

**Potentially interested parties** - Under the National Historic Preservation Act (NHPA), organizations that have requested to be informed of Federal actions at a particular site.

**Practical Quantitation Limit (PQL)** - The Final Risk Reduction Rule Guidance is used to identify the quantifiable limit of detection for sampled constituents at Pantex. This limit is defined as Practical Quantitation Limit. A PQL is the lowest level that can be accurately and reproducibly quantified.

**Prehistoric** - Of, relating to, or existing in times antedating written history. Prehistoric cultural

resources are those that pre-date written records of the human cultures that produced them.

**Process knowledge** - Used to characterize a waste stream when it is difficult to sample because of physical form, the waste is too heterogeneous to be characterized by one set of samples, or the sampling and analysis of the waste stream results in unacceptable risks of radiation exposure.

**Programmatic Agreement** - The document outlining specific plans for the management of cultural resources at the Pantex Plant before the long-term Cultural Resource Management Plan was implemented. The parties to the agreement were the U.S. Department of Energy, the President's Advisory Council on Historic Preservation, and the Texas State Historic Preservation Office.

**Pseudorabies** - A highly contagious disease affecting cattle, horses, dogs, swine, and other mammalian species, caused by porcine herpes virus 1, which has its reservoir in swine. In species other than swine, pseudorabies is highly fatal.

**Pullman soil series** - Silty clay loams; soils found in the interplaya areas at the Pantex Plant.

**Quaternary** - The most recent of the three periods of the Cenozoic Era in the geologic time scale. It follows the Neogene Period and spans from  $2.588 \pm 0.005$  million years ago to the present. It is divided into two epochs: the Pleistocene and the Holocene.

**Rabies** - A rapidly fatal disease of the central nervous system that may be transmitted to any warm-blooded animal. The disease starts with a fever, headache, muscle aches, nausea, and vomiting. It progresses to agitation, confusion, combativeness, increased salivation and decreased swallowing, followed by coma and death. It is transmitted to humans by the bite of an infected dog, cat, skunk, wolf, fox, raccoon, or bat.

**Radiation (nuclear)** - Particles (alpha, beta, neutrons) or photons (gamma) emitted from the nucleus of an unstable (radioactive) atom as a result of radioactive decay. It does not include non-ionizing radiation, such as microwaves or visible, infrared or ultraviolet light.

**Radioactive** - The state of emitting radiation in the form of waves (rays) or particles.

**Radioactivity** - The spontaneous emission of radiation, generally alpha or beta particles, often accompanied by gamma rays, from the nucleus of an unstable isotope.

**Randall soil series** - Clay soils present in the playa bottoms at the Pantex Plant.

**Raptor** - Birds of prey including various species of hawks, falcons, eagles, vultures and owls.

**Replicate analysis** - A repeated operation occurring within an analytical procedure, e.g., two or more analyses for the same constituent in an extract of a single sample. Replicate environmental samples measure the overall precision of the sampling or analytical methods, while replicate analyses are identical analyses carried out on the same sample multiple times. They measure analytical laboratory precision only.

**Resource Conservation and Recovery Act (RCRA)** - Federal statute which governs current and planned hazardous waste management activities.

**Risk Reduction Rules** - 30 TAC 335 Subchapter S, outline three risk reduction levels to be considered relative to the corrective measures.

**Risk Reduction Standard 1** - Closure/remediation to background levels by removing or decontaminating all waste, waste residues, leachate, and contaminated media to levels unaffected by waste management activities.

**Risk Reduction Standard 2** - Closure/remediation to health-based standards and criteria by removing,

containing, or decontaminating all waste, waste residues, leachate, and contaminated media to meet standards and criteria such that any substantial present and future threats to human health and the environment are very low.

**Risk Reduction Standard 3** - Closure/remediation with controls, which entails removal, containment, or decontamination of waste, waste residues, leachate, and contaminated media to such levels and in such a manner that any substantial present or future threats to human health and the environment are reduced to an acceptable level, based on use.

**Sanitization** - The irreversible modification or destruction of a component or part of a component of a nuclear weapon, device, trainer or test assembly, as necessary, to prevent revealing classified or otherwise controlled information, as required by the Atomic Energy Act of 1954, as amended.

**Saturated zone** - The zone in which the voids in the rock or soil are filled with water at a pressure greater than atmospheric. The water table is the top of the saturated zone in an unconfined aquifer.

**Sedimentation** - The process of deposition of sediment, especially by mechanical means from a state of suspension in air or water.

**Seismic** - Pertaining to any earth vibration, especially an earthquake.

**Sievert (Sv)** - The Système International d'Unités (SI units) unit of equivalent dose. One sievert is equivalent to 100 rem.

**Site** - A geographic entity comprising leased or owned land, buildings, and other structures required to perform program activities.

**Site (archeological)** - Any area or location occupied as a residence or used by humans for a sufficient length of time to leave physical remains or traces of occupancy. The sites are extremely

variable in size and may range from a single hunting camp to an extensive land surface with evidence of numerous settlements and activities. The site(s) may consist of secondarily deposited archeological remains.

**Slug test** - An aquifer test made either by pouring a small instantaneous charge of water into a well or by withdrawing a slug of water from the well. The rate of recovery of the water table to equilibrium conditions is monitored as the stress is applied to the aquifer. Information from slug tests can be used to estimate the hydraulic conductivity of the aquifer.

**Solid Waste Management Unit (SWMU)** - Any unit from which hazardous constituents may migrate, as defined by RCRA. A designated area that is, or is suspected to be, the source of a release of hazardous material into the environment that will require investigation and/or corrective action.

**Split** - One larger sample is split into "equal" parts. The goal of a split sample is to evaluate analytical accuracy. If a sample is split into two parts: one may go to the contractor, one to the regulator; or the two parts may go to two different labs for comparison purposes, or one may be sent to a laboratory for analysis; the second one held for later confirmatory analysis, or in case the first one is lost/broken.

**Standard deviation** - The absolute difference between one of a set of numbers and their means. It is a statistic used as a measure of dispersion in a distribution, the square root of the arithmetic average of the squares of the deviations from the mean.

**Storm water** - A precipitation event that leads to an accumulation of water; it includes storm water runoff, snowmelt runoff, surface runoff, and drainage.

**Supplement Analysis** - A document that DOE prepares in accordance with DOE NEPA regulations (10 CFR 1021.314(c)) to determine whether a supplemental or new EIS should be

prepared pursuant to CEQ NEPA regulations (40 CFR 1502.9(c)).

**Surface water** - Water that is open to the atmosphere and subject to surface runoff. Surface water includes storm water.

**Tertiary** - The first period of the Cenozoic era (after the Cretaceous of the Mesozoic era and before the Quaternary) thought to have covered the span of time between 65 and 2 Ma; also, the corresponding system of rocks.

**Texas Commission on Environmental Quality (TCEQ)** - The state agency responsible for the environmental quality of Texas. TCEQ has the lead regulatory role for RCRA-regulated waste generated at the Pantex Plant.

**Thermoluminescent Dosimeter (TLD)** - A device containing crystalline materials that, when struck by radiation, contain more energy than in their normal state. At the end of the measurement period, heat is used to anneal the crystals and free the energy, which emerges as a light pulse. The pulse is then mathematically converted to the dose received by the TLD. Correction factors in the conversion equation are adjusted for various filters, TLD crystal elements and incident radiation. The device can either be carried by a radiation worker, or, as used in this document, placed at a specific location to measure the cumulative radiation dose.

**Thorium** - A radioactive metallic element that occurs combined in minerals and is usually associated with rare earth elements. Thorium's atomic number is 90.

**Toxic Substances Control Act (TSCA)** - Federal statute that establishes requirements for identifying and controlling toxic chemical hazards to human health and the environment.

**Tracer** - A labeled element used to trace the course of a chemical or biological process.

**Transuranic waste (TRU)** - Waste, without regard to source or form, that is contaminated with alpha-emitting radionuclides of atomic

number greater than 92 (uranium) and with half-lives greater than 20 years in concentrations greater than 100 nanocuries per gram.

**Triassic** - The first period of the Mesozoic era (after the Permian of the Paleozoic era, and before the Jurassic) thought to have covered the span of time between 225 and 190 Ma; also, the corresponding system of rocks.

**Trihalomethanes** - One of the families of organic compounds (methane derivatives) in which three of the four hydrogen atoms in methane are substituted by a halogen atom in the molecular structure.

**2,4,6-trinitrotoluene (TNT)** - A flammable toxic compound ( $C_7H_5N_3O_6$ ) obtained by nitrating toluene and used as a high explosive and in chemical synthesis.

**Trip blanks** - Provided for each shipping container to be analyzed for VOCs. Analytical results from trip blanks are used to evaluate whether there was any contamination of the sample bottle during shipment from the manufacturer, storage of the bottles, during shipment to the laboratories, or during analysis at the laboratory.

**Tritiated** - Containing tritium.

**Tritium** - A radioactive isotope of hydrogen with one proton and two neutrons in its nucleus. It is chemically identical to natural hydrogen and reacts with other substances and is absorbed into the body in the same manner. Elemental tritium incorporates readily with water to form tritiated water (HTO) or oxidized tritium. When this tritiated water is present in the gaseous state in the atmosphere, it is referred to as tritiated water vapor. Tritium decays by beta emission with a radioactive half-life of about 12.5 years.

**Tularemia** - A disease caused by *Francisella tularensis* and transmitted to humans by rodents through the bite of a deer fly, *Chrysops discalis*, and other bloodsucking insects; it can also be acquired directly through the bite of an infected

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animal or through handling of an infected animal carcass.

**Uranium** - A silvery, heavy, radioactive, polyvalent metallic element that is found especially in pitchblende and uraninite and exists naturally as a mixture of three isotopes of mass number 234, 235, and 238 in the proportions of 0.006 percent, 0.71 percent, and 99.28 percent, respectively. Uranium has an atomic number of 92.

**Vadose zone** - Also called the unsaturated zone, the zone between the land surface and the water table. The pore spaces in the vadose zone contain water at less than atmospheric pressure, as well as air and other gases. Saturated bodies, such as perched aquifers, may exist in the vadose zone.

**Volatile organic compounds (VOCs)** - Organic compounds capable of being readily vaporized at normal temperatures and pressures. Examples are benzene, toluene, and carbon tetrachloride.

**Waste generator** - Any individual or group of individuals that generate radioactive, mixed, hazardous, or other types of wastes at the Pantex Plant.

**Waste minimization** - Refers to a practice that reduces the environmental or health hazards associated with hazardous wastes, pollutants, or contaminants after generation.

**Waste Tracking System Database** - Computerized log maintained by the Waste Operations Department.

**Watershed** - A ridge of high land dividing two areas that are drained by different river systems. It can also be the region draining into a river, river system, or body of water.

**Weapon component** - A part specifically designed for use in a weapon.

**Weir** - A fence or enclosure set in a waterway to raise the water level or to gauge or divert its flow.

**Wetlands** - Land or areas exhibiting hydric soil concentrations saturated or inundated soil during some portion of the year, and plant species tolerant of such conditions.

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**Chemicals, Elements, and Units of Measure**

ac	acres
Ag	silver
As	arsenic
Ba	barium
Be	beryllium
Bq	Becquerel
°C	degrees Celsius
Ca	calcium
Cd	cadmium
cfm	cubic feet per minute
Ci	Curie
cm	centimeter
CO	carbon monoxide
Cr	chromium
Cu	copper
cu yd	cubic yard
DMSO	dimethyl sulfoxide
DNX	hexahydro-1,3-Dinitroso-5-Nitro 1,3,5-triazine
dpm	disintegrations per minute
dps	disintegrations per second
$E \pm n$	exponential (E) is $10 \pm n$ where n is some number (see Appendix D: Helpful Information)
°F	degrees Fahrenheit
Fe	iron
ft	foot/feet
ft/sec	feet per second
ft <sup>2</sup>	square foot
ft <sup>3</sup>	cubic feet
g or gm	gram
g/dL	grams per deciliter
gal	gallon
gpd	gallons per day
gpm	gallons per minute
Hg	mercury
ha	hectares
hr	hour
HMX	octahydro-1,3,5,7-tetranitro 1,3,5,7-tetrazocine
in	inch(es)
K <sub>2</sub> O	potassium oxide
kg	kilogram
km	kilometer
kW	kilowatt
L	liter(s)
lb	pound
m	meter
m/s	meters per second
m <sup>2</sup>	square meter
m <sup>3</sup>	cubic meter (approx. 1.308 cubic yards)
Ma	million years ago
Mcf	thousand cubic feet
MEK	methyl ethyl ketone
MeV	Megavolt (a.k.a. Million electron volts)

## Chemicals, Elements, and Units of Measure

mg/dL	milligrams per deciliter
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mg/m <sup>3</sup>	milligrams per cubic meter
mi	mile
mi <sup>2</sup>	square mile
min	minute
MMBtu	one million British Thermal Units
Mn	manganese
MNX	hexahydro-1-Nitroso-3,5-Dinitro-1,3,5-triazine
mph	miles per hour
mps	meters per second
mrem/hr	millirem per hour
mSv	millisievert
μCi	microcurie
μCi/ml	microcuries per milliliter
μg/L	micrograms per liter
μg/m <sup>3</sup>	micrograms per cubic meter
μL	microliter
μmho/cm	micromhos per centimeter
μR	microroentgen
NO <sub>2</sub>	nitrogen dioxide
NO <sub>x</sub>	nitrogen oxides
O <sub>3</sub>	ozone
Pb	lead
PCBs	polychlorinated biphenyls
pCi/g	picocuries per gram
pCi/mL	picocuries per milliliter
PETN	Pentaerythritol tetranitrate
PM <sub>10</sub>	particulate matter with a mean aerodynamic diameter ≤10 micrometers
ppb	parts per billion
ppm	parts per million
psf	pounds per square foot
psi	pounds per square inch
R	Roentgen
rem	Roentgen equivalent man
RDX	hexahydro-1,3,5-trinitro-1,3,5-triazine
scfm	standard cubic ft per minute
sec	second
SO <sub>2</sub>	sulfur dioxide
SO <sub>x</sub>	sulfur oxides
SU	standard units
Sv	Sievert
TCE	trichloroethylene/ethene
THF	tetrahydrofuran
Ti	titanium
TNB	trinitrobenzene
TNT	trinitrotoluene
TNX	hexahydro-1,3,5-Trinitroso-1,3,5-triazine
TPY	tons per year
yr	year
Zn	zinc
μ	micro (1.0 x 10 <sup>-6</sup> )

## Executive Summary

*The U.S. Department of Energy (DOE) oversees the operation of the Pantex Plant through the National Nuclear Security Administration (NNSA) Production Office (NPO). Consolidated Nuclear Security, LLC (CNS Pantex) is the managing and operating contractor of the Pantex Plant under Contract No. DE-NA0001942. CNS Pantex managed the environmental aspects of its operations in a manner consistent with Integrated Safety Management (ISM), applicable environmental regulations, and best management practices.*

### **The Purpose of the Report**

The 2018 Annual Site Environmental Report (ASER) for the Pantex Plant summarizes the efforts, data, and status of Pantex's environmental protection, compliance, and restoration programs for calendar year 2018. This report is prepared in accordance with DOE Order 231.1B, Environment, Safety and Health Reporting (DOEf), and DOE Order 458.1, Radiation Protection of the Public and the Environment (DOEi). These orders outline the requirements for environmental protection programs at DOE facilities to ensure that programs fully comply with applicable federal, state, and local environmental laws and regulations, executive orders, and DOE policies.

### **Major Site Programs**

The Pantex Plant, located northeast of Amarillo, Texas, is the nation's primary facility for the assembly, dismantlement, modification, and maintenance of nuclear weapons. The Plant also supports the nuclear weapons stockpile by developing, testing, and fabricating high explosives components. The Pantex Plant site encompasses about 7,284 hectares (ha) (18,000 acres [ac]), although most operations are conducted on 809 ha (2,000 ac) of land. The Plant maintains its own water treatment, sewage, and steam-generating plants. All work at Pantex is carried out under three overarching priorities: the safety and health of workers and the public, the security of weapons and information, and the protection of the environment.

### **Environmental Management and Monitoring**

The Pantex Plant has a comprehensive environmental program. The CNS environmental policy defines the program that contains components of environmental management including, but not limited to, regulatory compliance, pollution prevention, and environmental monitoring.

Data from the monitoring program obtained in past years are summarized in previous ASERs, which are available in the DOE Information Repositories at the Amarillo Public Library Downtown Branch, in Amarillo, Texas and at the Carson County Library in Panhandle, Texas. The monitoring data, as well as the ASERs since 2011, have been made available on the Pantex website at <http://pantex.energy.gov>. Previous years copies of the Pantex ASER are available by contacting Pantex Communications at [public\\_communications@cns.doe.gov](mailto:public_communications@cns.doe.gov).

The purpose of the environmental monitoring component of the Pantex's Environmental Management System (EMS) is to provide indicators of potential impact to human health and the environment and to demonstrate compliance with applicable regulatory limits. The environmental monitoring program monitors air, groundwater, drinking water, surface water, wastewater, soil, vegetation, and fauna. Pantex also operates a meteorological monitoring program that supports several of the requirements. Samples for 2018 were routinely collected at diverse locations, and 27,274 analyses were performed for substances including explosives, metals, organic chemicals, inorganic chemicals, radionuclides, and water quality indicators.

## Executive Summary

The Pantex EMS provides the foundation to administer sound stewardship practices that protect natural and cultural resources while cost-effectively demonstrating compliance with environmental, public health and resource protection laws, regulations, and DOE requirements. Notable accomplishments in 2018 relating to the Pantex EMS include:

- Pantex was extremely active in conducting environmental outreach initiatives. The initiatives included sponsoring public meetings to share status of environmental management activities including groundwater status meetings, Natural and Cultural Resource Program accomplishments, Earth Day activities, and participating in a Science Bowl Competition for area Middle Schools and High Schools.
- In early 2019, the 2019 Presidential Migratory Bird Federal Stewardship Award was to be named from among three finalists: DOE/NNSA/Pantex, the National Park Service, and the Bureau of Ocean Energy Management in Coordination with the United States Geological Survey. USDOE/NNSA/Pantex was named the recipient of the award.
- Pantex has diverted ~45% of Municipal Solid Waste, and construction & demolition material/debris originally earmarked for landfills and identified alternate pathways for beneficial reuse.
- Approximately 95 percent of all electronics procured have met criteria for being environmentally sustainable.
- Due to the Pantex Renewable Energy Project (PREP), CNS has reduced the purchase of energy from nonrenewable sources.

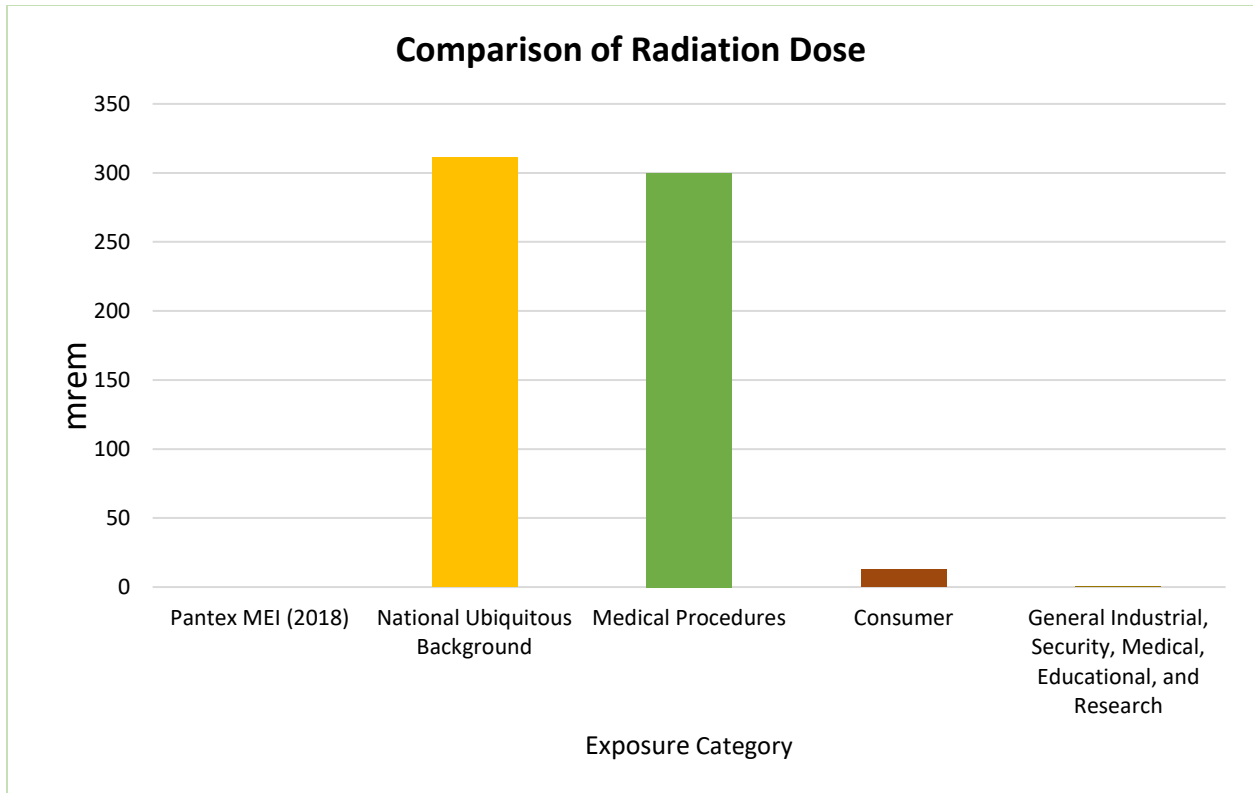
As required by DOE Order 436.1, Departmental Sustainability (DOEh), every three years the Pantex EMS is audited to determine the level of conformance with the International Organization for Standardization (ISO) 14001 Environmental Management Systems – Requirements with Guidance for Use (ISO). During 2018, an audit was conducted at the Pantex Plant. A “qualified” party outside the control or scope of the Pantex EMS Program performed the audit. The outcome of the audit indicated that Pantex continues to implement an EMS program that conforms to ISO 14001 standards. The next validation audit is scheduled to be performed in 2021.

### Radiation Dose

In 2018, the calculated annual radiation dose from releases to the atmosphere generated by Plant operations was  $1.70 \times 10^{-6}$  mrem/yr ( $1.70 \times 10^{-8}$  mSv/yr) for a hypothetical, maximally exposed member of the public (Table 1). This annual dose continues to be several orders of magnitude below the U.S. Environmental Protection Agency’s (EPA’s) standard for the air pathway of 10 mrem per year above background. The 2018 radiological monitoring results were consistent with those of previous years. The background radiation dose measured at control locations (excluding radon) were attributed to naturally occurring terrestrial and cosmic radiation, and averaged approximately 100 mrem for calendar year 2018. This is consistent with historical data. No unplanned radionuclide releases occurred at the Pantex Plant in 2018. The ambient air monitoring results for 2018 were generally similar to those from previous years. All results were below the applicable DOE Derived Concentration Standard (DCS).

**Table 1 – Pantex Radiation Dose for 2018 Compared to Regulatory Dosage Allowances**

Pantex Radiation Dose (mrem)	EPA Standard Air Pathway (mrem)	DOE Standard All Pathways (mrem)
0.00000170 ( $1.70 \times 10^{-6}$ )	10	100



**Figure 1 – Comparison of Radiation Dose**

**Drinking Water Monitoring**

Results from routine drinking water compliance monitoring in 2018 confirmed that the drinking water system at the Pantex Plant met water quality regulatory requirements. All analytical results for bacteria, chemical compounds, lead & copper, and disinfection by-products were below regulatory limits, and adequate levels of disinfectant were maintained in the distribution system. The Pantex Public Water System continues to be recognized by the Texas Commission on Environmental Quality (TCEQ) as a “Superior” supply system, the highest rating assigned by the state.

**Wastewater Monitoring**

During 2018, the Pantex Plant discharged more than 644 million liters (170 million gallons) of treated wastewater to the on-site playa lake. Pantex will reinitiate the beneficial reuse of its wastewater once the repairs to the subsurface irrigation system has been completed.

**Storm Water Monitoring**

Storm water sampling of run-off from industrial activities at the Pantex Plant is conducted in accordance with Texas Pollutant Discharge Elimination System (TPDES) Multi-sector General Permit No. TXR050000. Monitoring conducted during 2018 was consistent with past monitoring results. All sample results were within effluent limitations established by the general permit.

Environmental surveillance monitoring was conducted at the playas as a best management practice. Results obtained during 2018 were similar with past monitoring results. The playa data continues to support the position that operations at the Pantex Plant are not negatively affecting the water quality of the playas.

### **Soil Monitoring**

Results of soil monitoring conducted at the Pantex Burning Ground in 2018 were within established background comparison values. Results of soil monitoring conducted at the subsurface irrigation sites were consistent with previous year's results.

### **Flora and Fauna Monitoring**

Flora and Faunal surveillance is complementary to air, soil, and water monitoring in assessing potential short- and long-term effects of operations at the Pantex Plant on the environment. Animals at the Pantex Plant were sampled to determine whether Plant activities had an impact on them. Black-tailed prairie dogs and cottontail rabbits were the species selected for sampling because they interact with both primary (air, water) and secondary (vegetation) environmental media also being analyzed. Native vegetation and crops were sampled and compared to historical and control values.

### **Quality Assurance**

Chapter 13 of this report describes the Quality Assurance (QA) Program. QA is incorporated into all aspects of the CNS Pantex Environmental Program and includes performance checks, rigorous quality control checks, and intensive data management.

### **Environmental Remediation**

Historical waste management practices at the Plant resulted in impacts to on-site soil and perched groundwater. High explosives, solvents, and metals were found in the soil in the main operational areas, the Burning Ground, and in the perched groundwater beneath Pantex. Data collected in 2018 indicate that the groundwater remedies are protective of groundwater resources and all detections in the main drinking water aquifer remain below background or the groundwater protections standards.

Pantex has completed investigations and soil cleanup of all solid waste management units, with the exception of units that remain in an active status. This allowed Pantex to transition to Long-Term Stewardship (LTS) in 2009. A Record of Decision (ROD) was issued by the EPA in September 2008 that described the final remedial actions for all investigated units.

As part of the transition to LTS, Pantex operated and maintained the groundwater remediation systems, monitored the systems to determine effectiveness of the remedy, and maintained the soil remedies. Pantex installed two types of groundwater remediation systems: two in-situ bioremediation (ISB) and two pump and treat systems. Monitoring results indicate that the groundwater systems are effectively treating contamination and reducing saturated thickness in the perched aquifer as designed. The systems will continue to be monitored to determine the effectiveness of the remedy and to determine if changes to the systems will be required over time to ensure the continued success of remedial actions.

Soil remedies were also inspected, maintained, or scheduled for maintenance during 2018. The soil vapor extraction (SVE) system located at the Burning Ground continued to operate during 2018 and extracted over 381 kilograms (kg) (840 pounds [lb]) of volatile organics.

### **Pollution Prevention**

Efforts to reduce and eliminate waste from routine operations at the Pantex Plant have resulted in significant waste reductions over the last 30 years. The reduction of waste is even more important considering the Plant population and workload has increased as waste amounts have decreased. During 2018, Pantex

## Executive Summary

successfully recycled over 500,000 kg (1.1 million lb) of materials including over 17,690 kg (39,000 lb) of electronics.

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## Chapter 1 – Introduction

*The Pantex Plant site, consisting of 7,001 hectares (ha) (17,503 acres[ac]), is located 27 kilometers (km) (17 miles [mi]) northeast of Amarillo, Texas, in Carson County. The Plant was a World War II (WWII) munitions factory and was converted to a nuclear weapons assembly facility in 1951. Today, it is the nation’s primary assembly/disassembly facility supporting the nuclear weapons arsenal. Included within this chapter are brief discussions of the Plant location, history and mission, and facility description, followed by the climate, geology, hydrology, seismology, land use, and population of the area around the Pantex Plant.*

### 1.1 Site Location and Environmental Setting

The Pantex Plant site is located in Carson County in the Texas Panhandle, north of U.S. Highway 60. The Plant is located 27 km (17 mi)<sup>1</sup> northeast of downtown Amarillo (Figure 1.1). It is centered on approximately 7,001 hectare (17,503 acre) site. The site consists of land owned and leased by the Department of Energy (DOE). The DOE owns 4,681 ha (11,703 ac), including 3,683 ha (9,100 ac) in the main Plant area, 610 ha (1,526 ac) in four tracts purchased in the latter part of 2008 (east of Farm-to-Market [FM] 2373 near the main Plant area), and 436 ha (1,077 ac) at Pantex Lake, which is located approximately 4 km (2.5 mi) northeast of the main Plant area. There are no government industrial operations conducted at the Pantex Lake property. In addition, 2,347 ha (5,800 ac) of land south of the main Plant area are leased from Texas Tech University (TTU) for a safety and security buffer zone.

The Pantex Plant is located on the Llano Estacado (staked plains) portion of the Great Plains at an elevation of approximately 1,067 meters (m) (3,500 feet [ft]). The topography at the Pantex Plant is relatively flat, characterized by rolling grassy plains and numerous natural playa basins. The term “playa” is used to describe ephemeral shallow lakes, mostly less than 1 km (0.6 mi) in diameter. The region is a semi-arid farming and ranching area. The Pantex Plant is surrounded by agricultural land, but several industrial facilities are located nearby.

### 1.2 Facility History and Mission

The Pantex Plant is a government-owned, contractor-operated facility. DOE oversees the operation of the Pantex Plant through the National Nuclear Security Agency/Production Office (NNSA/NPO). At the end of 2018, approximately 4,750 persons (including Pantex contracted employees, federal employees, and subcontracted employees) were employed at the Plant. Mason & Hanger Corporation (MHC) was the Operation & Maintenance (O&M) contractor of the Pantex Plant from 1956 through May 1999 when it became a subsidiary of Day & Zimmermann, Inc. (D&Z). MHC (D&Z) was replaced as contractor by BWXT Pantex, LLC on February 1, 2001. BWXT Pantex combined elements of BWXT Technologies, Honeywell, and Bechtel. Effective in January 2008, the name of the company was officially changed to Babcock & Wilcox Technical Services Pantex, LLC (B&W Pantex). On July 1, 2014, CNS became the O&M contractor of the Pantex Plant.

From 1942 to 1945, the U.S. used the Pantex Ordnance Plant for loading conventional artillery shells and bombs. In 1951, the Atomic Energy Commission (AEC) arranged to begin rehabilitating portions of the original Plant and constructing new facilities for nuclear weapons operations. In 1974, the Energy Research and Development Administration (ERDA) replaced the AEC and took responsibility for the operation of

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<sup>1</sup> This report will generally use the convention of identifying a unit of measure in Système Internationale (abbreviated SI) units and providing the “English unit” equivalent in parentheses, for example “X kilometers (Y miles).” Because radiological measurements are compared to several limits that are generally specified using “English units,” the convention is reversed for those measurements, for example “X pCi/mL (Y Bq/m<sup>3</sup>).” In a few instances only an “English” unit is indicated in accordance with the most common technical usage.

Chapter 1 – Introduction

the Pantex Plant, and in 1977, the ERDA was replaced by the DOE. In 2000, the DOE created and designated the NNSA to manage the nuclear weapons facilities and laboratories.

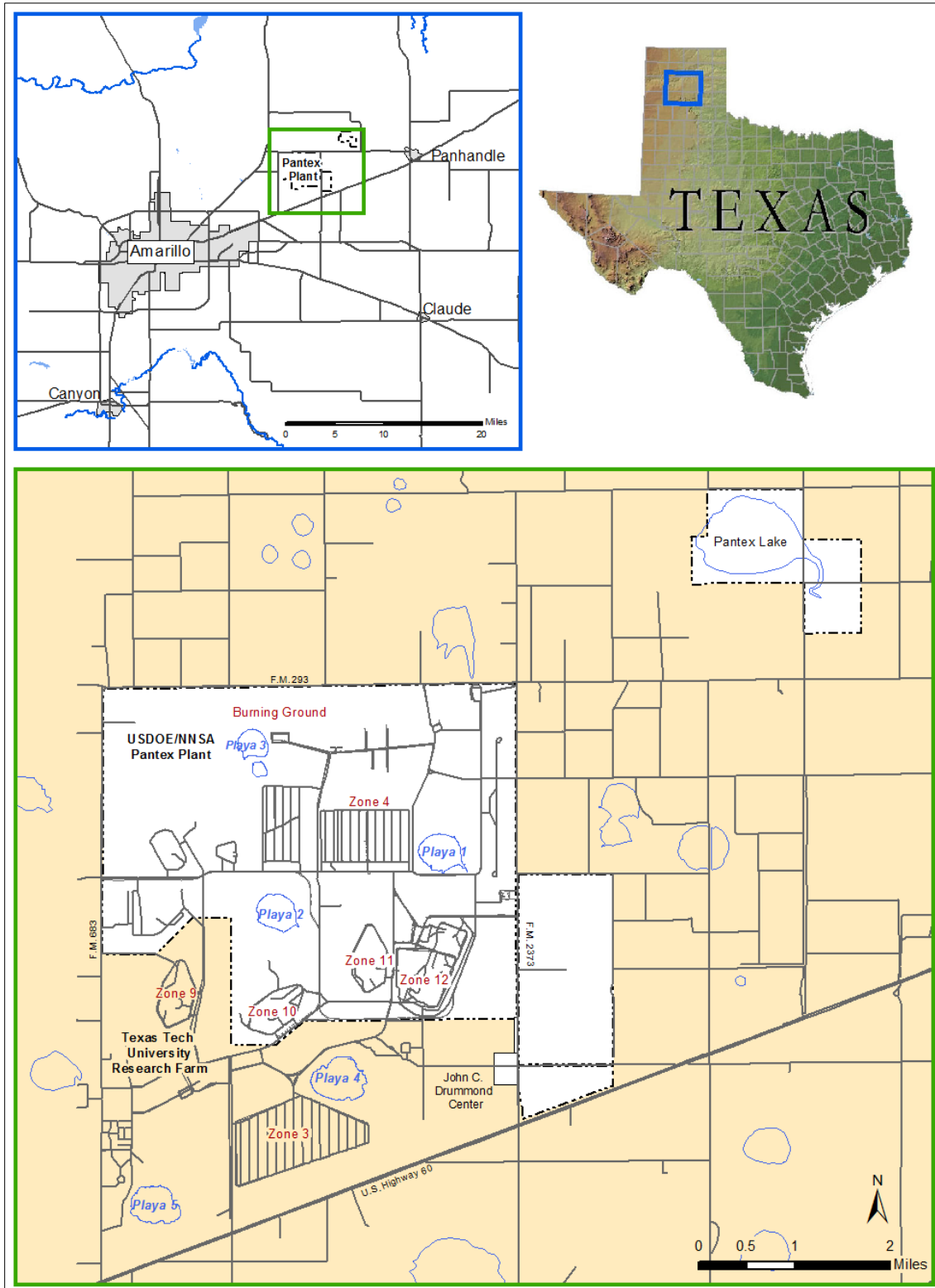


Figure 1.1 – Pantex Plant Site Location and Zones

The Pantex Plant's primary mission is to:

- **Assemble** nuclear weapons for the nation's stockpile,
- **Disassemble** nuclear weapons being retired from the stockpile,
- **Evaluate, repair, and retrofit** nuclear weapons in the stockpile,
- **Provide** interim storage for plutonium pits, and
- **Develop, fabricate, and test** chemical explosives and explosive components for nuclear weapons and to support DOE initiatives.

Weapon assembly, disassembly, maintenance, and evaluation activities involve short-term handling (but not processing) of encapsulated tritium, uranium, and plutonium, as well as a variety of nonradioactive hazardous or toxic chemicals. In addition, environmental restoration of the facility is an integral part of the DOE environmental management's mission to clean up its sites.

### 1.3 Facility Description

The Plant is composed of several functional areas, commonly referred to as numbered zones (see the lower portion of Figure 1.1). Overall, there are more than 630 buildings at the Plant. Many of these areas are grouped into large functional zones. Included within the zones are a weapons assembly/disassembly area, a weapons staging area, an area for experimental explosives development, a drinking water treatment plant, a sanitary wastewater treatment facility, a vehicle maintenance facility and administrative areas. Other functional areas include a utilities area for steam and compressed air, an explosives test-firing facility, a Burning Ground for thermally processing (i.e., burning or flashing) explosive materials, pump and treat groundwater remediation facilities, several agricultural tracts which are irrigated via a subsurface fluid distribution system, and landfills.

The weapons assembly/disassembly area covers approximately 80 ha (200 ac) and contains more than 100 buildings. Nuclear components, parts received from other DOE plants, chemical explosive components, and metal parts fabricated at the Pantex Plant can be assembled into nuclear weapons in this zone. Nuclear weapons are also disassembled there.

One zone is used for general warehousing and temporary holding (or staging) of weapons and weapon components awaiting movement to another area for modification, repair, or disassembly; for shipment to other DOE facilities for reworking; for shipment to a facility for sanitization; or for shipment to the military. The warehouse area is also used for interim storage of plutonium components from disassembly operations.

The explosives development area consists of facilities for synthesizing, formulating, and characterizing experimental explosives. This zone is under construction to become the Pantex Center of Excellence (CoE) for high explosives.

The explosives test-firing facility (commonly called "firing sites") includes several test-shot stands and small-quantity, test-firing chambers for measuring detonation properties of explosive components. The firing sites also include supporting facilities for setting up test-shots, interpreting the results, and sanitizing some components.

The Burning Ground is used for processing explosives, explosive components, and explosives-contaminated materials and waste by means of controlled open burning and flashing.

The land disposal area, north of Zone 10, is divided into two landfill sites, one of which currently receives nonhazardous solid wastes, primarily construction debris, and one that receives nonhazardous solid waste management unit debris. Before 1989, the Plant's domestic solid waste was sent to an on-site sanitary landfill for disposal. Since then, this waste has been processed to remove recyclable materials and the non-

recyclable material is sent to an off-site landfill. Practices preclude disposal of hazardous materials in on-site landfills; therefore, hazardous materials are transported off-site for disposal in accordance with applicable regulations.

Wastewater generated at the Pantex Plant is routed through a wastewater collection system to a wastewater treatment facility. On October 6, 2003, the Texas Commission on Environmental Quality (TCEQ) issued Pantex a Texas Land Application Permit (TLAP) that authorizes beneficial reuse of the wastewater for the purpose of agricultural irrigation via a subsurface fluid distribution system. Construction of the subsurface distribution system was completed prior to the end of 2004. During 2017, major filter leaks developed in the system and use of the system was temporarily discontinued. Repairs are being made to the system so that the treated effluent from the wastewater treatment facility and from the perched aquifer pump and treat systems will once again be discharged to this subsurface irrigation system. Pantex is also authorized to discharge wastewater to an on-site playa lake pursuant to a Texas Water Quality Permit (TWQP) issued by the TCEQ.

The drinking water system, common to many zones, consists of production wells, water treatment/pumping facilities, storage tanks, and associated distribution lines. This system also supplies water to the high-pressure fire protection system.

Land east of FM 2373 has not been assigned a formal zone designation. However, wind turbines for the generation of electrical power and associated support equipment have been installed for beneficial purposes.

#### **1.4 Climatological Data**

The area's climate is classified as semi-arid and is characterized by hot summers and relatively cold winters, with large variations in daily temperatures, low relative humidity, and irregularly spaced rainfall of moderate amounts. Three-fourths of the average precipitation, 50.1 centimeters, (cm) (19.7 inches [in]), generally occurs from April to September. This growing season precipitation commonly falls with thunderstorm activity. The average annual snowfall is 45.5 cm (17.9 in) (DOCa). Snow usually melts within a few days after it falls. Heavier snowfalls of 25.4 cm (10 in) or more, usually with near blizzard conditions, average once every five years and last two to three days. The potential gross lake surface evaporation in the area is estimated to be about 139.7 cm (55 in) (Bomar, 1995) or 280 percent of the average annual precipitation.

The Amarillo area is subject to extreme and rapid temperature changes, especially during the fall and winter months when cold fronts from the northern Rocky Mountain and Plains states sweep across the area. Substantial temperature drops within a 12-hour period are not uncommon (DOCa).

Humidity averages are low, occasionally dropping below 20 percent in the spring. Low humidity moderates the effect of summer afternoon high temperatures, permits evaporative cooling systems to be very effective, and provides many pleasant evenings and nights. Severe local storms are infrequent throughout the cool season, but occasional thunderstorms with large hail, lightning, and damaging wind occur during the warm season, especially during the spring. These storms are often accompanied by heavy rain, which can produce local flooding, particularly of roads and streets.

The Pantex Plant is located in an area with a relatively high frequency of tornadoes, convective wind events<sup>2</sup> and hail. An average of 17 tornadoes occurred each year in the 20 counties of the Texas Panhandle and the adjacent three counties of the Oklahoma Panhandle during the period between 1950 and 2018 (DOCb). While the threat of tornadoes is real, tornado occurrences in Amarillo are generally rare. Tornadoes are

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<sup>2</sup> High speed "straight-line" winds produced in the downdraft region of a thunderstorm.

most common from April to June. There were a total of 10 tornadoes reported in the Texas and Oklahoma Panhandles during 2018 (DOCb), approximately 1/6th of the number observed (58) during the very active year of 2007.

Based upon a review of the several monthly preliminary climatological data forms prepared by the National Weather Service (NWS) Forecast Office for Amarillo (located at Rick Husband International Airport) the mean temperature at the official NWS location during 2018 was 15.1 degrees Celsius (°C) (59.1 degrees Fahrenheit [°F]), slightly above the normal annual mean temperature in Amarillo of 14.1°C (57.3°F). During 2018, the official NWS rain gauge recorded 34.5 cm (13.6 in) of precipitation, approximately 70 percent of the normal amount. (DOCa).

The Pantex Plant maintains a meteorological monitoring station on the northeast corner of the site. The monitoring station is an instrumented 60 m (197 ft) tower located approximately 3.7 km (2.3 mi) north of the Zone 12 production area. The tower is equipped with two sets of sensors, located at the 10 and 60 m (33 and 197 ft) levels. Wind speed, wind direction, and temperature sensors are located at both levels and a relative humidity sensor is located at the 10 m (33 ft) level. A barometer measures the atmospheric pressure on the tower approximately 1.8 m (6 ft) above the tower base. A pyranometer (instrument that measures insolation or incoming solar radiation) and a tipping bucket rain gauge are located adjacent to the tower at approximately 1 m (3.3 ft) above ground level. Sensor measurements are generally taken every five seconds and stored in a “data logger” (mini-computer) located at the tower. Every 15 minutes, the system calculates statistical parameters (e.g., the average, maximum and standard deviation of the measurements from the previous 15 minute interval) for most sensors<sup>3</sup> and transfers the meteorological data for the latest 15 minute interval to a remote server. The data from the Plant’s meteorological tower are compared with those obtained from the Amarillo Airport NWS site located approximately 16 km (10 mi) to the west-southwest of the Pantex Plant’s meteorological tower to determine if the instrumentation is operating correctly. On a monthly basis, data outliers are identified and, when necessary, eliminated from the meteorological data set.

The frequencies of wind direction and speed during 2018 at the Pantex Plant are illustrated by the “wind rose” (graphical depictions of the annual frequency distribution of wind speed and the direction from which the wind has blown) in Figure 1.2. The figure indicates that, as in most previous years, a large percentage (approximately 55 percent) of the winds blew from southerly directions during the year.

Table 1.1 is a compilation of climatological data (temperature, relative humidity, precipitation; including the water equivalent of any snowfall and wind speed) for 2018 from the Pantex Plant or Amarillo Airport NWS meteorological instrumentation. The range of mean monthly temperatures during the year measured at the Pantex Plant’s meteorological tower and the monthly precipitation totals as measured at the Amarillo Airport NWS site are shown in Figures 1.3 and 1.4.

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<sup>3</sup> The number of one-hundredths of an inch of rain received (corresponding to the number of times the “tipping cup” has “tipped over”) during the 15 minute interval is the only parameter transferred for “precipitation”.

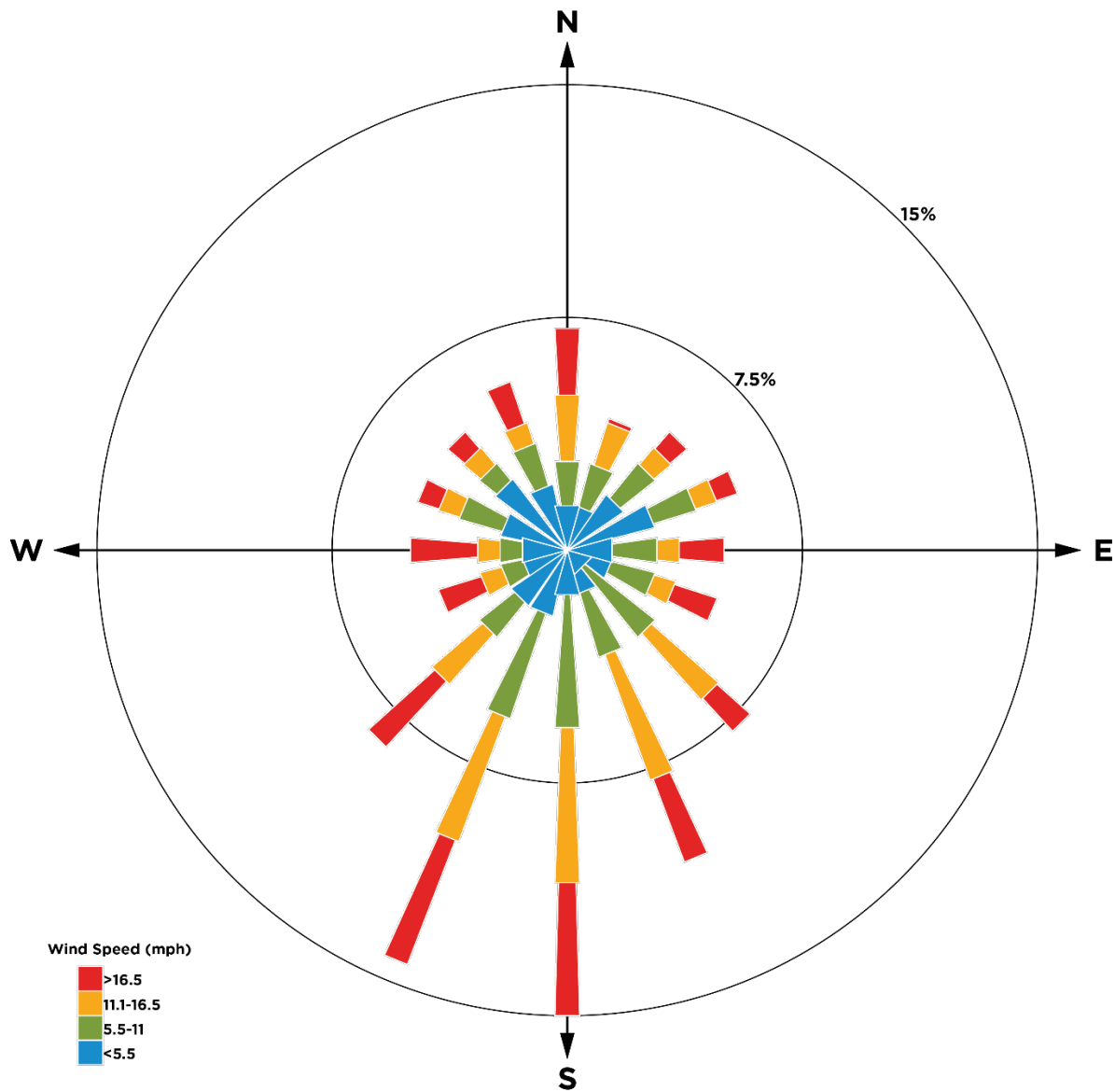


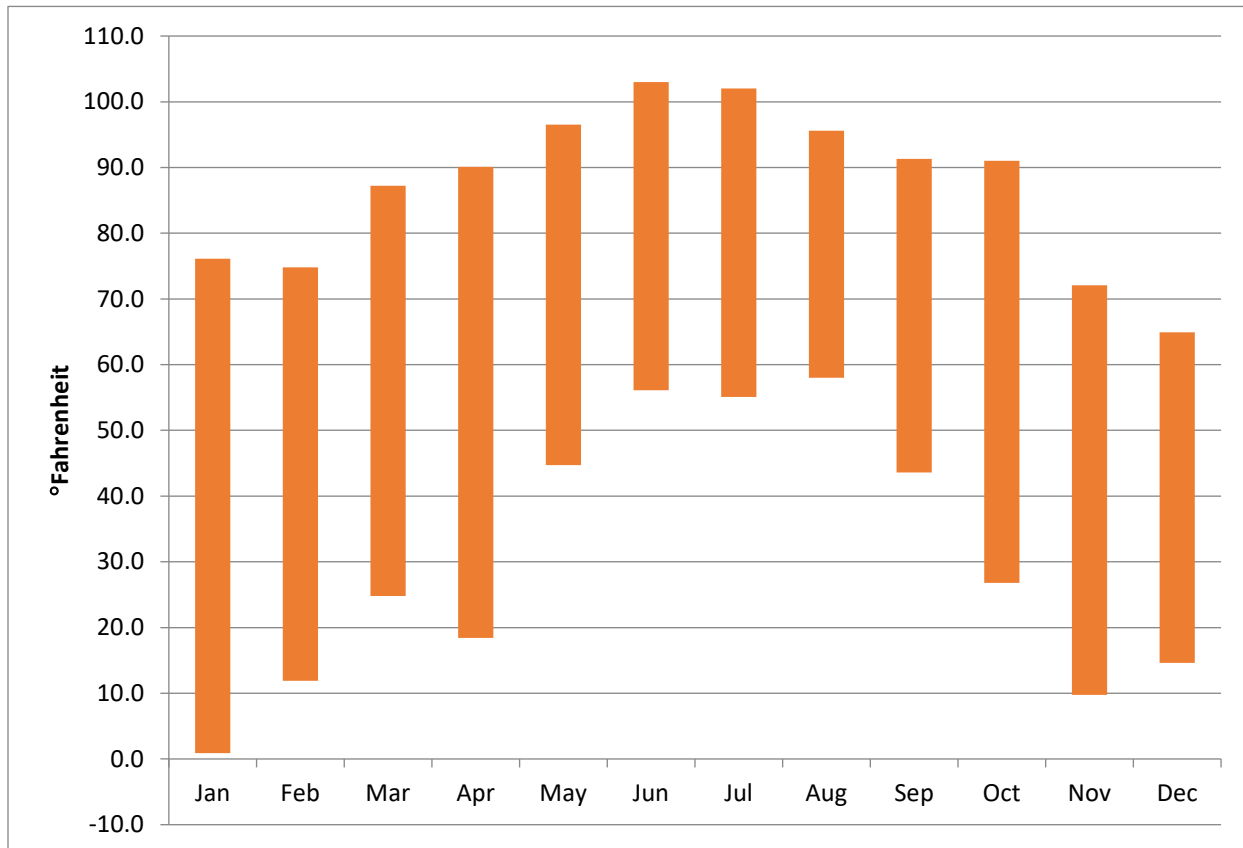
Figure 1.2 – Pantex Plant Annual Wind Rose for 2018

**Table 1.1 – Pantex 2018 Climatological Data by Month**

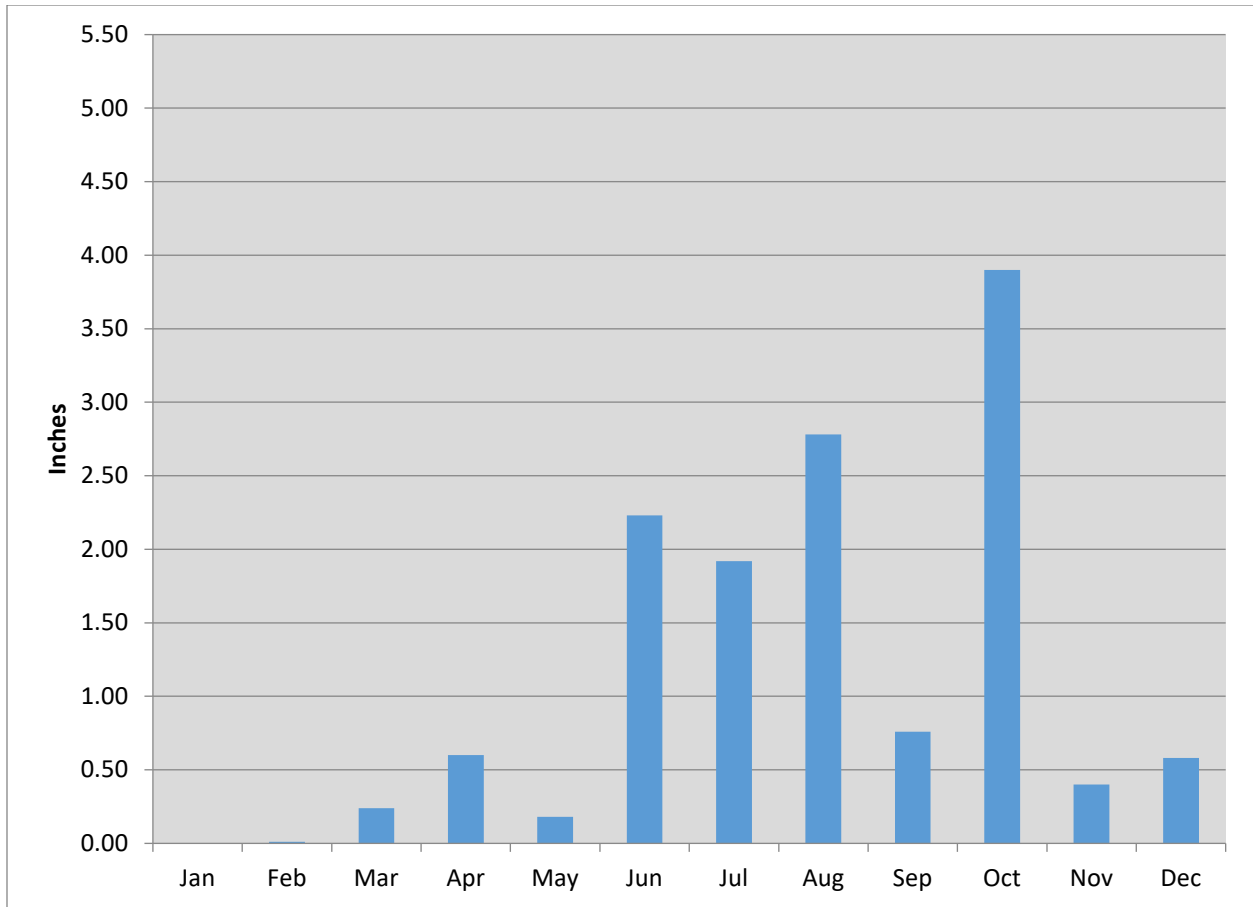
Month	Temperature °C (°F)			Mean Relative Humidity (percent)	Precipitation <sup>a</sup> cm (inches)	Wind Speed m/s (mph)	
	Maximum	Minimum	Mean Monthly			Mean	Maximum
January	24.5 (76.1)	-17.3 (0.9)	2.4 (36.3)	40	0.00 (0.00)	5.6 (12.5)	20.0 (44.8)
February	23.8 (74.8)	-11.2 (11.9)	3.4 (38.1)	50	0.03 (0.01)	6.1 (13.6)	16.3 (36.5)
March	30.7 (87.2)	-4.0 (24.8)	10.7 (51.3)	39	0.61 (0.24)	6.3 (14.1)	31.4 (70.3)
April	32.3 (90.1)	-7.6 (18.4)	11.7 (53.1)	42	1.52 (0.60)	7.9 (17.6)	32.2 (72.1)
May	35.8 (96.5)	7.1 (44.7)	22.7 (72.8)	43	0.46 (0.18)	6.9 (15.5)	39.4 (88.2)
June	39.4 (103.3)	13.4 (56.1)	25.5 (77.9)	48	5.66 (2.23)	6.3 (14.1)	17.6 (39.3)
July	38.9 (102.0)	12.8 (55.1)	25.8 (78.5)	50	4.88 (1.92)	4.3 (9.7)	16.6 (37.1)
August	35.3 (95.6)	14.4 (58.0)	24.7 (76.4)	53	7.06 (2.78)	4.9 (11.0)	23.6 (52.7)
September	32.9 (91.3)	6.4 (43.6)	20.4 (68.8)	64	1.93 (0.76)	5.4 (12.1)	24.1 (54.0)
October	32.8 (91.0)	-2.9 (26.8)	12.8 (55.0)	70	9.90 (3.90)	8.4 (18.8)	27.2 (60.8)
November	22.3 (72.1)	-12.4 (9.7)	5.4 (41.7)	58	1.02 (0.40)	6.9 (15.5)	26.5 (59.3)
December	18.3 (64.9)	-9.7 (14.6)	3.1 (37.6)	57	1.47 (0.58)	6.0 (13.4)	22.5 (50.4)
<b>Annual<sup>b</sup></b>			<b>14.1 (57.3)</b>	<b>51</b>	<b>34.54 (13.60)</b>	<b>5.9 (13.1)</b>	

<sup>a</sup> Includes water equivalent of snowfall. (Precipitation data from Amarillo Airport NWS site.)

<sup>b</sup> Total precipitation and the annual mean of parameter (when indicated) except for precipitation is indicated. Annual maximum and/or minimum values of temperature and wind speed may be obtained by reviewing the data in the appropriate column



**Figure 1.3 – Pantex Plant Monthly Temperature Range During 2018**



**Figure 1.4 – Amarillo National Weather Service (NWS) Precipitation During 2018**

### 1.5 Geology

The primary surface deposits at the Pantex Plant are the Pullman and Randall soil series, which grade downward to the Blackwater Draw Formation. This formation consists of about 15 m (50 ft) of interbedded silty clays with caliche and very fine sands with caliche.

Underlying the Blackwater Draw Formation, the Ogallala Formation consists of interbedded sands, silts, clays, and gravels. The base of the Ogallala Formation is an irregular surface that represents the pre-Ogallala topography. As a result, depths to the base of the Ogallala vary. At the Pantex Plant, the vertical distance to the base of the Ogallala varies from 90 m (300 ft) at the southwest corner to 220 m (720 ft) at the northeast corner of the property (Purtymun and Becker, 1982).

Underlying the Ogallala Formation is sedimentary rock of the Dockum Group, consisting of shale, clayey siltstone, and sandstone. The deep geology (1,200 m [4,000 ft]) below the Plant has a major influence on the natural radiation environment, because radon is released from the underlying granitic rocks.

### 1.6 Hydrology

The principal surface water feature on the Southern High Plains is the Canadian River, which flows southwest to northeast approximately 27 km (17 mi) north of the Plant. Plant surface waters do not drain into this system, but for the most part discharge into on-site playas. Storm water from agricultural areas at the periphery of the Plant drain into off-site playas. From the various playas, water either evaporates or infiltrates the soil. Two principal subsurface water-bearing units exist beneath the Pantex Plant and adjacent



areas: the Ogallala Aquifer and the underlying Dockum Group Aquifer. The perched aquifer lies within the vadose, or unsaturated, zone above the Ogallala Aquifer. The vadose zone consists of as much as 152 m (500 ft) of sediment that lies between the land surface and the Ogallala Aquifer.

### **1.6.1 Ogallala Aquifer**

The water-bearing units within the Ogallala Formation beneath the Pantex Plant are the perched aquifer in the vadose zone and the Ogallala Aquifer below. A discontinuous perched aquifer is present above the main zone of saturation. Perched aquifers form above clayey layers that have low permeability. Data collected from wells at the Pantex Plant indicate that the zone of saturation in the perched aquifer varies in thickness by as much as 15 to 25 m (70 ft). Depths from the surface to the perched aquifer range from 64 to 85 m (209 to 279 ft).

The main Ogallala Aquifer lies beneath the perched water zones. Depth to the main Ogallala Aquifer ranges from 102 to 152 m (335 to 500 ft) below ground surface. The saturated thickness varies from 12 to 122 m (39 to 400 ft) (PGCD, 1980). The aquifer is defined as the basal water-saturated portion of the Ogallala Formation and is a principal water supply on the High Plains. The regional gradient of the Ogallala Aquifer beneath the Pantex Plant trends from the southwest to the northeast, where the zone of saturation is thickest. The Plant's production wells are located in this northeast area. The City of Amarillo's Carson County Well Field is located north and northeast of the Pantex Plant's well field.

### **1.6.2 Dockum Group Aquifer**

The Dockum Group Aquifer lies under the Ogallala Formation at the Pantex Plant. Water contained in sandstone layers within the Dockum Group supplies domestic and livestock wells south and southeast of the Pantex Plant. Other wells reaching the Dockum Group Aquifer are located 16 km (10 mi) south and west of the Plant. The aquifer may be semi-confined with respect to the overlying Ogallala Aquifer because of lateral variations in the Ogallala and shale layers within the Dockum Group.

### **1.6.3 Water Use**

The major surface water source near the Pantex Plant is the Canadian River, which flows into man-made Lake Meredith approximately 40 km (25 mi) north of the Plant. Many local communities use water from Lake Meredith for domestic purposes, when water depth is sufficient. The major groundwater source in the vicinity of the Plant is the Ogallala Aquifer, which is used as a domestic source by numerous municipalities, and by industries in the High Plains. Historical groundwater withdrawals, and long-term pumping from the Ogallala in Carson County and the surrounding eight-county area, have exceeded the natural recharge rate to the Ogallala. These overdrafts have removed large volumes of groundwater from recoverable storage, and have caused substantial water-level declines.

The large demands of the Amarillo area, which are primarily agricultural, are responsible for the drop in the water table. The average change in “depth to water” from 1,209 Ogallala Aquifer observation wells in the Panhandle during 1988 to 1997 was 0.45 m (1.49 ft). Groundwater withdrawals from the Ogallala Aquifer in Carson County have averaged approximately 148 billion liters (L) (39 billion gallons [gal]) over the last several years. This groundwater withdrawal rate is more than 10 times greater than the estimated annual recharge rate of 1.4 billion L (358 million gal). Groundwater withdrawal rates are expected to decline each decade to approximately 79 billion L (21 billion gal) in 2060 (Crowell, 2007).

The City of Amarillo, the largest municipal Ogallala water user in the area, pumps water for public use from the Carson County Well Field north and northeast of the Plant. The Pantex Plant obtains water from five wells in the northeast corner of the site. In 2018, Pantex pumped approximately 421 million L (111 million gal) of water from the Ogallala Aquifer. Most of the water used at the Pantex Plant is for domestic

purposes. Through an agreement with TTU, the Pantex Plant provides water to the TTU research farm properties for domestic and livestock uses.

### **1.7 Seismology**

Seismic events have occurred infrequently in the region, and their magnitudes have been low. The stress conditions at the site are such that the possibility of high-order seismic events is extremely unlikely. A qualitative understanding of present conditions at the Pantex Plant indicates that anticipated seismic activity is well below the level that is necessary to cause significant damage to structures at the Plant. The potential for local or regional earthquakes (with a magnitude great enough to damage structures at the site to the degree that hazardous materials would be released) is extremely low (McGrath, 1995).

### **1.8 Land Use and Population**

The land around the Pantex Plant is used mainly for winter wheat and grain sorghum farming, for ranching, and for mining (oil and gas). Although dryland farming is dominant, some fields are irrigated from the Ogallala Aquifer or, less commonly, from local playas. Ranching in the region consists of cow-calf and yearling operations. The economy of the rural Panhandle region depends mainly on agriculture, but diversification has occurred in the more populated counties of the region and includes manufacturing, distribution, food processing, and medical services. Nationally known businesses that are major employers in the greater Amarillo area include Bell Helicopter; Tyson Foods (a single rail beef-slaughtering operation); Pantex Plant; Owens-Corning Fiberglass (a fiberglass reinforcement Plant); ASARCO (a large silver and copper refiner); and Cactus Feeders, one of the largest cattle-feeding operations in the world. Conoco-Phillips Petroleum and Xcel Energy are also major industrial presences in the Panhandle region.

A land-use census of the residential population surrounding the Pantex Plant showed that most of the population is located west-southwest of the Pantex Plant in the Amarillo metropolitan area. Population data from the 2010 Census are now available at most tracking levels and were used to generate Figure 1.5 (DOCc), showing the population distribution at 8-km (5-mi) intervals within 80 k (50 mi) of the Plant. According to the 2010 Census, the total population within 50 miles of the Pantex Plant is 316,132 people.

The total population of the 20 county area (defined as the Texas Panhandle) surrounding the Plant is 389,721. The population of the City of Amarillo (190,695 in 2010) represents about 49 percent of the counties' population. Another approximately 32 percent of the population lives in other incorporated cities, and about 19 percent reside in unincorporated areas. The communities of Pampa, Borger, Hereford, Dumas, and Canyon each have populations between 13,000 and 18,000. The 20 county areas can be described as sparsely populated, with Potter and Randall Counties being the exception. Excluding Potter and Randall Counties, the general population density of each county ranges from 12 to 132 persons per square mile. Potter, Randall, Carson, and Armstrong Counties make up the Amarillo Metropolitan Statistical Area. Hutchinson County (in which Borger is located) and Gray County (in which Pampa is located) are now classified as micropolitan statistical areas (DOCc). Hartley, Moore, Roberts, Oldham, Deaf Smith, Donley, Dallam, Sherman, Hansford, Ochilree, Lipscomb, Hemphill, Wheeler, and Collingsworth are the remaining counties of the defined area; although, the population contained in the northerly portions of Castro, Swisher, and Briscoe counties is also included in the 80 km (50 mi) population estimate described above.

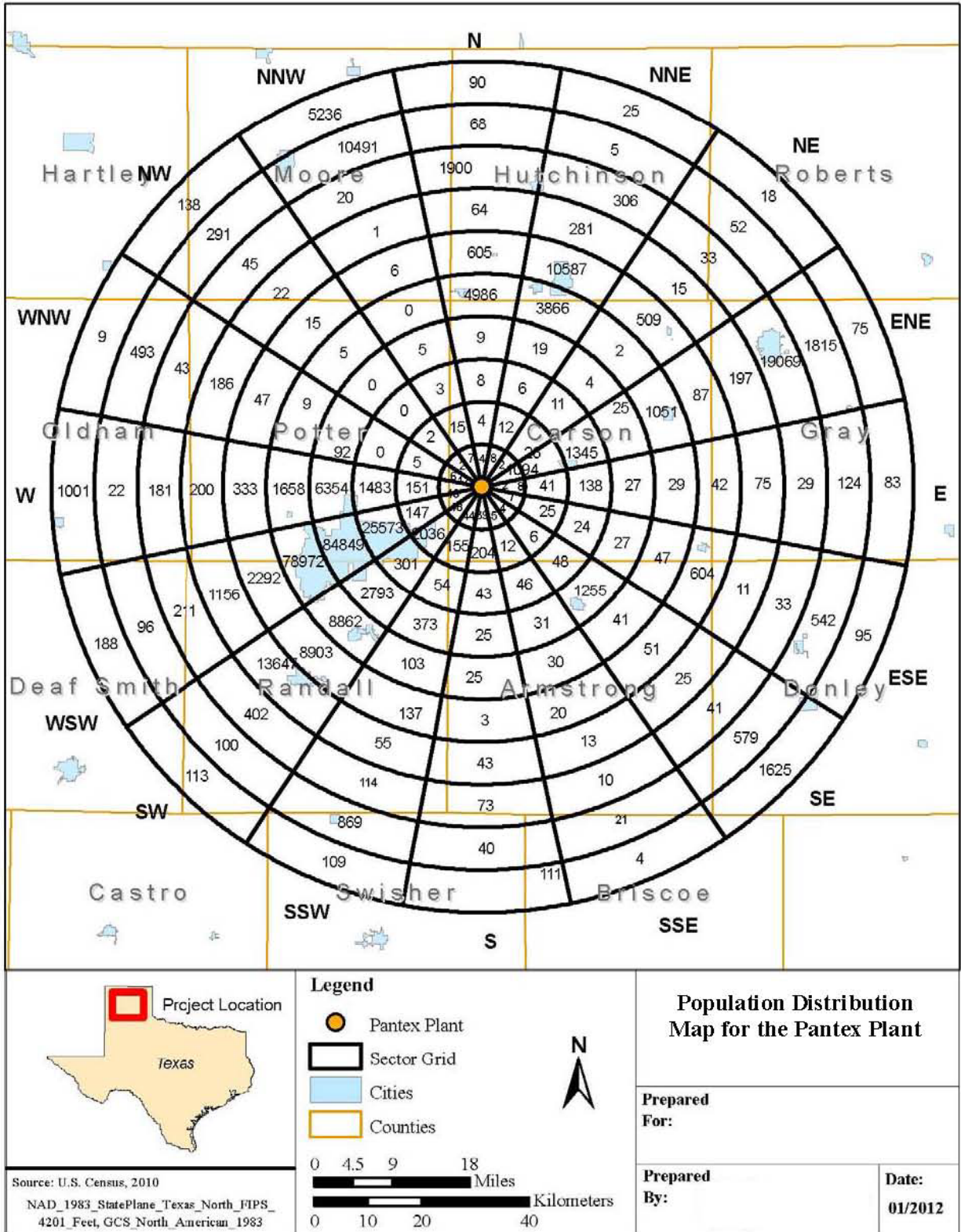


Figure 1.5 – Population Distribution within 50 Miles of Pantex Plant (2010)

### **1.9 Organization of the Report**

The remainder of this report is organized into 12 chapters and four appendices:

Chapter 2 discusses regulatory requirements for environmental compliance during 2018 and describes the Plant's compliance-related issues and activities. It presents results of various regulatory inspections and environmental activities and lists the environmental permits issued to the Pantex Plant.

Chapter 3 provides a brief summary of the environmental programs that are conducted at the Pantex Plant. Overviews are provided for environmental management, pollution prevention, natural and cultural resources management, environmental restoration, and sustainability initiatives.

Chapter 4 describes the environmental radiological monitoring program, which deals with the potential exposure of the public and the environment to radiation resulting from Plant operations. Also discussed are results of the environmental Thermoluminescent Dosimetry (TLD) program and other radiological monitoring programs for various environmental media (i.e., air, groundwater, surface water, plants, and animals).

Chapters 5 through 12 discuss radiological and non-radiological monitoring and surveillance programs for individual environmental media. Chapter 5 discusses the air-monitoring program. The groundwater, drinking water, wastewater, and surface water monitoring programs are discussed in Chapters 6, 7, 8, and 9, respectively. Chapter 10 describes the soil-monitoring program, and faunal and vegetation monitoring are discussed in Chapters 11 and 12, respectively. Each of these chapters includes a description of the monitoring program for the specific medium and an analysis of radiological (if available) and non-radiological data for the 2018 samples.

Chapter 13 reviews the Pantex Plant's quality assurance program for environmental monitoring efforts, as initiated in response to Title 10 of the Code of Federal Regulations (CFR), Chapter 830.120 and DOE Order 414.1D (DOEg). The chapter also includes an analysis of quality control samples collected during 2018 and a data validation summary.

Appendix A lists all of the analytes for which environmental analyses were conducted.

Appendix B lists all of the birds sighted at the Pantex Plant.

Appendix C provides references.

Appendix D provides supplemental information.

## Chapter 2 – Compliance Summary

*Pantex policy is to conduct all operations in compliance with applicable environmental statutes, regulations, and the requirements of the various authorizations issued to the Plant. This chapter reviews current issues and actions related to these requirements.*

### 2.1 Environmental Regulations

This chapter summarizes the compliance status of the Pantex Plant for 2018. It describes initiatives and clean-up agreements in place, regulatory authorizations issued to the Plant, and measures to support the Department of Energy (DOE) environmental performance indicators. Table 2.1 presents the major environmental regulations applicable to operations at the Pantex Plant.

**Table 2.1 – Major Environmental Regulations Applicable to Pantex Plant**

Regulatory Description	Authority	Codification	Status
<p>ARCHAEOLOGICAL RESOURCE PROTECTION ACT (ARPA)</p> <p>ARPA provides for the protection of archeological resources and sites located on public and Native American lands.</p>	<p>Federal: Advisory Council on Historic Preservation</p> <p>State: State Historic Preservation Office (SHPO)</p>	<p>Federal: Title 36 of the Code of Federal Regulations (CFR), Chapter 79 (39 CFR 79), 43 CFR 7</p>	<p>All archeological surveys and testing at the Pantex Plant conformed to ARPA standards.</p>
<p>CLEAN AIR ACT (CAA)</p> <p>CAA and the Texas Clean Air Act (TCAA), through their implementing regulations, control the release of regulated emissions to the atmosphere and provide for the maintenance of ambient air quality.</p>	<p>Federal: Environmental Protection Agency (EPA)</p> <p>State: Texas Commission on Environmental Quality (TCEQ)</p> <p>Texas Department of State Health Services (TDSHS)</p>	<p>Federal: 40 CFR 50-82</p> <p>State: Title 30 of the Texas Administrative Code (TAC), Chapter 101 through Chapter 122 (30 TAC 101-122) &amp; 305</p> <p>25 TAC 295 (Asbestos only)</p>	<p>The Pantex Plant complies with permits and Permits-by-Rule issued or promulgated by the TCEQ to authorize releases of pollutants to the atmosphere.</p> <p>The Pantex Plant complies with the applicable requirements codified in the CFR and TAC (including those dealing with emissions of radionuclides at DOE facilities (40 CFR 61, Subpart H).</p> <p>Pantex is a self-certified “Minor” emission source under the Federal Operating Permit program.</p>
<p>COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, AND LIABILITY ACT (CERCLA)</p> <p>CERCLA provides the regulatory framework for the remediation of releases of hazardous substances and cleanup of inactive hazardous substance disposal sites. Section 107 provides for the</p>	<p>Federal: EPA</p>	<p>Federal: 40 CFR 300, 302, 355, &amp; 370</p>	<p>The Pantex Plant has been on the National Priorities List (NPL) since 1994. The EPA, TCEQ, and National Nuclear Security Administration Production Office (NPO) have signed an Interagency Agreement (IAG) concerning the conduct of the remediation at the Pantex Plant.</p> <p>A Record of Decision (ROD) was issued and approved in</p>

Chapter 2 – Compliance Summary

Regulatory Description	Authority	Codification	Status
protection of natural resources on publicly owned property through designation of Natural Resource Trustees.			2008 and Pantex was added to the Construction Completion List in 2010. Interested Co-Trustees have been involved in the planning and completion of the Ecological Risk Assessment (ERA) for Pantex, and selection of the final remedy. The Agency for Toxic Substances and Disease Registry published its final report <i>Public Health Assessment-Pantex Plant</i> in September 1998.
<p>ENDANGERED SPECIES ACT (ESA)</p> <p>ESA prohibits federal agencies from taking any action that would jeopardize the continued existence of endangered or threatened species or result in the destruction or adverse modification of a critical habitat.</p>	Federal: U.S. Fish and Wildlife Service (USFWS)	Federal: 50 CFR 10; 50 CFR 17; Title 16 of the United States Code, Chapter 153 (16 USC 153), et seq.	Ongoing and proposed actions are assessed as to their potential adverse effects on threatened and endangered species.
PROTECTION of ENDANGERED SPECIES (STATE)	State: Texas Parks and Wildlife Department (TPWD)	State: TPW Code, 68	Ongoing and proposed actions are assessed as to their potential adverse effects on threatened and endangered species.
<p>FEDERAL INSECTICIDE, FUNGICIDE, AND RODENTICIDE ACT (FIFRA)</p> <p>FIFRA governs the manufacture and use of biocides, specifically the use, storage, and disposal of all pesticides and pesticide containers and residues.</p>	<p>Federal: EPA</p> <p>State: Texas Department of Agriculture; Structural Pest Control Board</p>	<p>Federal: 40 CFR 170-171</p> <p>State: 4 TAC 7.1-7.40; Structural Pest Control Act (Art. 135b-5)</p>	<p>State-licensed personnel apply pesticides in accordance with applicable regulations.</p> <p>The Plant implemented a land-applied chemical use plan in 1996. The plan was updated in 2016.</p>
<p>FEDERAL WATER POLLUTION CONTROL ACT / CLEAN WATER ACT (CWA)</p> <p>The Texas Water Code, through its implementing regulations, regulates the quality of water discharged to waters of the State of Texas.</p>	<p>Federal: EPA</p> <p>State: TCEQ</p>	<p>Federal: 40 CFR 120-136 &amp; 40 CFR 300 - 583</p> <p>State: 30 TAC 205-299, 305, 309, 317 &amp; 319</p>	<p>As currently defined, the Pantex Plant does not discharge its wastewaters to 'Waters of the United States'.</p> <p>The Pantex Plant discharges its industrial wastewaters pursuant to Permits WQ0002296000, WQ0004397000, and UIC 5W2000017.</p> <p>The Pantex Plant has coverage under the Texas Pollutant Discharge Elimination System (TPDES)</p>

Chapter 2 – Compliance Summary

Regulatory Description	Authority	Codification	Status
			<p>Construction General Permit, for storm water via Permit No. TXR150000. It complies with requirements of the permit whenever applicable to a project. As of the end of 2018, two active projects had been registered with the TCEQ.</p> <p>The Plant operates under TCEQ General Permit for Discharges of Storm Water from Industrial Sources Registration No. TXR05CD31.</p>
MEDICAL WASTE	<p>Federal: U.S. Department of Transportation (DOT)</p> <p>State: TDSHS</p>	<p>Federal: 49 CFR 173</p> <p>State: 30 TAC 330.1201-1221</p>	The Plant manages medical waste in accordance with applicable regulations.
<p>MIGRATORY BIRD TREATY ACT</p> <p>Establishes criteria for the protection of migratory birds. Pantex provides habitat for many migratory bird species protected by federal law. All migratory birds, their parts, and their nests were fully protected as required by statute.</p>	Federal: USFWS	Federal: 50 CFR 10 pursuant to 16 USC 704-707 and 712	<p>Actions being considered at the Pantex Plant are reviewed through the National Environmental Policy Act (NEPA) process, which considers impacts to migratory species.</p> <p>Nuisance and other bird situations are handled within compliance of the Migratory Bird Treaty Act.</p>
PROTECTION OF MIGRATORY BIRDS (STATE)	State: TPWD	State: TPW Code 64 (2-5, 7, & 26-27)	<p>Actions being considered at the Pantex Plant are reviewed through the NEPA process, which considers impacts to migratory species.</p> <p>Nuisance and other bird situations are handled within compliance of state regulations.</p>
<p>Executive Order 13186: Responsibilities for Federal Agencies to Protect Migratory Birds (2001)</p> <p>Establishes commitment to migratory bird protection, management, research, and outreach on federal properties. Reaffirms relationship between the USFWS and other federal agencies.</p>	Federal: DOE	Volume 66 Federal Register, page 3853 (66 FR 3853), 2001	Actions being considered at the Pantex Plant are reviewed through the NEPA process, which considers impacts to migratory species. This Executive Order (EO) adds additional language beyond the Migratory Bird Treaty Act to consider impacts to habitat.
NATIONAL ENVIRONMENTAL POLICY ACT (NEPA)	Federal: DOE; Council for Environmental Quality (CEQ)	Federal: 10 CFR 1021, 40 CFR 1500-1508	In 2018, six Standard NEPA Review Forms, 34 Internal NEPA Review Forms, and four amendments were prepared.

Chapter 2 – Compliance Summary

Regulatory Description	Authority	Codification	Status
<p>NEPA establishes a broad national policy to conduct federal activities in ways that promote the general welfare of the environment. NEPA procedures must ensure that environmental information is available to public officials and citizens before decisions are made and before actions are taken.</p>			<p>In 2018, two Environmental Assessments (EAs) were approved by NPO.</p> <p>In 2018, the 5-Year Pantex Supplemental Analysis for the Environmental Impact Statement (EIS) was approved.</p>
<p>PROTECTION OF BIRDS, NONGAME SPECIES, AND FUR-BEARING ANIMALS</p> <p>Requires the protection of all indigenous birds and ring-necked pheasants, non-game species, and fur-bearing animals except where exceptions are stated in the TPWD Code.</p>	<p>Federal: USFWS</p> <p>State: TPWD</p>	<p>Federal: 50 CFR 10</p> <p>State: TPWD Code 67 and 71</p>	<p>Actions being considered at the Pantex Plant are reviewed through the NEPA process, which considers impacts to all protected species.</p>
<p>RESOURCE CONSERVATION AND RECOVERY ACT (RCRA)</p> <p>RCRA and the Texas Solid Waste Disposal Act govern the generation, storage, handling, treatment, and disposal of solid waste, including hazardous waste. These statutes and regulations also regulate underground storage tanks and spill cleanup.</p>	<p>Federal: EPA</p> <p>State: TCEQ</p>	<p>Federal: 40 CFR 260-280</p> <p>State: 30 TAC 305, 327, and 335</p> <p>State: 30 TAC 334</p>	<p>The Pantex Plant is defined as a large-quantity generator. Permit HW-50284 authorizes the management of hazardous wastes in various storage and processing units at the Plant. Compliance Plan CP-50284 (now HW-50284) addresses corrective action requirements at the Plant.</p> <p>The Plant operates five regulated underground storage tanks.</p>
<p>SAFE DRINKING WATER ACT (SDWA)</p> <p>SDWA and the Texas Water Code govern public water supplies.</p>	<p>Federal: EPA</p> <p>State: TCEQ</p>	<p>Federal: 40 CFR 141-143</p> <p>State: 30 TAC 290</p>	<p>Pantex operates a Non-Transient, Non-Community Public Water Supply System (No. 0330007). The system is recognized as a Superior Public Water System by the TCEQ.</p>
<p>TOXIC SUBSTANCES CONTROL ACT (TSCA)</p> <p>TSCA requires the characterization of toxicity and other harmful properties of manufactured substances and regulates the manufacture, distribution, and use of regulated materials.</p>	<p>Federal: EPA</p>	<p>Federal: 40 CFR 700-766 &amp; 10 CFR 850</p>	<p>The Plant manages polychlorinated biphenyl (PCBs), asbestos, beryllium, and chemicals in compliance with applicable regulations.</p>



## 2.2 Clean Air Act

Most requirements of the Federal CAA in Texas are implemented under the TCAA, which is administered by the TCEQ, as approved by the EPA through the Texas State Implementation Plan. The exceptions to this delegation of authority from the EPA include: 40 CFR 61, Subpart H (Emissions of Radionuclides Other Than Radon from DOE Facilities), 40 CFR 61, Subpart M (National Emissions Standard for Asbestos) and regulations dealing with greenhouse gasses. The primary regulatory authority for 40 CFR 61, Subpart M, is delegated to the TDSHS.

### 2.2.1 40 CFR 61 Subpart H (Emissions of Radionuclides Other Than Radon from DOE Facilities)

According to the standard established by the EPA at 40 CFR 61.92, 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 an effective dose equivalent of 10 millirem per year (mrem/yr) or 0.10 milliSievert per year (mSv/yr). Based upon evaluations using the most conservative assumptions about the emissions of radionuclides from several Plant locations that have the potential to emit radioactive materials, Pantex has determined that the maximum effective dose equivalent that any member of the public received in 2018 was  $1.70 \times 10^{-6}$  mrem/yr ( $1.70 \times 10^{-8}$  mSv/yr). Accordingly, Pantex is in compliance with the EPA standard. Continuous emission monitoring, as described in 40 CFR 61.93, is not required of any source at the Pantex Plant, based on each source's emission potential. The Plant does perform periodic confirmatory measurements, as well as modeling, to assure compliance with 40 CFR 61 Subpart H regulations.

In accordance with 40 CFR 61.96, all new construction projects and activities (or modifications to existing structures or activities) that have the potential to emit radioactive materials are evaluated to determine if the effective dose equivalent, caused by all emission is less than 1 percent of the 40 CFR 61.92 standard (i.e., is less than 0.1 mrem/yr [0.001 mSv/yr]). During 2018, none of the evaluations resulted in the identification of exceedances of this reduced standard, and accordingly, there was no need to make an application for approval or notifications of startup to the EPA under the provisions of 40 CFR 61.96.

### 2.2.2 40 CFR 61 Subpart M (National Emissions Standard for Asbestos)

Each year, Pantex files a "Notification of Consolidated Small Operations Removing Asbestos-Containing Material" with the TDSHS for maintenance activities to be conducted by the Plant in the next calendar year. To verify that operations are consistent with the notification, Pantex keeps a log of all its affected maintenance activities to track quantities of material disturbed.

Subcontractors at the Pantex Plant are required to prepare separate notifications for work that qualifies as "demolition" or "renovation" as defined in 40 CFR 61, Subpart M, and 25 TAC 295.61, which implements the "Texas Asbestos Health Protection Act." Separate notifications are also required for jobs conducted by Pantex personnel that involve amounts that would require job-specific notifications. Pantex maintains the required certifications for the personnel who plan, oversee, and conduct these efforts. By filing the required forms and maintaining the described records, Pantex demonstrates that it is in compliance with 40 CFR 61, Subpart M.

### 2.2.3 40 CFR 68 (Chemical Accident Prevention)

Pantex has established and maintains controls on the introduction of new chemicals to any area of the Plant. Through this process, Pantex has been able to demonstrate that it has control of the chemicals in use. It continues to ensure that the quantities of chemicals at any location are below the threshold quantities stated in 40 CFR 68, thus, exempting Pantex from having to perform risk management planning.

### 2.2.4 40 CFR 82 (Ozone Depleting Substances)

Pantex installs and maintains stationary and motor vehicle air conditioning systems at the Plant. The technicians that perform this work are licensed to perform the work. Approved recycling devices are used

as needed while conducting these efforts. Pantex maintains records of training and maintenance activities to demonstrate compliance with these regulations.

**2.2.5 Air Quality Permits and Authorizations**

Pantex continues to use a combination of an air quality permit issued under 30 TAC 116 (Permit No. 84802), de minimis activities as authorized by 30 TAC 116.119, and authorizations issued under 30 TAC 106 (Permits by Rule [PBR]) to authorize operations conducted at the Plant. During 2018, Pantex initiated the process of renewing Permit No. 84802, per state requirements.

**2.2.6 Federal Operating Permit Program**

The Title V Federal Operating Permit Program is administered and enforced by the EPA Region 6 Office and the TCEQ. During 2018, Pantex maintained documentation demonstrating that it was not a major source, as defined by the Federal Operating Permit Program.

**2.2.7 Air Quality Investigation**

The TCEQ did not perform an air quality related compliance inspection of the Pantex Plant during 2018.

**2.2.8 Emission Tracking and Calculation**

**2.2.8.1 Scope of the Pantex Plant Emission Tracking System**

The Pantex Plant is subject to the Federal CAA and the state of Texas regulations under 30 TAC 101, 106, 111, 112, 113, 116, 117, 118, and 122. The main scope or function of the Plant’s air emission tracking system is to monitor process emissions, in order to (a) maintain the facility designation of “Synthetic Minor” under the federal Title V program, and (b) demonstrate compliance with authorizations issued to the Pantex Plant. The Pantex Plant initiated a comprehensive system for tracking emissions from specific sources (facilities) in September of 1999, and has continued to update the tracking process to comply with changing regulations and best management practices. Pantex Plant processes that have emissions are conducted under the authority of various regulations and authorizations [Permits, Standard Exemptions (SE), and PBR]. Table 2.2, below, identifies the tracked emission sources at Pantex and their authorizations.

**Table 2.2 – Tracked Emission Sources at Pantex**

Process: <sup>a</sup>	Authorization Permit #	Standard Exemption <sup>b</sup>	Permit By Rule
HE Synthesis Facility	Permit 84802		
HE Fabrication	Permit 84802		
Firing Site Activities	Permit 84802		
Boiler House	Permit 84802		
Stationary Standby Emergency Engines	Permit 84802		
Boiler House, Diesel Storage	Permit 84802		
Burning Ground Activities	Permit 84802		
Hazardous Waste Storage	Permit 84802		
Hazardous Waste Processing	Permit 84802		
Welding and Cutting		SE 39	
Dual Chamber Incinerator	Permit 84802		
Plastics Shop	Permit 84802		
Epoxy Foam Production	Registration 43702		PBR 262
Component Sanitization	Registration 41577		PBR 261 & 262
Machining		SE 41	PBR 432 & 452
Vehicle Maintenance Facility (VMF) Fueling Operations	Permit 84802		
Hazardous Waste Treatment & Processing Facility (HWTPF) Liquid Processing Facility	Permit 84802		
Pantex Site-wide Cooling Towers	Permit 84802		

Process: <sup>a</sup>	Authorization Permit #	Standard Exemption <sup>b</sup>	Permit By Rule
Stationary Standby Emergency Engines	Permit 84802		
Painting Facilities	Registration 32674, 52638, 52639	SE 75	
Pressing & Transferring HE & Mock		SE 106 & 118	
Burning Ground-Soil Vapor Extraction	Registration 70894		PBR 533
Miscellaneous Chemical Operations: e.g., Emissions of HAP from laboratories, small coating operations and fugitive sources.		SE 34	PBR 106.122, PBR 106.433, “de minimus”
Chemical Transfer Operations	Registration 72373		PBR 262, 472, and 473
Drum Management Operations	Registration 92876		PBR 261, 262, and 512
High Explosive Pressing Facility	Registration 145558		PBR 261, 262
Emergency Water Pump	Registration 87270		PBR 512

<sup>a</sup> Authorization dates (the effective dates) can be found in Table 2.5.

<sup>b</sup> Standard Exemptions pre-date and were replaced by PBR.

### 2.2.8.2 Program Structure and Requirements

The Pantex Plant is categorized as a Synthetic Minor air emission source. The upper threshold of emission limits for a facility to remain in this category is 25 tons per year of Hazardous Air Pollutants (HAP) (or 10 tons of a single HAP) and 100 tons per year of nitrogen oxides (NOx), carbon monoxide (CO), volatile organic compounds (VOCs), sulfur oxides (SOx), lead (PB) particulate matter (PM), and HAPs. Under this designation, a facility is not required to declare its emissions every year to the TCEQ; however, a certification of Potential to Emit (PTE) is required by 30 TAC 122.122 when significant changes of emissions take place. The PTE, once submitted to the TCEQ, becomes a federally enforceable document for allowable emissions. Essentially, the PTE establishes emission limits that are administratively set by Pantex and authorized/enforceable by the TCEQ and the EPA.

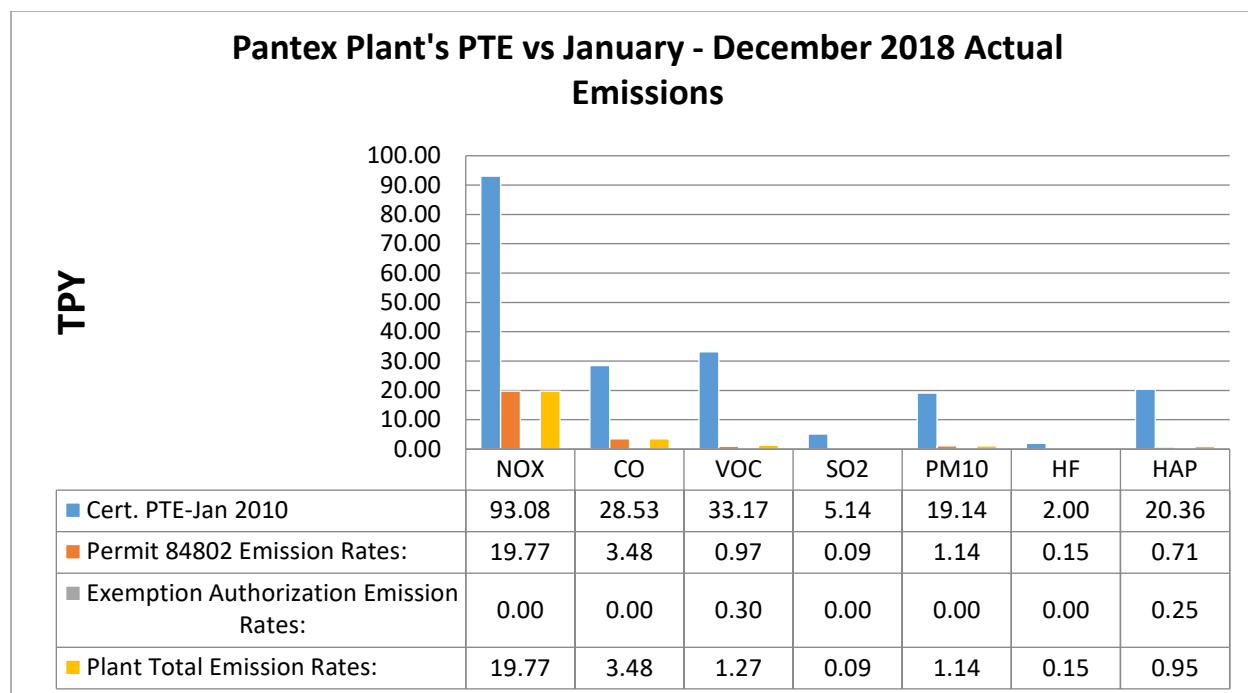
The Pantex Plant maintains a tracking process to verify compliance with certified emissions limits. This tracking process is implemented through Air Quality Management Requirement (AQMR) documents, which are placed into the every-day operational procedures/activities that have either point source or fugitive emissions. AQMRs are management-driven documents that outline regulatory requirements for operators to follow based upon process activities and the requirements of the federal and state air emissions regulations. The approved AQMRs incorporate sections of the authorization that outline the internal reporting and recordkeeping requirements for process operators. Operational data are gathered by process operators and then input on a monthly basis into enhanced commercial off-the-shelf computer software. The software uses emission factors from source tests, manufacturer’s data, and EPA documentation to calculate both hourly and rolling 12-month emissions.

### 2.2.8.3 Types and Tracking of Emissions

During 2018, Pantex tracked the emissions from 30 different processes both at specific locations and grouped sources across the Plant. Pantex personnel responsible for air program compliance gathered facility data on emissions of common air pollutants including NOx, CO, VOCs, SOx, PM, and HAPs. The data, once gathered, are compiled into a monthly report that compares the cumulative past 12 month emissions for the Plant, to the annual limits set in the authorized PTE.

### 2.2.8.4 Conclusions of Air Emission Tracking for 2018

Over the 12 months of air emission tracking for 2018, operations at the Pantex Plant remained well below the certified and authorized PTE levels for each of the pollutants tracked. Figure 2.1 is a graphic presentation of the emission information gathered from January through December 2018, expressed in relation to the PTE certification in Tons per Year (TPY). It provides a demonstration that the Pantex Plant continues to meet the requirements of the Title V program for the designation as a Synthetic Minor Source.



**Figure 2.1 – Pantex Plant’s PTE vs January – December 2018 Actual Emissions**

### 2.3 Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund)

Because the Pantex Plant is listed on the NPL, CERCLA Section 107 (Title 42 of the United States Code, Chapter 9607) is applicable. Section 107 provides for the designation of federal and state trustees who are responsible for assessing damages, for injury to, destruction of, and loss of natural resources. As the Pantex Plant’s primary Natural Resource Trustee [per 40 CFR 300.600(b)(3)], the DOE is responsible for encouraging the involvement of designated federal and state trustees. To meet this responsibility, DOE held meetings with state and federal agencies. DOE and EPA jointly issued an Interagency Agreement (IAG) in December 2007 in conclusion of negotiations between DOE, Pantex, EPA, and TCEQ. This agreement became effective in February 2008.

Pantex submitted the Site Management Plan (SMP), a primary document required by Article 7.2 of the IAG in November 2008. The SMP is a schedule with deadlines and timetables for completion of all primary documents and additional work identified pursuant to the IAG. The SMP is submitted annually to update schedules for the Five-Year Review and the Final Remedial Action Completion Report. No additional work has been identified for inclusion in the SMP.

Accordingly, Pantex was added to the Construction Completion List, signifying the start of the O&M phase of the remedy. Progress reports are prepared and submitted to EPA and TCEQ quarterly to communicate the status and accomplishments of the remedial action systems. Also, an annual report is prepared to document a more thorough evaluation, and five-year reviews are conducted to ensure periodic comprehensive analyses of the protectiveness of the selected remedy. The first five-year review was completed in 2013, with the second five-year review started in 2018.

### 2.4 Endangered Species Act

The Pantex Plant provides habitat for several species protected by federal and state endangered species laws. In 1992, the Pantex Plant began a program to assess its natural resources (See Chapter 3). Each year,

wildlife observations are recorded and state and federal rare species lists are examined for changes. These observations include data collected by subcontractors working on wildlife projects at Pantex. The current status of endangered or threatened species, as well as species of concern, known to appear on or near the Pantex Plant (Carson and Potter counties) is summarized in Table 2.3. The Pantex Plant is in compliance with the applicable provisions of the Endangered Species Act.

**Table 2.3 – Endangered, Threatened, and Candidate Species and Species of Concern Known to Appear on or near Pantex Plant**

Common Name	Scientific Name	Present in 2018	Federal Status	State Status
<b><u>Birds</u></b>				
Peregrine falcon <sup>a</sup>	<i>Falco peregrinus anatum/tundrius</i>	-	Delisted	Threatened
Baird's sparrow	<i>Ammodramus bairdii</i>	-	-	Concern
Bald eagle	<i>Haliaeetus leucocephalus</i>	Yes	Delisted	Delisted
Ferruginous hawk	<i>Buteo regalis</i>	Yes	-	Concern
Interior least tern	<i>Sterna antillarum athalassos</i>	-	Endangered	Endangered
Lesser prairie chicken	<i>Tympanuchus pallidicinctus</i>	-	-	Concern
Mountain plover	<i>Charadrius montanus</i>	-	-	Concern
Western Snowy plover	<i>Charadrius alexandrinus</i>	-	-	Concern
Western burrowing owl	<i>Athene cunicularia hypugea</i>	Yes	-	Concern
Prairie falcon	<i>Falco mexicanus</i>	-	-	Concern
White-faced ibis	<i>Plegadis chihi</i>	Yes	-	Threatened
Whooping crane	<i>Grus americana</i>	-	Endangered	Endangered
<b><u>Mammals</u></b>				
Big free-tailed bat	<i>Nyctinomops macrotis</i>	Yes	-	Concern
Black-tailed prairie dog	<i>Cynomys ludovicianus</i>	Yes	-	Concern
Cave myotis bat	<i>Myotis velifer</i>	-	-	Concern
Pale Townsend's big-eared bat	<i>Corynorhinus townsendii pallescens</i>	-	-	Concern
Plains spotted skunk	<i>Spilogale putorius interrupta</i>	-	-	Concern
Swift fox	<i>Vulpes velox</i>	-	-	Concern
Western small-footed bat	<i>Myotis ciliolabrum</i>	-	-	Concern
<b><u>Reptiles</u></b>				
Texas horned lizard	<i>Phrynosoma cornutum</i>	Yes	-	Threatened

<sup>a</sup> *F.p. tundrius* is classified as threatened based only on similarity.

Several species are listed for Carson County or surrounding counties, but are not included in Table 2.3 because of their dependence on habitat that are not found on High Plains soils, or because they are considered extirpated from the region. The Red Knots (*Calidris carnutus rufa*) are long-distance migrant birds that would not likely ever be observed on the High Plains soils. The Lesser Prairie Chicken (*Tympanuchus allidicinctus*) is normally confined to large areas of aeolian dunes well east and southwest of the Pantex Plant, and its presence in Carson County is indicated by a single record “of one Lesser Prairie Chicken.” The Arkansas River shiner (*Notropis girardi*) and peppered chub (*Macrhybopsis tetranema*) would only be expected in streams on the Canadian River floodplain located in adjacent Potter County. The Wiest's Sphinx Moth (*Euproserpinus wiesti*) is listed, but its host plants are restricted to aeolian dunes in the Canadian River valley. The Mexican mud-plantain (*Heteranthera mexicana*) is an aquatic plant that grows sporadically and has been documented a few times growing in Panhandle ditches and ponds. The gray wolf (*Canis lupus*) and black-footed ferret (*Mustela nigripes*) are listed but are considered extirpated

in this area. Ferret releases are being made in surrounding states, as the captive-reared program has resulted in an ample captive population. Captive ferret numbers are so high that the USFWS is relaxing protocol concerning requirements for acceptable release sites. Thus, dispersing ferrets could potentially occur in the region. The American black bear (*Urus americanus amblyceps*; New Mexico subspecies) occasionally wanders into and through the region (one record at Pantex); but only the Louisiana subspecies (*U.a. luteolus*) is considered truly threatened (state; threatened). Due to similarity in appearance both are listed as threatened (state).

### 2.5 Federal Insecticide, Fungicide, and Rodenticide Act

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) regulates the manufacture and use of pesticides. The EPA has federal jurisdiction pursuant to 40 CFR 150-189, and the Texas Department of Agriculture and the Structural Pest Control Board have state jurisdiction pursuant to 4 TAC 7. Regulations promulgated under FIFRA govern the use, storage, and disposal of pesticides and pesticide containers. State-licensed personnel, in accordance with federal and state regulations, apply pesticides needed for operations at the Pantex Plant.

#### 2.5.1 Agricultural Pesticide Use in 2018

Texas Tech Research Farm (TTRF) submitted 16 agricultural spray requests during the 2018 growing season, however only 10 applications were made. All 16 agricultural spray requests were reviewed and approved by Pantex and NPO. Pantex made 35 applications during 2018. The majority of these applications were for weed control in Zone 4, Zone 11, Zone 12, and the associated Perimeter Intrusion Detection and Surveillance beds. The second most frequent pesticides used were insecticides for spiders and mosquitos. Contractors submitted four applications to control or suppress weeds and prairie dogs, as specified in the contract work completed at Pantex in 2018. Table 2.4 shows the number of pesticide applications conducted at Pantex since 2008.

**Table 2.4 – Number of Pesticide Applications Conducted at Pantex**

Year of Pesticide Applications	Texas Tech Research Farm	Maintenance Department	Contractors	Total
2008	28	105	2	135
2009	32	81	23	136
2010	44	55	36	135
2011	21	150	4	175
2012	33	121	7	161
2013	36	113	13	162
2014	23	122	15	160
2015	25	81	4	110
2016	18	57	12	87
2017	18	59	0	77
2018	10	35	4	49

### 2.6 Federal Water Pollution Control Act (or Clean Water Act) and Texas Water Code

The Pantex Plant does not discharge wastewaters into or adjacent to waters of the United States; thus, Pantex is not subject to the Federal Water Pollution Control Act. Pantex is subject to the requirements of the Texas Water Code. All discharges must be done in compliance with the requirements of the Texas Water Code and its implementing regulations.

During 2018, Pantex maintained two permits and one authorization issued by the TCEQ authorizing the

## Chapter 2 – Compliance Summary

disposal of treated industrial and domestic wastewaters. Pantex disposed all of its treated industrial and domestic wastewaters via discharge to an on-site playa lake. Pantex is authorized by Permit WQ0004397000 (Texas Land Application Permit [TLAP]) and Underground Injection Control (UIC) Authorization 5W2000017 to discharge treated wastewater through a subsurface fluid distribution system. Combined, these authorizations support the production of approximately 162 hectares (400 acres) of crops. The TLAP authorizes the disposal of treated wastewaters when the subsurface irrigation area is covered by vegetation. The UIC authorization allows the application of limited quantities of treated wastewater to the irrigation area during periods when the agricultural fields are fallow.

During 2017, major filter leaks developed in the system, and use of the system was temporarily discontinued. After June 2017, all treated industrial and domestic wastewaters were discharged via a surface water outfall into Playa Lake 1, per Texas Water Quality Permit WQ0002296000. Repairs are anticipated to be completed in the future so that the treated effluent from the wastewater treatment facility and from the perched aquifer pump and treat systems will once again be discharged to the subsurface fluid distribution system.

Pantex is authorized to discharge storm water from the Plant-site under the TPDES Storm Water Industrial Multi-Sector General Permit TXR05CD31.

Pantex obtains coverage as needed under the TPDES Storm Water General Permit for Construction Activities (Permit TXR150000). The Notices of Intent for individual projects that were filed pursuant to the permit and active in 2018 and other Pantex environmental authorizations and permits are listed in Table 2.5.

**Table 2.5 – Permits Issued to Pantex Plant**

Building or Activity	Permit Number	Issuing Agency	Effective Date	Expiration Date
<b>Air</b>				
Air Quality Permit	84802	TCEQ	09/21/2011	05/04/2019
All other small sources	Standard Exemptions, De Minimis authorization, and Permit by Rule	TCEQ	Various dates	When changes occur to the process that modify the character or nature of the air emission, or modify the process so that the PBR may no longer be used.
Clean Air Act Title V Declaration, 30 TAC 122	N/A	TCEQ	05/22/2000 (first filing)	None
<b>Solid Waste</b>				
Solid Waste Registration Number	TX4890110527 30459	EPA TCEQ	10/30/1980 10/30/1980	None None
Industrial and Solid Waste Management Site Permit RCRA Compliance Plan	HW-50284	TCEQ	05/30/2014	05/30/2024
UIC TLAP associated	5W2000017	TCEQ	11/29/2004	When cancelled.
UIC- Environmental Restoration Program	5X2600215	TCEQ	10/23/2001	When cancelled.
UIC - Environmental Restoration Program	5X2500106	TCEQ	11/28/2005	When cancelled.
<b>Water</b>				
Texas Water Quality Permit	WQ0002296000	TCEQ	08/24/2016	12/01/2020
TLAP	WQ0004397000	TCEQ	04/12/2013	01/01/2020
TPDES Multi-Sector (Industrial)	TXR05CD31	TCEQ	06/19/2018	08/14/2021

Building or Activity	Permit Number	Issuing Agency	Effective Date	Expiration Date
Storm Water Permit				
TPDES Storm Water General Permit for Construction Activities	TXR150000	TCEQ	03/01/2013	03/01/2018
Pantex ASC Offsite Utilities	TXR150030531	TCEQ	12/27/2016	Upon completion
<b>Natural Resources</b>				
Scientific Permit	SPR-1296-844	TXPWD	12/05/2011	12/05/2020
Letter of Authorization: Trap and Release Fur-bearing Animals	None	TXPWD	07/28/2000 (Initial)	Renewed annually.
Bee Removal Permit	TX-6-18-07	Texas Apiary Inspection Service	08/10/2010 (Initial)	Renewed annually.
Intrastate Bee and Equipment Permit	01/12/2003	Texas Apiary Inspection Service	08/10/2010 (Initial)	Renewed annually.

At seven of its more remote buildings, Pantex operates “On-site Sewage Facilities” (OSSFs) or septic tank systems, to dispose of domestic wastewaters from these buildings. Newer OSSFs have been approved by the TCEQ via permits. However, several of the systems were installed prior to the promulgation of applicable regulations and are not currently registered. As unregistered OSSFs are replaced, permits authorizing the upgrading or installation of the new system will be acquired from the TCEQ.

**2.6.1 Wastewater Discharge Permit Inspections**

The TCEQ conducted a Comprehensive Compliance Investigation of Permit WQ0004397000 during calendar year 2018. During the inspection, no deficiencies or findings were noted. But, in June, Pantex had two separate sanitary sewer over-flow events (unauthorized discharge). These events were identified as resolved and no further actions were required.

**2.7 Medical Waste**

Medical waste at the Pantex Plant is regulated by the DOT, the State of Texas, and associated Plant requirements. Pantex remains in compliance with applicable requirements.

**2.8 National Environmental Policy Act**

NEPA establishes requirements that federal agencies must meet to make well-informed decisions on proposed activities. The decisions must be based on alternatives that consider detailed information concerning potential significant environmental impacts. To minimize environmental impacts from operations at the Pantex Plant, proposed activities are reviewed for NEPA requirements.

At Pantex, the NEPA process is initiated by completing a NEPA Review Form (NRF). The NRF includes a description of the proposed action that subject matter experts review for potential environmental concerns. The levels of NEPA documentation range from internal reviews that tier off previously approved NEPA documents, categorical exclusions, EAs, and Environmental Impact Statements (EIS). Implementation Guidance for DOE Policy on Documentation and Online Posting of Categorical Exclusion Determinations: NEPA Process Transparency and Openness, October 16, 2009, mandates that all determinations for categorical exclusions involving classes of actions listed in Appendix B to Subpart D of the DOE’s NEPA regulations, 10 CFR 1021 be published online.

Every five years, the DOE is required to evaluate Site-wide EISs (SWEIS) by means of a Supplement Analysis (SA). Based on the SA, DOE determines whether the existing SWEIS remains adequate, or whether to prepare a new SWEIS or supplement the existing SWEIS. The determination and supporting analysis will be made available in the appropriate DOE Information Repositories, the Pantex website, and



the DOE Office of NEPA Policy and Compliance website for a reasonable time. The most current SA for the Pantex Plant was approved by NPO in June 2018. In 2018, six Standard NRFs (Categorical Exclusion determinations), 34 Internal NRFs, and four amendments were prepared and approved. Categorical Exclusion determinations for six Standard NRFs and four amendments were posted on the Pantex website. In 2018, two EAs were approved by NPO.

## **2.9 National Historic Preservation Act, Archaeological Resource Protection Act, and Native American Graves Protection and Repatriation Act**

In October 2004, NPO, Pantex, SHPO, and the President’s Advisory Council on Historic Preservation (Advisory Council) completed execution of a Programmatic Agreement and Cultural Resource Management Plan (PA/CRMP) (PANTEXj). This PA/CRMP ensures compliance with Sections 106 and 110 of the NHPA, providing for more efficient and effective review of Plant projects having the potential to impact prehistoric, WWII era, or Cold War era properties. In addition, the PA/CRMP outlines a range of preservation activities planned for the Plant’s compliance program. The PA/CRMP provides for the systematic management of all archeological and historic resources at the Pantex Plant under a single document.

Compliance with the ARPA requirements for site protection and collections curation is addressed in the PA/CRMP. Even though Native American mortuary remains or funerary artifacts have not been found at the Plant, compliance with the Native American Graves Protection and Repatriation Act is also addressed in the plan. Both archeological and natural resources at the Pantex Plant are closely concentrated around four playa lakes. These playa and floodplain areas have been reserved for comprehensive ecosystem management, resulting in preservation of many of the Plant’s archeological sites.

Fulfilling the Plant’s cultural resource management obligations under Section 106 of the NHPA, 34 projects were evaluated in 2018 under the PA/CRMP. Of these projects, 31 did not involve either National Register-eligible properties or possible adverse effects. For the remaining three projects, a prior notification and a walk-down prior to start-up was required to avoid impacts to the National-Register-eligible properties.

## **2.10 Resource Conservation and Recovery Act**

### **2.10.1 Active Waste Management**

The types of wastes generated at the Pantex Plant include hazardous waste, universal waste, non-hazardous industrial solid waste, waste regulated by the TSCA, low-level radioactive waste, mixed low-level radioactive waste, and sanitary waste. Wastes generated from the operation, maintenance, and environmental cleanup at the Pantex Plant in calendar year 2018 are summarized in Table 2.6. Overall, the amount of waste generated in 2018 decreased 11.1 percent from 2017. This is due primarily to decreased activity in the environmental restoration projects and the deactivation and decommissioning of excess facilities and construction projects.

During 2018, 387.3 cubic meters (m<sup>3</sup>) of hazardous waste was generated at the Pantex Plant. Typical hazardous wastes generated included explosives-contaminated solids, spent organic solvents, and solids contaminated with spent organic solvents, metals, and/or explosives. Hazardous wastes were managed in satellite accumulation areas (less than 208-L [55-gal] waste accumulation sites), less than 90-day waste accumulation sites, or permitted waste management units. Some hazardous wastes, such as explosives, were processed on-site before the process residues were shipped off-site for final treatment and disposal. During the year, environmental restoration projects and deactivation and decommissioning of excess facilities and construction projects contributed 8.4 percent of the total hazardous waste generated. Hazardous wastes and residues from hazardous waste processing are shipped to commercial facilities authorized for final treatment and disposal or, as applicable, recycling.

**Table 2.6 – Waste Volumes Generated at Pantex (in cubic meters)**

Waste Type	1993	2015	2016	2017	2018	Percent Increase or (Decrease) from 1993	Percent Increase or (Decrease) from 2017
Non-hazardous Industrial Solid Waste	10,885	4,497.7	3,641	2,693	3,420	(68.6)	(27)
Sanitary Waste	612	908.4	965.2	927.3	927.3	51.5	(0.0)
Hazardous Waste	369.6	418.5	460.2	398.9	387.3	4.8	(2.8)
Low-Level Waste	287	28.1	36.2	47.6	16.1	(94.4)	31.5
Mixed Waste	37.5	20.5	0.12	0.45	0.0	(100)	100
TSCA Waste	112.9	82.8	3.3	430.9	245.8	91.1	43
Universal Waste <sup>a</sup>	-	18.3	13.8	13.2	16.7	-	(26.5)
<b>Total</b>	<b>12,304</b>	<b>5,974.3</b>	<b>5,119.8</b>	<b>4,511.3</b>	<b>5,013.2</b>	<b>(59.3)</b>	<b>(11.1)</b>

<sup>a</sup> In 2001, Pantex began managing some hazardous waste under the Universal Waste Rules.

During 2018, 3,420 m<sup>3</sup> of non-hazardous industrial solid waste was generated at the Pantex Plant. Non-hazardous industrial solid wastes generated were characterized as either Class 1 non-hazardous industrial solid waste or Class 2 non-hazardous industrial solid waste, as defined by 30 TAC 335. Class 1 non-hazardous industrial solid wastes generated at Pantex were managed in a similar manner as hazardous waste, including shipment to off-site treatment and/or disposal facilities. Some Class 2 non-hazardous industrial solid wastes (inert and insoluble materials such as bricks, concrete, glass, dirt, and certain plastics and rubber items that are not readily degradable) were disposed in an on-site Class 2 non-hazardous industrial solid waste landfill. Other Class 2 non-hazardous industrial solid wastes, generally liquids, were shipped to commercial facilities for treatment and disposal.

The Pantex Plant's environmental restoration projects and deactivation and decommissioning of excess facilities and construction projects contributed 27.7 percent of the total non-hazardous industrial solid waste generated during 2018. In addition, during the year, 927.3 m<sup>3</sup> of sanitary waste (cafeteria waste and general office trash) was generated at the Pantex Plant. Sanitary wastes were also characterized as Class 2 non-hazardous industrial solid wastes and disposed of at authorized off-site landfills.

The Pantex Plant generated 245.8 m<sup>3</sup> of waste regulated by TSCA, during 2018. These wastes include asbestos, asbestos-containing material, and materials containing or contaminated by PCBs. During the year, environmental restoration projects and deactivation and decommissioning of excess facilities and construction projects contributed to 99.6 percent of the total TSCA waste generated. All TSCA wastes were shipped off-site for final treatment and disposal.

During 2018, 16.7 m<sup>3</sup> of waste that were managed as universal wastes was generated at the Pantex Plant. Universal wastes are defined as hazardous wastes that are subject to alternative management standards in lieu of regulation, except as provided in applicable sections of the TAC. Universal wastes include batteries, pesticides, paint and paint-related waste, and fluorescent lamps. During the year, environmental restoration projects contributed to 3.7 percent of the total universal waste generated. These wastes are shipped off-site for final treatment, disposal, or, as applicable, recycling.

The Pantex Plant generated 16.1 m<sup>3</sup> of low-level radioactive waste during 2018. The low-level radioactive wastes were generated by weapons-related activities.

Assembly and disassembly of weapons can result in some wastes that include both radioactive and hazardous constituents, which are referred to as “mixed waste.” The hazardous portion of the mixed waste is regulated by the TCEQ pursuant to RCRA regulations. The radioactive portion is regulated pursuant to the Atomic Energy Act. During 2018, no mixed waste was generated at the Pantex Plant.

### **2.10.2 Hazardous Waste Permit Modifications**

The Pantex Plant did submit an application to modify Permit HW-50284 during 2018. The TCEQ approved the Class 1 and 1-1 Hazardous Waste Permit Modification on April 11, 2018. The changes included adding CNS as a co-operator, adding the ability to macro-encapsulate waste at a building, adding authorization to accept waste from an off-site office building, and adding a central accumulation area to the list of less than 90-day accumulation sites in the Contingency Plan.

### **2.10.3 Annual Resource Conservation and Recovery Act Inspection**

The annual RCRA waste site inspection was conducted by the TCEQ on July 1 - August 2, 2018. The inspection included facility walk-downs of all hazardous waste permitted locations, all less-than-90-day waste accumulation sites, and most waste accumulation areas located in Zone 12 North. The inspection also included a records review to ensure compliance with the Pantex Plant hazardous waste permit and the applicable requirements from the CFR and the TAC. This year’s inspection concluded with no findings or issues identified.

Additionally, during the RCRA inspection, the TCEQ inspector completed a Texas Tier Two Right-To-Know investigation. The inspection reviews all reporting and planning requirements of Section 302-303 of the Emergency Planning and Community Right-To-Know Act (see also section 2.13 below), also known as the Superfund Amendments and Reauthorization Act Title III. The inspection was also completed with no findings or issues identified.

### **2.10.4 Release Site and Potential Release Site Investigation, Monitoring, and Corrective Action**

Progress reports, required by Table VII of HW-50284 (TCEQa) and Article 16.4 of the Pantex IAG, were submitted to both the TCEQ and EPA in 2018. The annual report contained a full reporting of all monitoring information for 2017. Quarterly progress reports were also submitted in 2018 in accordance with the schedule in the approved Sampling and Analysis Plan (SAP) and Table VII of Permit HW-50284. These reports focused on the continued operation of the remedies and on monitoring results from key groundwater wells.

### **2.10.5 Underground Storage Tanks**

The Plant operated five regulated underground Petroleum Storage Tanks (PSTs) during 2018. Of the five regulated underground storage tanks at Pantex, two are used for emergency generator fuel storage. Three other PSTs at the Plant are used for vehicle fueling. These tanks store unleaded gasoline, diesel, and a gasoline–ethanol mix (E-85). An inspection of all five underground PSTs was performed by the TCEQ during May 2019. This inspection was completed with no findings or issues identified.

## **2.11 Safe Drinking Water Act**

The Plant operates a Non-community, Non-transient Public Drinking Water System, which is registered with the TCEQ. This category of systems identifies private systems that continuously supply water to a small group of people; i.e., schools and factories. The Plant obtains its drinking water from the Ogallala Aquifer through five wells located at the northeast corner of the Plant.

### **2.11.1 Drinking Water Inspection**

On August 29, 2018, a TCEQ subcontractor collected samples from the water system. All sample results were below any regulatory limits and action levels. The TCEQ did not perform a comprehensive Compliance Inspection of the Public Water System during 2018.

### **2.11.2 Drinking Water System Achievements**

On December 17, 2009, the TCEQ notified Pantex that its PWS had achieved a “Superior Rating”. Organizations receiving the Superior Public Water System Rating are recognized for their overall excellence in all aspects of operating a PWS. The Pantex Plant maintained its Superior Public Drinking Water System Rating during 2018.

## **2.12 Toxic Substances Control Act**

The major objective of the TSCA is to ensure that the risk to humans and the environment, posed by toxic materials, has been characterized and understood before they are introduced into commerce. The goal is to regulate chemicals that present unreasonable risk to human health or the environment. Of the materials regulated by TSCA, those containing asbestos, beryllium and materials and parts containing, contaminated by, or potentially contaminated by PCBs are managed at the Pantex Plant.

As a user of chemical substances, Pantex complies with applicable regulations issued under the Act, refrains from using PCBs, except as allowed by EPA regulations, and refrains from using any chemical substance that Plant personnel know, or have reason to believe, has been manufactured, produced, or distributed in violation of the Act. As of December 31, 1996, all new parts and equipment that contain PCBs, used at the Pantex Plant, have PCBs that are in concentrations of less than 50 parts per million.

### **2.13 Emergency Planning and Community Right-to-Know Act**

The Emergency Planning and Community Right-to-Know Act, which was enacted as part of the Superfund Amendment and Reauthorization Act of 1986 (SARA), requires that the public be provided with information about hazardous chemicals in the community; and establishes emergency planning and notification procedures to protect the public in the event of a release. In order to accomplish these goals, the Emergency Planning and Community Right-to-Know Act and Executive Order 12856 require that the Pantex Plant file several annual reports with the EPA (Table 2.7) and participate in Local Emergency Planning Committee activities. The Pantex Plant remains in compliance with provisions of this statute.

### **2.14 Floodplains/Wetlands Environmental Review Requirements (10 CFR 1022)**

Floodplain management is taken into account when surface water or land use plans are prepared or evaluated. The U.S. Army Corps of Engineers (USACE), Tulsa District, completed a floodplain delineation report in January 1995 (USACE, 1995), revising an earlier delineation. In calendar year 2018, all proposed activities at the Pantex Plant were evaluated during the NEPA process for potential impacts on floodplains and wetlands and other criteria required by 10 CFR 1022.

**Table 2.7 – 2018 Activities for Compliance with the Emergency Planning and Community Right-to-Know Act**

Requirement	Applicable	Comment
Planning Notification (SARA 302-303)	Yes	Three chemicals defined as “Extremely Hazardous Substance” by SARA 302-303 were stored at Pantex in quantities above the threshold planning quantities in 2018.
Extremely Hazardous Substance Notification (SARA 304)	Yes	There were no accidental releases of “Extremely Hazardous Substance” as defined by SARA 304 that exceeded quantities in 2018.
Material Safety Data Sheet/Chemical Inventory (SARA 311-312)	Yes	This requirement was satisfied by the Texas Tier Two Report <sup>a</sup> . Twenty-three chemicals were listed in the report for 2018.
Toxic Chemical Release Inventory Reporting (SARA 313)	Yes	A Toxic Chemical Release Inventory Report was required for calendar year 2018.

<sup>a</sup> Report submitted annually to the Chief, Hazard Communication Branch, Occupational Safety and Health Division, Texas Department of Health, the Local Emergency Planning Committee, and the local Fire Department.

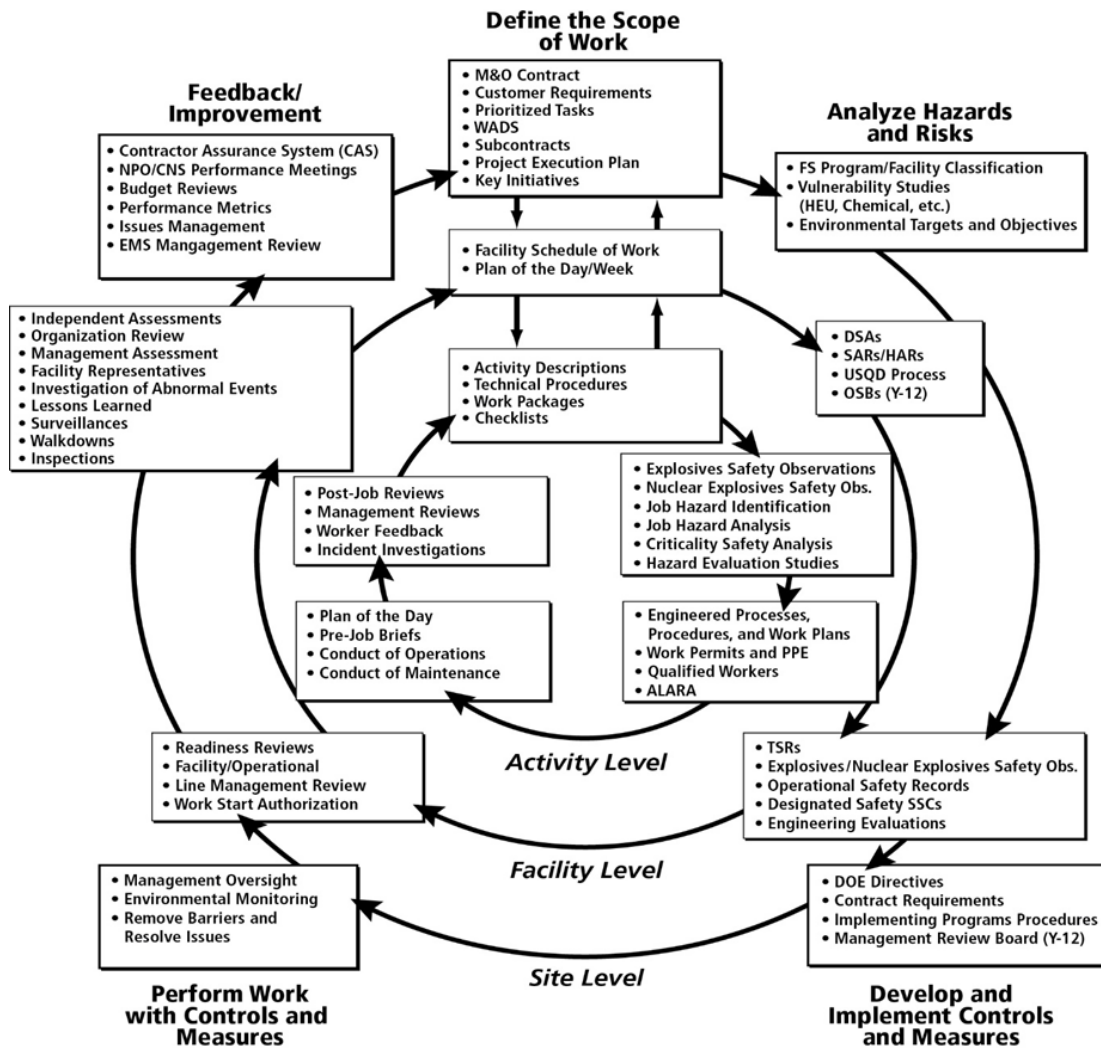
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### Chapter 3 – Environmental Management Information

To implement sound stewardship practices that are protective of the air, water, land, and other natural and cultural resources impacted by Consolidated Nuclear Security, LLC (CNS) operations, a comprehensive Environmental Management System (EMS) has been developed. The Pantex EMS is a major component of the Integrated Safety Management System (ISM). These integrated systems envelop all personnel that work at the Plant and all of the Plant’s activities, products, and services and are the means by which Department of Energy (DOE) cost effectively meets or exceeds compliance with applicable environmental, public health, and resource protection requirements.

#### 3.1 Environmental Management System

The ultimate goal of the CNS ISM is to achieve an effective integration of safety, environmental, security, and quality programs so that missions are accomplished while protecting the public, the worker, and the environment. Figure 3.1 represents the CNS work activity structure. The Core Functions define how CNS safety management functions are performed and provide structured methodology for the ISM & EMS Programs.



YGG-00-0846R19

Figure 3.1 – CNS Integrated Safety Management Program

As a component of the CNS ISM, Pantex has an EMS that meets the requirements of DOE Order 436.1 *Departmental Sustainability* (DOEh). The EMS provides for systematic planning, integrated execution, and evaluation of programs for: 1) public health and environmental protection, 2) environmental sustainability, 3) pollution prevention (P2), 4) recycling, and 5) compliance with applicable environmental protection requirements. It includes policies, procedures, and training to identify activities with significant environmental impacts, to manage, control, and mitigate the impacts of these activities, and to assess performance and implement corrective actions where needed. Environmental aspects and impacts are reviewed annually and measurable environmental objectives and specific targets are developed for implementation. In accordance with DOE 436.1, the Plant’s EMS is modeled on the International Organization for Standardization (ISO) 14001, *Environmental Management Systems – Requirements with Guidance for Use*, 2004.

DOE defines its key clean energy and sustainability strategies and goals in its Site Sustainability Plan (SSP). Each DOE site is required to prepare an annual SSP that expresses the site’s performance status and planned actions for meeting DOE’s SSP goals and broader sustainability program. Pantex uses its EMS as a platform for SSP implementation, as well as for other programs with objectives and measurable targets that contribute to meeting sustainability goals.

Each year, significant environmental impacts associated with Plant operations are evaluated to determine potential goals for the following year. The objectives and associated specific targets are set to improve the management of identified environmentally significant aspects related to Pantex activities, products, and services. By adopting objectives, the Pantex Plant commits to achieving the management goals and ensures that appropriate resources (technical, organizational, infrastructure, financial, human, and special skills) will be considered to accomplish the environmental targets. Appropriate authority and responsibility are assigned to each relevant function and level within the organization to meet the objectives. Table 3.1 represents the status of Objectives and Targets for FY 2018.

**Table 3.1 – CNS Pantex Objectives and Targets for 2018**

Objective	Target(s)	Status/Comments
Maximize use of Ogallala Aquifer	Maximize use of Primary & Secondary Ogallala Aquifer using recommendations from Asset Management Plan (AMP) study performed by PNNL in FY16.	On-going
Determine Pantex Conformance to ISO 14001-2004	To ensure that each EMS conforms to ISO 14001, DOE O 436.1 requires that each EMS shall be the subject of a formal audit by a qualified party outside the control or scope of the EMS every three years. Pantex Plant complete the triannual Independent Audit to the requirements of the International Organization for Standardization’s ISO 14001-2004.	The subject audit(s) were completed by November 30, 2018.
Depletion of Natural Resources	Upon footprint reduction assure utilities are discontinued from buildings as close to the source as practicable.	On-going



### 3.1.1 EMS Accomplishments for 2018

In accordance with the current DOE Order 436.1 *Departmental Sustainability*, Pantex continues to implement and maintain a formal EMS using the ISO 14001 Standard as the platform for site implementation. To meet the intent of this DOE Order the Pantex EMS has been the subject of required formal triennial audits by qualified auditors outside the control or scope of the EMS on four occasions and has successfully been identified as conforming to ISO 14001 at each audit.

Opportunities for continuous improvement are the emphasis of regularly scheduled building environmental walk down surveillances. These surveillances focus on EMS principles, energy and water conservation, environmental sustainability, recycling, safety, and P2. Special attention has been provided to assist DOE and Pantex subcontractors in the subcontractor lay-down yards to maintain compliance with EMS expectations and to instill in the subcontractors that the quality of an EMS is also their concern.

Select accomplishments of the environmental programs at Pantex include but are not limited to:

- Pantex continues to promote sustainable acquisition and procurement to the maximum extent practicable, ensuring bio-preferred and bio-based provisions and clauses are included in 95 percent of applicable contracts.
- Pantex has diverted ~45 percent of Municipal Solid Waste, and construction & demolition material/debris originally earmarked for landfills and identified alternate pathways for beneficial reuse.
- CNS has achieved sufficient energy savings to enable both Pantex and Y-12 to meet clean and renewable electric energy targets.
- Pantex was selected as DOE's nominee for the Presidential Migratory Bird Federal Stewardship Award.

### 3.1.2 Energy

In the remainder of this Section, the goals established by the DOE Sustainability Performance Office (SPO) are expressed in fiscal years from DOE determined baselines. Pantex reported progress towards meeting these goals in a SSP produced after the completion of FY 2018. For the purpose of this document, the progress during CY 2018 is also reported as applicable. Success in reducing energy use at Pantex has historically been realized from energy savings activities such as: (1) utilizing the Energy Management Control System (EMCS) to implement and maintain night, weekend and holiday setbacks; (2) installation of occupancy sensors to control lighting in areas in several facilities with low occupancy rates (conference rooms, break rooms, restrooms); (3) installation of new or retrofitted advanced meters that are integrated with a communication network and dedicated server that stores the meter readings for use with the Environmental Protection Agency's (EPA's) Portfolio Manager building benchmarking system; (4) procurement of equipment such as Energy Star products that are more energy efficient and (5) continuous and retro-building commissioning. Other innovative building strategies, such as cool roofs and low-flow fixtures, are also used to minimize the consumption of energy, water, and materials. In 2018, the Pantex Plant continued to use an alternate work schedule, which has helped reduce energy consumption for a large number of administrative personnel. Relocation of approximately 1,100 employees to a newly constructed energy-efficient facility (John C. Drummond Center) during April 2018 and the resulting reduction of "footprint" after the demolition of legacy facilities over the next 10 years will also reduce energy consumption in the future. However, the major source of reductions in energy intensity has been the installation of the Pantex Renewable Energy Project (PREP) (see Figure 3.2) in the summer of 2014.



**Figure 3.2 – Pantex Renewable Energy Project<sup>1</sup>**

Since 2016 a new goal (included in guidance from the U.S. DOE SPO<sup>2</sup>) requires a 25 percent reduction in energy intensity by FY 2025 from a FY 2015 baseline. Pantex has achieved a 5 percent reduction in energy intensity from the 2015 baseline as the energy intensity decreased from 164.9 kBtu/ft<sup>2</sup>/year for FY 2015 to 157.0 kBtu/ft<sup>2</sup>/year for FY 2018. Again, the decrease in energy intensity is primarily attributable to the renewable energy production from PREP.

During CY 2018, the PREP supplied 50,390 MWh (equivalent to 171,929 MMBtu) of electricity to Pantex and the local electrical grid. Because this renewable energy was produced on-site, EPC Act 2005 Section 203 allows for a double bonus and more than 350,000 MMBtu of renewable electrical energy can be used in calculations of compliance with target percentages established by the SPO regarding the ratio of an agency's total electric and thermal energy accounted for by renewable and alternative energy (also known as "Clean Energy"<sup>3</sup>) and the ratio of renewable electric energy to the total agency electric energy consumption. There are currently no alternative energy technologies used at Pantex. Accordingly, the magnitude of "Renewable Electric Energy" and "Clean Energy" used in the numerator of the above ratio calculations are equivalent.

The total electrical consumption during FY 2018 was 45,816 MWh (equivalent to 156,325 MMBtu). Accordingly, the percentage of "Renewable Electric Energy" (with the use of the aforementioned "bonus") during FY 2018 exceeded SPO targets. The total electric and thermal energy consumed at Pantex during FY 2018 was 533,003 MMBtu. Again, with the use of the "bonus", the percentage of "Clean Energy" during FY 2018 exceeded SPO targets.

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<sup>1</sup> Pantex Renewable Energy Project (PREP) consists of five 2.3-MW-Siemens wind turbines

<sup>2</sup> Scheduled to be incorporated in a future revision to DOE O 436.1

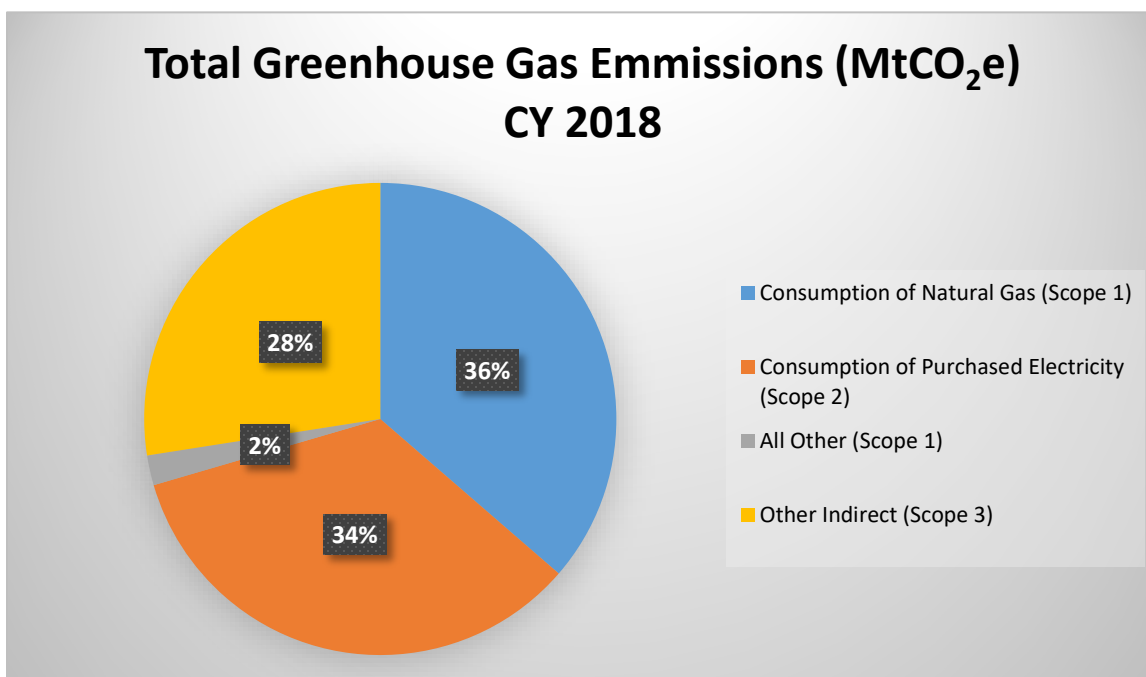
<sup>3</sup> See the definition of these several terms in the glossary.

### 3.1.3 Greenhouse Gases

Guidance from the SPO has expanded upon the energy reduction and environmental performance requirements indicated in DOE Order 436.1 by setting requirements in several areas, including the management of Greenhouse Gases<sup>4</sup> (GHGs). The guidance requires a 50 percent reduction of Scope 1 & 2 GHG emissions and 25 percent reduction of Scope 3 GHG emissions by FY 2025 from their respective 2008 baselines.

The largest component of the GHG emissions accredited to the Pantex Plant are those from federally owned or controlled sources such as the combustion of natural gas used to produce steam onsite and the use of petroleum fuels in fleet and other vehicles and equipment as well as fugitive emissions from refrigerants and wastewater treatment operations. These emissions and those generated through the purchase and use of electricity generated off-site (Scope 2 or Energy Indirect GHG emissions) yielded more than 74,747<sup>5</sup> metric tons CO<sub>2</sub> equivalent (MtCO<sub>2e</sub>) of GHGs in 2008.

During FY 2018, the operation of Pantex yielded a total of 45,413 MtCO<sub>2e</sub>. Of this total, 19,964 MtCO<sub>2e</sub> was due to the combustion of natural gas, 2,212 MtCO<sub>2e</sub> due to other Scope 1 sources, 21,802 MtCO<sub>2e</sub> due to the purchase and use of electricity generated off-site (Scope 2 sources) and 17,445 MtCO<sub>2e</sub> was due to Scope 3 GHG emissions. These emissions are illustrated in Figure 3.3.



**Figure 3.3 – Total CY 2018 GHG Emissions**

By the operation of the PREP during CY 2018, Pantex did not need to purchase as much electricity and the quantity of Scope 2 GHG emissions continued to be reduced from baseline year (FY 2008) levels. In addition by reducing energy consumption by the means discussed in Section 3.1.2 above, Pantex has concurrently reduced the generation of Scope 2 GHGs. Although some components of Scope 1 emissions such as fugitive emissions and emissions associated with on-site wastewater treatment have remained fairly

<sup>4</sup> See the definition of this term and those for Scopes 1, 2, & 3 GHGs in the Glossary.

<sup>5</sup> An additional 23,412 MtCO<sub>2e</sub> was generated from emissions associated with air and ground travel, employee commuting, transmission and distribution losses and other Scope 3 (Other Indirect) GHGs. Thus a total of 99,802 MtCO<sub>2e</sub> GHGs was associated with Pantex operations during FY 2008, the baseline year for goals relating to GHGs.

constant, the Plant also continued efforts to reduce Scope 1 emissions by improving operations of the Pantex fleet, reducing petroleum fuel use, using more hybrid vehicles for better gas mileage, using Alternative Fuel Vehicles (AFVs) and ensuring the fleet is the right size for the National Nuclear Security Agency (NNSA) mission. Potential future reductions in the generation of Scope 2 GHGs are anticipated to occur as operation of the PREP continues.

Pantex also continues to reduce Scope 3 (Other Indirect) GHG emissions compared to the FY 2008 baseline. CY 2018 Scope 3 GHG emissions have continued to decrease (primarily due to reductions in travel). In addition, a reduction in the quantity of emissions associated with employee commuting has occurred with the conversion of all Pantex personnel to an alternative shift working every other Friday, and the encouragement of telecommuting programs in select organizations. With less energy being directly purchased from the regional vendor, transmission and distribution losses as well as the associated Scope 3 GHG emissions have also been diminished.

### **3.1.4 Water**

Pantex has been required, beginning in 2008, to reduce water intensity<sup>6</sup> relative to the baseline of the Plant's water consumption in 2007 of ~ 486 million L (129 million gal). Pantex has continued to develop and implement initiatives based upon requirements in DOE O 436.1 to reduce annual use and meet sustainability goals integrated into our SSP.

During CY 2018, water consumption was approximately 421 million L (111 million gal). While Pantex shows about a 5.0 percent increase in square footage since the baseline year, water intensity has decreased about 13% from the baseline year.

Although some repair and replacement has occurred during the last several years, leaking WWII era water lines, inefficient water-cooled equipment, and other factors caused a noticeable increase in water intensity during 2015 thru 2017. Focused repairs during FY 2018, the relocation of approximately one-third of the Pantex population to the new John C. Drummond Center in April 2018 and planned demolition and decommissioning of approximately 50 legacy facilities that require costly maintenance should enable Pantex to continue the trend of reduction in water intensity.

## **3.2 Oversight**

### **3.2.1 Federal Agencies**

The results of compliance inspections and/or other oversight activities conducted by the EPA in 2018 are discussed in Chapter 2 of this document.

### **3.2.2 State of Texas**

The results of compliance activities conducted by various state agencies in are discussed in Chapter 2 of this document. An additional oversight mechanism was initiated in 1989 when the Secretary of Energy invited the host State of each DOE facility to oversee the evaluation of environmental impacts from facility operations. As a result, the DOE entered into a five-year Agreement in Principle with the State of Texas in August 1990, which was re-negotiated in 1995, 2000, 2005, 2010, and 2015. The current agreement is in effect through September 30, 2020. It focuses on general cooperation with all state agencies, including emergency management. Six state agencies are involved: the Governor's Office (acting through the State Energy Conservation Office), the Texas Attorney General's Office, the Texas Commission on Environmental Quality (TCEQ), the Texas Department of Public Safety (DPS)-Division of Emergency

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<sup>6</sup> The ratio of the number of gallons of water used divided by the square footage ("footprint") of the site.

Management, the Texas Department of State Health Services (TDSHS)-Radiation Control, and the Texas Bureau of Economic Geology.

The agreement also provides for joint emergency planning with Carson, Armstrong, and Potter counties, and the City of Amarillo. A number of meetings between DOE and these agencies were held in 2018. In addition, DOE provided information to the State of Texas, as required, and the State conducted its own environmental sampling and research, and participated in joint emergency exercises and drills with the Pantex Plant and local jurisdictions.

### 3.3 Pollution Prevention

Activities in support of the P2 Program are waste elimination, material substitution, waste minimization, recycling, and energy and water conservation. Pantex performs Pollution Prevention Opportunity Assessments (PPOAs) on Plant processes to identify new ideas for waste reduction. The team that performs the PPOA works with the owner of the process to implement the waste reduction recommendations. In 2018, two PPOAs were performed.

In accordance with DOE O 436.1, Pantex has continued an active recycling program, which reduces the waste disposal volumes and saves taxpayers' money. Results of ongoing recycling initiatives in 2018 are shown in Table 3.2.

**Table 3.2 – Pantex Plant Site-wide Recycling for 2018**

2018 Totals		
Recycled Material	Pounds	Kilograms
Aluminum (Scrap Metal)	5,171	2,346
Batteries	108,049	49,010
Computers & Other Electronics	39,894	18,096
Concrete & Asphalt	191,780	86,990
Corrugated Cardboard	104,921	47,591
Engine Oils	27,820	12,619
Fluorescent Bulbs	4,098	1,859
Newspapers/Magazines/Phonebooks	41,542	18,843
Non-Suspension Scrap Metals	338,869	153,708
Office and Mixed Paper	212,500	96,388
Oil Filters	1,750	794
Plastic	6,240	2,830
Tires/Scrap Rubber	27,440	12,447
<b>Total</b>	<b>1,110,074</b>	<b>503,521</b>

In 2006, Pantex joined and became an ongoing partner of the EPA Federal Electronics Challenge (FEC) and pledged to make progress toward meeting all FEC criteria for environmentally responsible management of electronic equipment. The Pantex process for computer disposition meets the FEC criteria for recycling and reuse of computer equipment. Through these ongoing efforts Pantex has demonstrated an environmentally friendly approach to lifecycle management of electronic equipment while ensuring the protection of national security information from unauthorized disclosure.

### 3.4 Natural Resources

#### 3.4.1 Flora and Fauna

Across most of the Southern High Plains, cultivation and other developments have reduced the acreage of native habitat. These types of reductions have occurred at Pantex. The remaining areas of near-native habitat at the Plant are small and include wetlands and shortgrass prairie uplands located near the playas.

A biological assessment at the Pantex Plant, completed in 1996, addressed the impacts of continuing Plant operations on endangered or threatened species and species of concern that may occur in or migrate through the area. The assessment was approved by the U.S. Fish & Wildlife Service (USFWS), and it concurred with the conclusion that continued Plant operations would not be likely to adversely affect any federally-listed threatened or endangered species (PANTEXb). This was reaffirmed in subsequent Supplement Analyses (2003, 2009, 2013, and 2018) for the State-wide Environmental Impact Statement (SWEIS). Lists of threatened and endangered species, species of concern, and information regarding designations of critical habitat are monitored regularly for changes in status. Results of animal and plant sampling are discussed in Chapters 11 and 12.

#### 3.4.2 Fauna (Mammals)

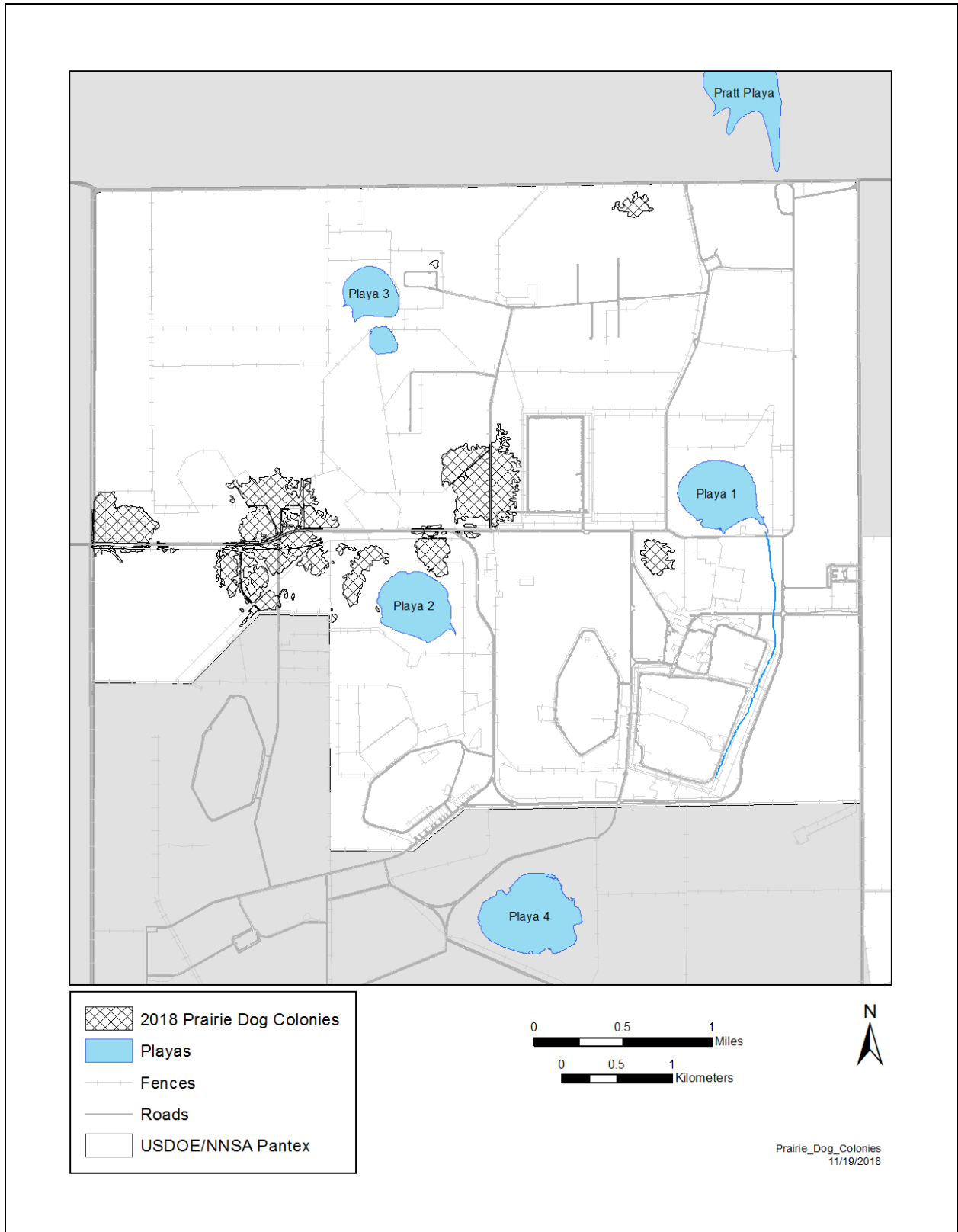
At least 15 species of mammals were recorded at the Pantex Plant in 2018 during field activities and nuisance animal responses (Table 3.3). The all-time mammal list for Pantex includes 46 species. Spotlight surveys in 2018 revealed badgers (*Taxidea taxus*), black-tailed jackrabbits (*Lepus californicus*), bobcats (*Lynx rufous*), cottontails (*Sylvilagus spp.*), coyotes (*Canis latrans*), mule deer (*Odocoileus hemionus*), pronghorn (*Antilocapra americana*), red fox (*Vulpes vulpes*), striped skunks (*Mephitis mephitis*), white-tailed deer (*Odocoileus virginianus*), and a black-tailed prairie dog (*Cynomys ludovicianus*).

In 2018, a survey of black-tailed prairie dog (*Cynomys ludovicianus*) colonies conducted with the assistance of Global Positioning System (GPS) equipment revealed that the colonies occupied about 170.1 hectares (420.2 acres) at Pantex (including Pantex Lake; Figures 3.4 and 3.5). Although prairie dogs are occasionally controlled where they have spread into areas of operational concern (landfills, etc.), there were no control activities conducted in 2018.

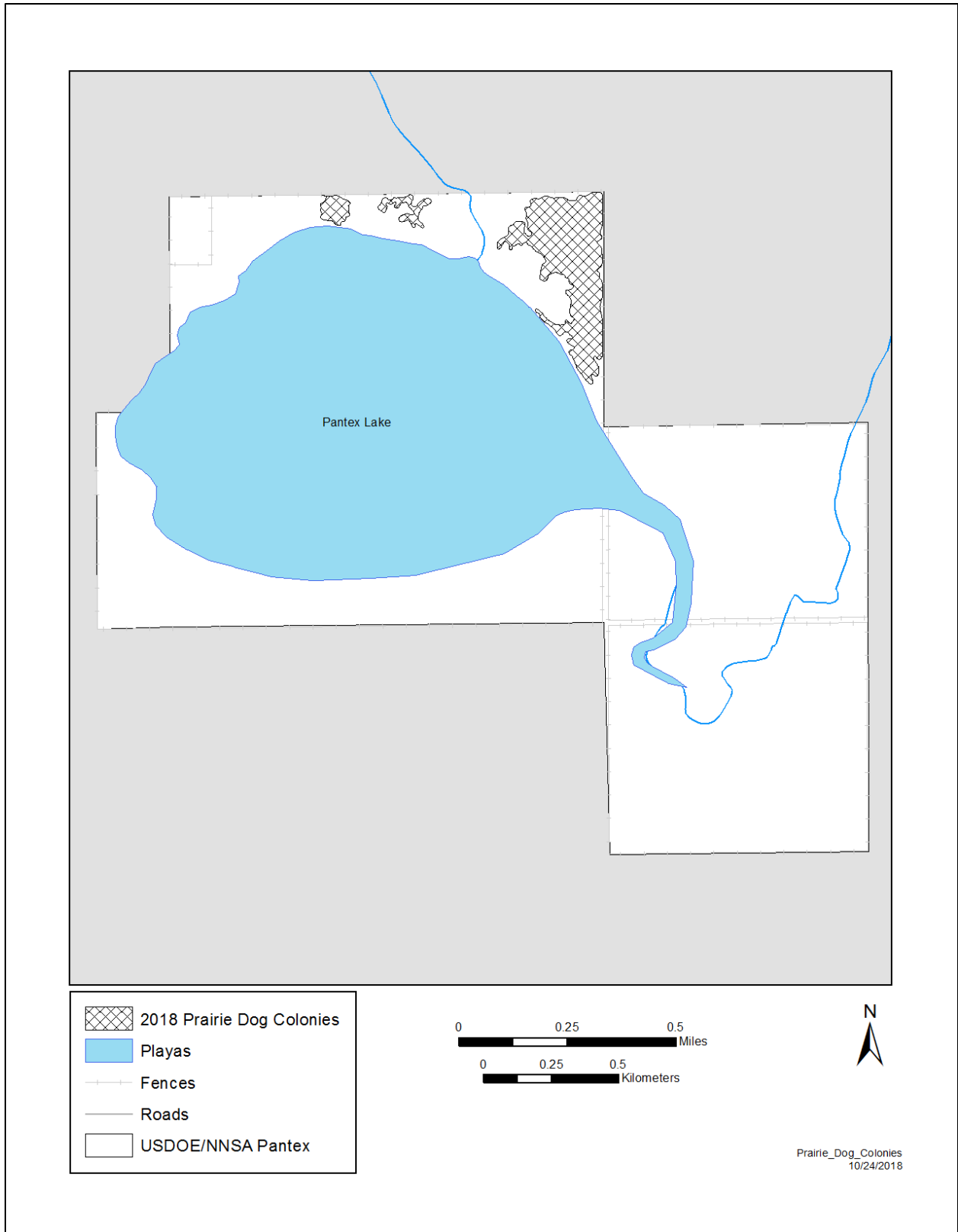
**Table 3.3 – Mammals Identified at Pantex Plant During 2018**

Common Name	Scientific Name	Playa 1	Playa 2	Playa 3	Pantex Lake	East Property	Other Area
Big free-tailed bat	<i>Nyctinomops macrotis</i>						X
Black-tailed jackrabbit	<i>Lepus californicus</i>		X		X		X
Black-tailed prairie dog	<i>Cynomys ludovicianus</i>		X		X		X
Bobcat	<i>Lynx rufous</i>						X
Brazilian free-tailed bat	<i>Tadarida brasiliensis</i>						X
Cottontail	<i>Sylvilagus spp.</i> <sup>a</sup>	X	X		X		X
Coyote	<i>Canis latrans</i>		X				X
Feral Cat	<i>Felis catus/sylvestris</i>						X
Mule deer	<i>Odocoileus hemionus</i>	X					X
Nine-banded armadillo	<i>Dasypus novemcinctus</i>						X
Pronghorn	<i>Antilocapra americana</i>						X
Red fox	<i>Vulpes vulpes</i>						X
Southern plains woodrat	<i>Neotoma micropus</i>						X
Striped skunk	<i>Mephitis mephitis</i>						X
White-tailed deer	<i>Odocoileus virginianus</i>	X					X

<sup>a</sup> Desert (*S. audubonii*) and eastern (*S. floridanus*) cottontails could occur on the Plant and, thus, the “at least 12 species”.



**Figure 3.4 – Locations of Prairie Dog Colonies at Pantex Plant, 2018**



**Figure 3.5 – Location of Prairie Dog Colonies at Pantex Lake, 2018**



### 3.4.3 Fauna (Birds)

Migratory birds are an important part of the Pantex Plant's natural resources. A bird checklist for the Pantex Plant compiled by K. D. Seyffert indicates the species and their abundances expected in the Pantex Plant area during various seasons of the year, based on habitat types and knowledge of migrations through the local area (Seyffert, 1994). The *Integrated Plan for Playa Management at Pantex Plant and Wildlife Management at Pantex* (PANTEXf) provides for monitoring of birds across the Plant. Twenty-two species of birds were recorded at Pantex during 2018 (Appendix B) and the all-time bird list for Pantex includes 202 species.

Pantex was the DOE/NNSA's sole-allotted nomination for the 2017 Presidential Migratory Bird Federal Stewardship Award, which included elements of management, research, collaborations, and outreach. Pantex continued to promote bird conservation through public outreach such as articles, presentations and the Purple Martin Banding and Outreach Program. There was a year delay in the process due to the new administration's review of Department of Interior committees and councils, but the process was reinitiated in December of 2018. In early 2019, the 2019 Presidential Migratory Bird Federal Stewardship Award was to be named from among three finalists: USDOE/NNSA/Pantex, the National Park Service, and the Bureau of Ocean Energy Management in Coordination with the United States Geological Survey. USDOE/NNSA/Pantex was named the recipient of the award.

A contract with the U. S. Geological Survey's Texas Cooperative Fish and Wildlife Research Unit at Texas Tech University (TTU) includes satellite-tracking of Swainson's hawks (*Buteo swainsoni*) with PTT/satellite transmitters. Adult and juvenile Swainson's hawks have been tracked in relation to wind turbine fields, nesting territories, fall migration, and wintering areas.

Pantex collaborates with York University, University of Manitoba, and the Purple Martin Conservation Association and maintains a study site for deployment of geolocator and GPS. data-loggers on eastern purple martins (*Progne subis subis*) as part of an international collaboration studying this declining songbird. GPS technology confirmed roosts locations and habitat throughout the migrations and winter.

During 2018, Pantex and collaborators shared research results through presentations at the Texas Chapter of The Wildlife Society (one each, purple martins and Swainson's hawks), Southwest Association of Naturalists (Swainson's hawks and mortality from wind turbines), and the U.S.G.S. Texas Cooperative Fish and Wildlife Research Unit Cooperator's Annual Meeting (Swainson's hawks). Two manuscripts were accepted for publication in the scientific literature (in press, Wildlife Society Bulletin and American Naturalist; both on purple martins).

### 3.4.4 Amphibians and Reptiles

Six species of amphibians and reptiles were recorded at the Pantex Plant in 2018 during field activities and nuisance animal responses (Table 3.4). The all-time amphibian and reptile list for Pantex includes 27 species.

**Table 3.4 – Amphibians and Reptiles Identified at Pantex Plant During 2018**

Common Name	Scientific Name	Playa 1	Playa 2	Playa 3	Pantex Lake	East Property	Other Area
Bullsnake	<i>Pituophis melanoleucus sayi</i>						X
Central plains milksnake	<i>Lampropeltis triangulum gentilis</i>						X
Checkered garter snake	<i>Thamnophis marcianus marcianus</i>						X
Common kingsnake	<i>Lampropeltis getula splendida</i>						X
Prairie rattlesnake	<i>Crotalus viridis viridis</i>						X
Texas horned lizard	<i>Phrynosoma cornutum</i>						X

### 3.4.5 Pollinators

In 2018, and in support of the *Presidential Memorandum, “Sustainable Practices for Designed Landscaping and Supporting Pollinators on Federal Landscapes”* and the *Department of Energy Pollinator Protection Plan*, Pantex initiated a contract with the University of Oklahoma’s Plains Institute/Oklahoma Biological Survey for research exploring the potential of weather radar for monitoring migrations of insect pollinators. In particular, it is hoped that the study could prove valuable in developing a monitoring tool for the monarch butterfly (*Danaus plexippus plexippus*), a species that has been proposed for listing as *threatened* under the Endangered Species Act. First year’s results included radar images of monarch butterfly migrations across the Great Plains and indications of greater than two million individual butterflies in an image from Amarillo’s National Weather Service radar.

### 3.4.6 Nuisance Animal Management

In 2018, Environmental Compliance Department (ECD) staff addressed 193 nuisance animal situations and these involved feral cats, domestic dogs, Eurasian collared-doves, rock pigeons, and twelve wildlife species. Twenty-eight striped skunks were trapped and delivered to the Amarillo Animal Control Facility by ECD and 40 cottontail rabbits were removed from Perimeter Intrusion Detection and Surveillance (PIDAS) bed areas by Security. No rock pigeons were harvested by Security in 2018.

## 3.5 Cultural Resources

Cultural resources identified at the Pantex Plant include archeological sites from prehistoric Native Americans; standing structures that were once part of the WWII-era Pantex Ordnance Plant (1942-1945); and buildings, structures, and equipment associated with the Plant’s Cold War operations (1951-1991). In addition, many artifacts and historical documents have been preserved which are valuable sources for interpreting prehistoric and historic human activities at the Plant. Some of these cultural resources are eligible for inclusion in the *National Register of Historic Places (National Register)*; thus, requiring protection and preservation under the National Historic Preservation Act (NHPA) and related Cultural Resource Management (CRM) requirements. The Plant’s CRM program ensures compliance with all applicable state and federal requirements.

The goal of the CRM program is to manage the Plant’s cultural resources efficiently and systematically, taking into account both the Plant’s continuing mission and historic preservation concerns. This goal is achieved through coordination with the Plant’s project review process for compliance with the National Environmental Policy Act (NEPA), and through consultation with the State Historic Preservation Office

(SHPO) and the President’s Advisory Council on Historic Preservation (Advisory Council). In October 2004, DOE, the Pantex Plant, the Texas SHPO, and the Advisory Council completed execution of a Programmatic Agreement/Cultural Resource Management Plan (PA/CRMP) (PANTEJ). This PA/CRMP ensures compliance with Section 106 of the NHPA, providing for more efficient and effective review of Plant projects having the potential to impact prehistoric, WWII era, and Cold War era properties, objects, artifacts and records. In addition, the PA/CRMP outlines a range of preservation activities planned for the Plant’s compliance program. The PA/CRMP provides for the systematic management of all archeological and historic resources at the Pantex Plant under a single document. No changes were made to the program in 2018.

### **3.5.1 Archeology**

The Pantex Plant lies within the southern Great Plains archeological province; specifically, within the High Plains Ecological Region of the Texas Panhandle. Approximately half of the DOE-owned and leased land at the Pantex Plant has been systematically surveyed for archeological resources and based upon those surveys, a site-location model was developed. In 1995, a 960-hectare (ha) (2,400-acre [ac]) survey confirmed that prehistoric archeological sites at the Pantex Plant are situated within approximately 0.4 kilometer (0.25 mile) of playas or their major drainage locations. Conversely, such sites do not occur in interplaya upland areas (Largent, 1995).

The 69 archeological sites identified at the Pantex Plant consist of 57 Native American prehistoric sites represented by lithic scatters of animal bone artifacts and 12 Euro-American farmstead sites represented by foundation remains and small artifact scatters. In consultation with the SHPO, Pantex determined that the 12 historic sites are not eligible for inclusion in the *National Register*. Pantex and the SHPO concluded that two of the 57 prehistoric sites (41CZ66 and 41CZ23) are potentially eligible for the *National Register*, but that additional field work would be required to make a final eligibility determination. Pantex will continue to protect these two sites and monitor them on a regular basis, as though they are eligible. If additional features are exposed and found, excavation will proceed if they cannot be adequately protected in-situ. These exposed features will be analyzed, mapped, collected, and excavated by archeological methods. All archeological reports, records, photographs, maps and artifacts will be archived at the Plant in accordance with applicable federal regulations. In addition, 22 of the prehistoric sites are protected within playa management units surrounding the four DOE-owned playas.

In the fall of 1996, Plant personnel monitoring for erosion discovered a number of large bones belonging to a bison. An emergency excavation was completed under the supervision of a qualified archeologist. The bones were identified and preserved. Today, the bison bones have been placed in a permanent exhibit within the Pantex Visitor Center located in Building 16-12.

For Calendar Year 2018, staff members monitored archeological sites on four separate occasions. Only one small bone fragment was identified and was left in situ.

### **3.5.2 World War II (WWII)**

In 1942, the U.S. Army Ordnance Department chose this site for construction of a bomb-loading facility. The 6,475-ha (16,000-ac) industrial Pantex Ordnance Plant, designed and constructed in only nine months, sprang up in the middle of a traditional rural farming and ranching community, bringing with it great social and demographic change. It was constructed by the United States Army Corps of Engineers (USACE) and operated by the Certain-teed Products Corporation to produce bombs and artillery shells.

The WWII-era historical resources of the Pantex Plant consist of 118 standing buildings and structures, all of which have been surveyed and recorded. In consultation with the SHPO, Pantex has determined that these properties are not eligible for inclusion in the *National Register* within a WWII context. The WWII

era buildings and structures have been preserved to some extent through survey documentation, photographs, individual site forms, and oral histories.

The Pantex Visitor Center includes a WWII exhibit which includes world events from the beginning of the fundamental activities for tactical and thermonuclear weapons that were developed and proved, to the creation of physical infrastructure of the nuclear weapon complex that led to the growth of the stockpile and its effect on Pantex.

The Pantex Records Operation Center continues to maintain and store historical records and a variety of different media for preservation purposes. Collections include facility maps, aerial maps and additional Cold War as-built drawings, as well as Plant layout plans of former zones. In addition, a collection of Cold War-era photographs, written material, and other items have been collected and stored.

### **3.5.3 Cold War**

The NHPA typically applies only to historic properties that are at least 50 years old unless they are of “exceptional importance” (NPS Bulletin 15). However, 69 buildings that were constructed during WWII and used during the Cold War are eligible for inclusion in the *National Register* under the Cold War context. Many properties at the Pantex Plant are associated with the Cold War arms race and are of exceptional importance. As a final assembly, maintenance, surveillance, and disassembly facility for the nation’s nuclear weapons arsenal, the Pantex Plant lies at the very heart of Cold War history.

The period of Cold War operations at the Pantex Plant date from 1951, when the Plant was reclaimed by the Atomic Energy Commission (AEC) as part of the expanding nuclear weapons complex, to the September 1991 address to the nation by then-President, George H.W. Bush directing the dismantlement of a portion of the nation’s nuclear weapon stockpile; thereby, changing the Pantex mission from one of nuclear weapon assembly to one of disassembly. The Cold War-era historical resources of the Pantex Plant consist of approximately 650 buildings and structures and a large inventory of process-related equipment and documents. The historical resources of this period are among the Plant’s most significant, and offer a valuable contribution to the nation’s cultural heritage.

The Pantex Plant Master Site Plan, 2017-2040, specifically lists improvements and preservation of buildings listed in the PA/CRMP for in-situ preservation (PANTEXe). The ten facilities designated for in-situ preservation are additionally included in all NEPA reviews. A cultural resources management specialist reviews NEPA documentation to identify adverse effects on historical structures, objects, and archeological sites. Historical equipment tooling, trainers and other components were acquired and have been inventoried and moved into a historical facility until funding can be obtained for a classified exhibit. These projects strengthen continued use of the historical facilities, which confirms Pantex’s pledge for implementing preservation activities.

Preservation activities continue through identification and evaluation of facilities by maintaining the Pantex Visitor Center and railcar displays, collection of artifacts and records, monitoring archeological sites, educational outreach, and other preservation activities. Fifty-two outreach activities for Pantex history occurred in Calendar Year 2018, including history presentations to newly hired staff members, students, and community leaders.

### **3.6 Educational Resources and Outreach Opportunities at Pantex Plant**

Pantex scientists, engineers, and wildlife specialists continued to donate their time and talent to area schools by speaking to students about science careers and helping stimulate student’s interest in science, technology, engineering, and math (STEM). The most notable event each year is the Pantex Science Bowl where middle school and high school students from all across the Texas Panhandle compete for a chance

to advance to the National Science Bowl in Washington, D.C. Pantex also supported four area schools advance their STEM education through donations made to their robotics programs. Pantexans provided several presentations to school, community, and professional groups on a variety of topics including the history and importance of Pantex, wildlife management and research, the world of engineering, and other topics such as “phases of matter.”

### **3.7 Environmental Restoration**

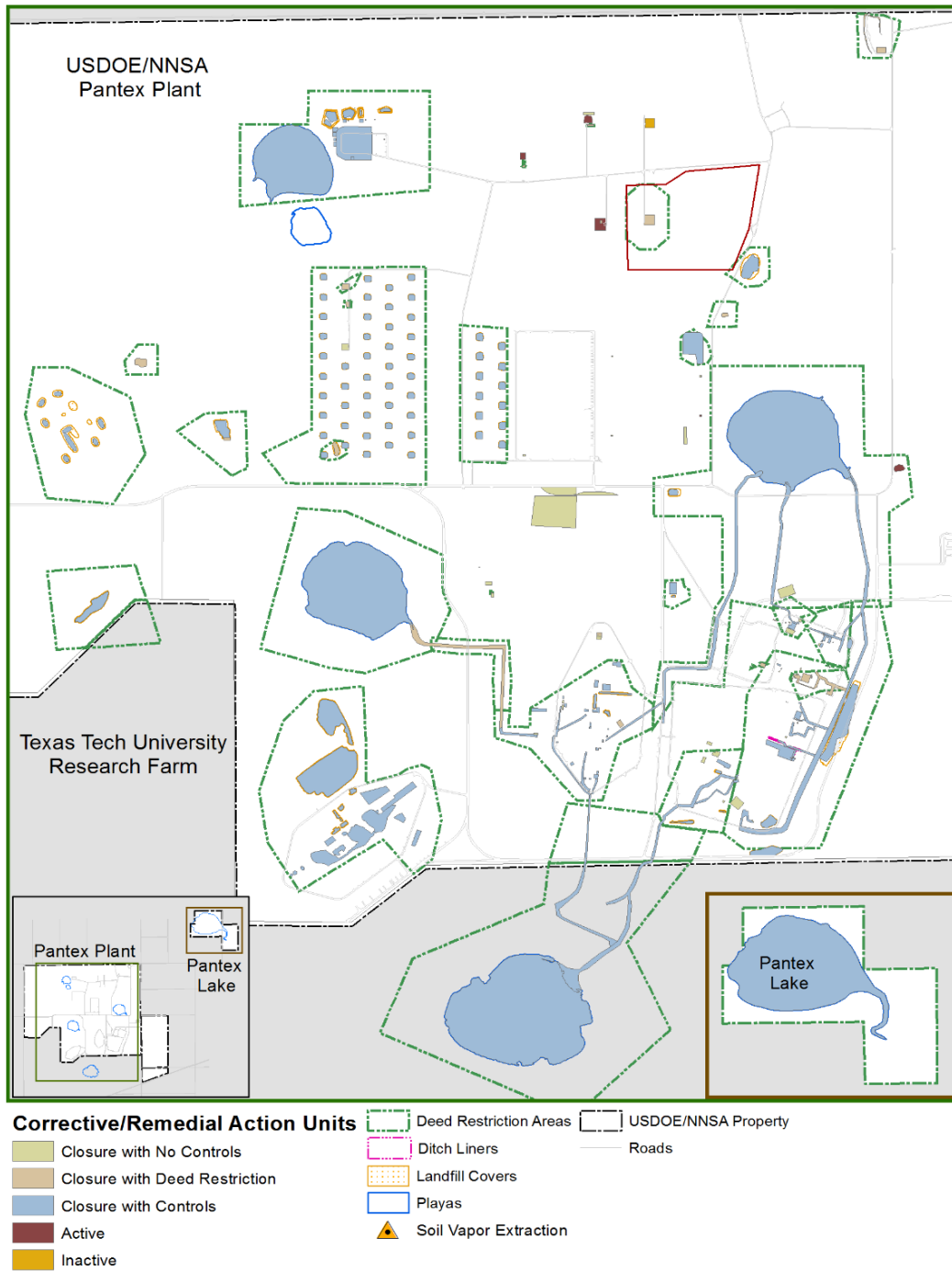
Historical waste management practices at the Pantex Plant resulted in impacts to on-site soil and perched groundwater. These historical practices included disposal of spent solvents in unlined pits and sumps, and disposal of high explosive (HE) wastewater and industrial wastes into unlined ditches and playas. As a result, HEs, solvents, and metals were found in the soil at solid waste management units (SWMUs) at Pantex and in the uppermost (perched) groundwater beneath the Pantex Plant. Pantex and regulatory agencies identified 254 units for further investigation and cleanup. Investigations that identified the nature and extent of contamination at SWMUs and associated groundwater were submitted to the TCEQ and EPA in the form of Resource Conservation and Recovery Act (RCRA) Facility Investigation Reports. Those investigation reports closed many units through interim remedial actions and no further action determinations. Other units were evaluated in human health and ecological risk assessments to identify further remedial actions necessary to protect human health and the environment. Figure 3.6 depicts the location and status of the units. The 15 units still in active use will be closed in accordance with Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and RCRA permit provisions when they become inactive, are determined to be of no further use, and funding is obtained for investigation, cleanup, and closure of the site. One unit is now inactive and funding has been requested to address the site.

Those units requiring further remedial actions were assessed in a corrective measures study to identify and recommend final remedial actions. A detailed summary of actions for the 254 units can be found in the Pantex Site-Wide Record of Decision (ROD), (Pantex Plant and Sapere, 2008). The final approved remedial actions are detailed in the ROD. On-going remedial actions focus on:

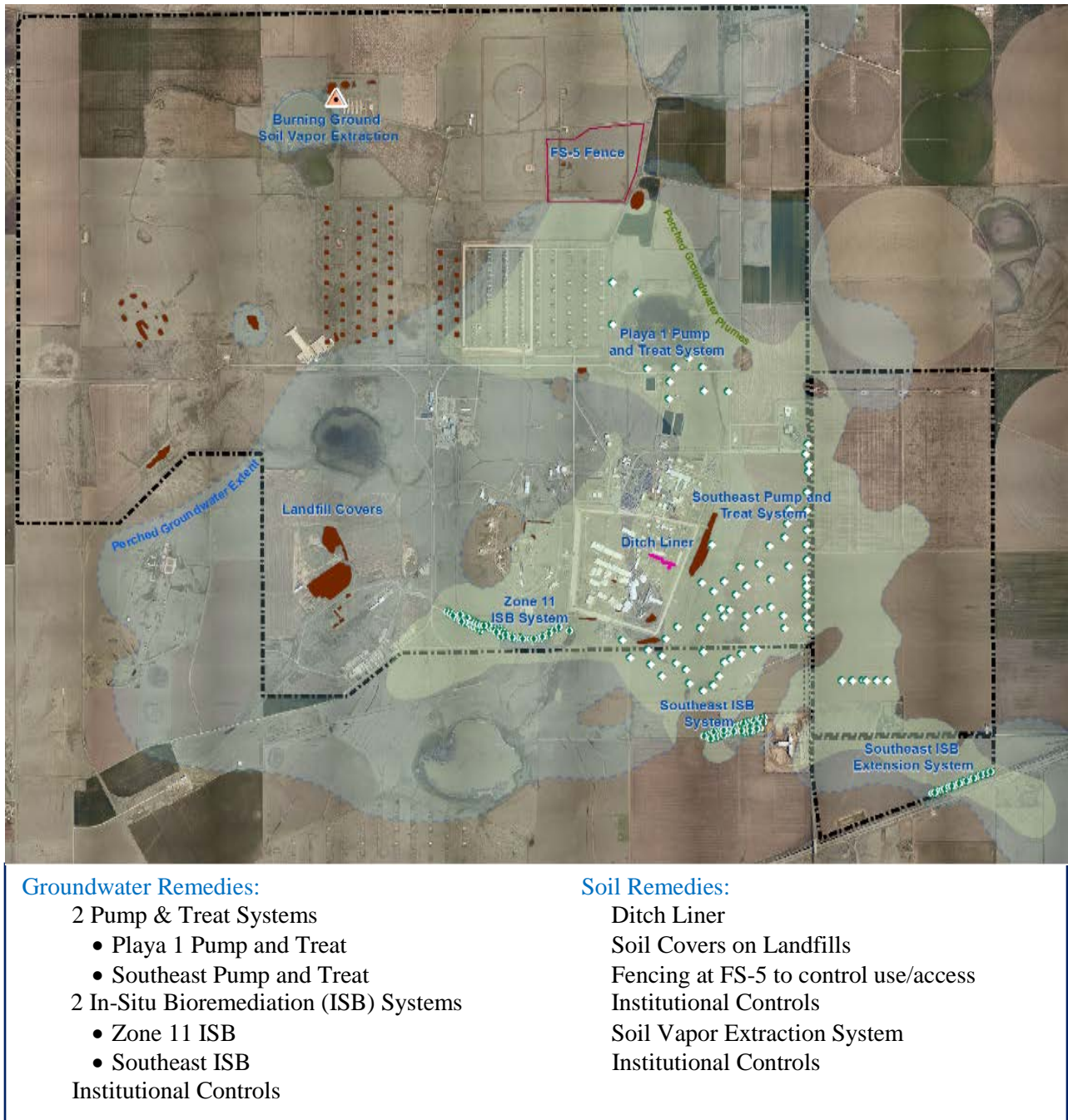
- Cleanup and removal of perched groundwater to protect the underlying drinking water aquifer,
- Removal of soil gas and residual non-aqueous phase liquid (NAPL) in the soil at the Burning Ground for future protection of groundwater resources,
- Institutional controls to protect workers, control perched groundwater use, and control drilling into and through perched groundwater, and
- Maintenance of soil remedies (ditch liner and soil covers) for groundwater protection.

#### **3.7.1 Environmental Restoration Milestones**

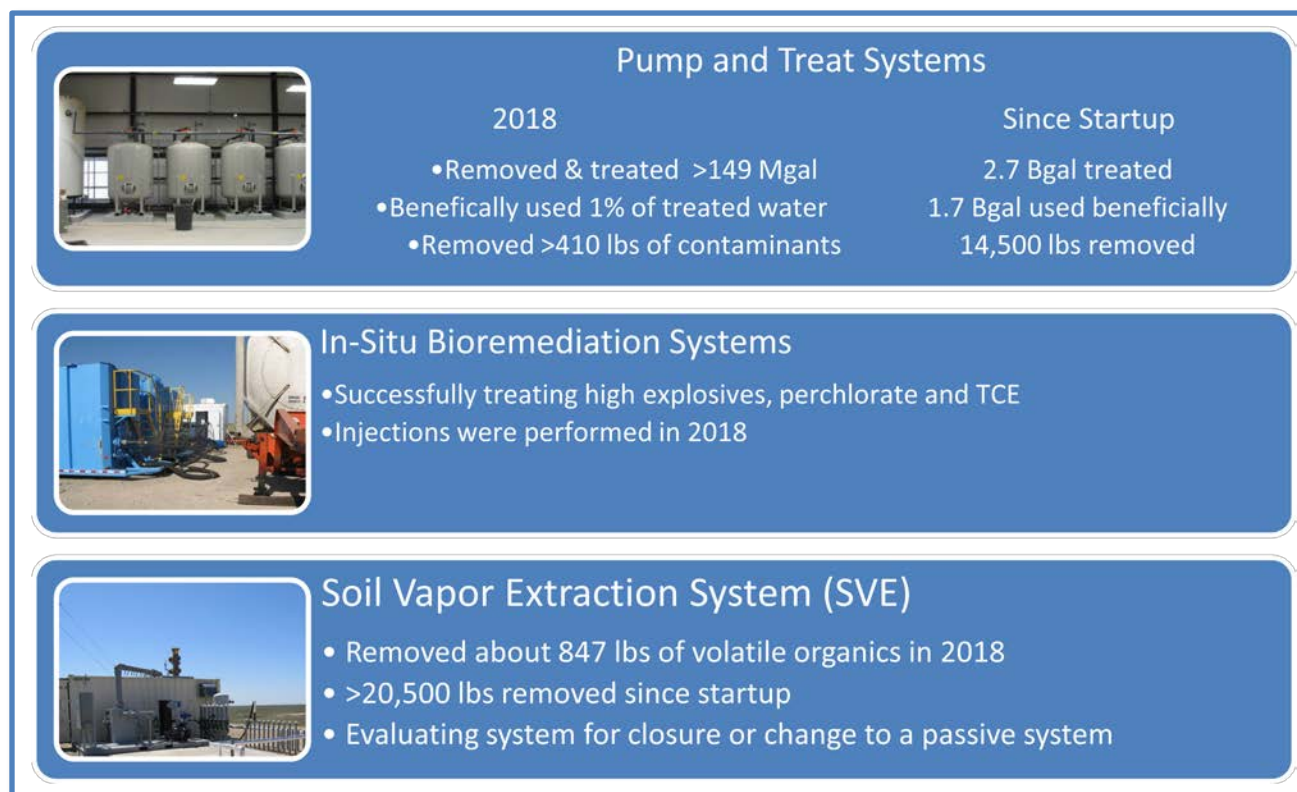
During 2018, Pantex completed several milestones under the continued Long-Term Stewardship (LTS) of environmental units. LTS includes the long-term Operation and Maintenance (O&M) of the remediation systems, monitoring of the systems to ensure that cleanup goals established in the ROD and Compliance Plan will be met, maintenance of soil remedies and institutional controls, and reporting of that information to regulatory agencies and the public. Remedial Action systems at Pantex are depicted in Figure 3.7 and the Major Milestones for the 2018 Remedial Actions are shown in Figure 3.8.



**Figure 3.6 – Location and Status of Solid Waste Management Units**



**Figure 3.7 – Remedial Actions at Pantex**



**Figure 3.8 – Major Milestones for 2018 Remedial Actions**

**Pump and Treat Systems:** The Pump and Treat Systems were installed to address contamination in areas where there is generally greater than 4.6 m (15 ft) of saturation in the perched groundwater. These systems are designed to remove and treat groundwater to achieve contaminant mass reduction and reduction in the saturated thickness of the perched aquifer. Reduction in saturated thickness will significantly reduce the migration of contaminants both vertically and horizontally so that natural breakdown processes can occur over time. To achieve the remediation goals, the Pump and Treat Systems treat the extracted water to remove contaminant mass from the water before the effluent is sent to the Wastewater Treatment Facility (WWTF) and irrigation system for beneficial use, although the Southeast Pump and Treat System (SEPTS) retains the capability for injection back into the perched zone when necessary. The SEPTS has been operating since 1995 when it was started as a treatability study. It has been expanded with more extraction wells and the capacity to treat boron and hexavalent chromium to continue to address the southeastern portion of the groundwater plumes. Construction of the Playa 1 Pump and Treat System (PIPTS) was started in late 2008, and the system became fully operational in January 2009.

To reach the goal of reducing saturated thickness, the Pump and Treat Systems have a goal of operating 90 percent of the time and at 90 percent of treatment capacity if the WWTF and irrigation system can receive all of the treated water. Pantex revised the goals during 2014 to prioritize treatment and use of the water to align operation with the goal of reducing saturated thickness. During 2018, only 1 percent of the treated water was beneficially used due to the shutdown of the subsurface fluid distribution system resulting from the filter bank break that occurred in 2017. Performance of the Pump and Treat Systems for 2018 is depicted in Figure 3.9. Engineering evaluation of the irrigation filter bank break indicated that repairs are complex and will take an extended period of time. For this reason, treated water has been released to Playa 1 or



injected into the perched groundwater since the shutdown of the system. Since the release to Playa 1 and injection near the SEPTS does not align with goals to reduce water infiltration to the perched aquifer, Pantex has reduced throughput of both systems. A combination of injection and release of treated water to Playa 1 is currently used to manage the treated water from the systems. Pantex is planning for the construction of surface irrigation components at the Pantex property east of FM 2373, pending approval of funding.

In addition to removing impacted water from the perched aquifer, the pump and treat systems remove contaminant mass from the groundwater that is extracted from the aquifer. The P1PTS primarily removes the high explosive RDX and the SEPTS primarily removes RDX and hexavalent chromium (Cr<sup>+6</sup>). Figure 3.10 provides the mass removal for HEs and chromium for 2018, as well as totals since startup of the systems. The SEPTS has been operating longer, and the greatest concentrations of HEs are found in the SEPTS extraction well field, so mass removal is higher at that system.

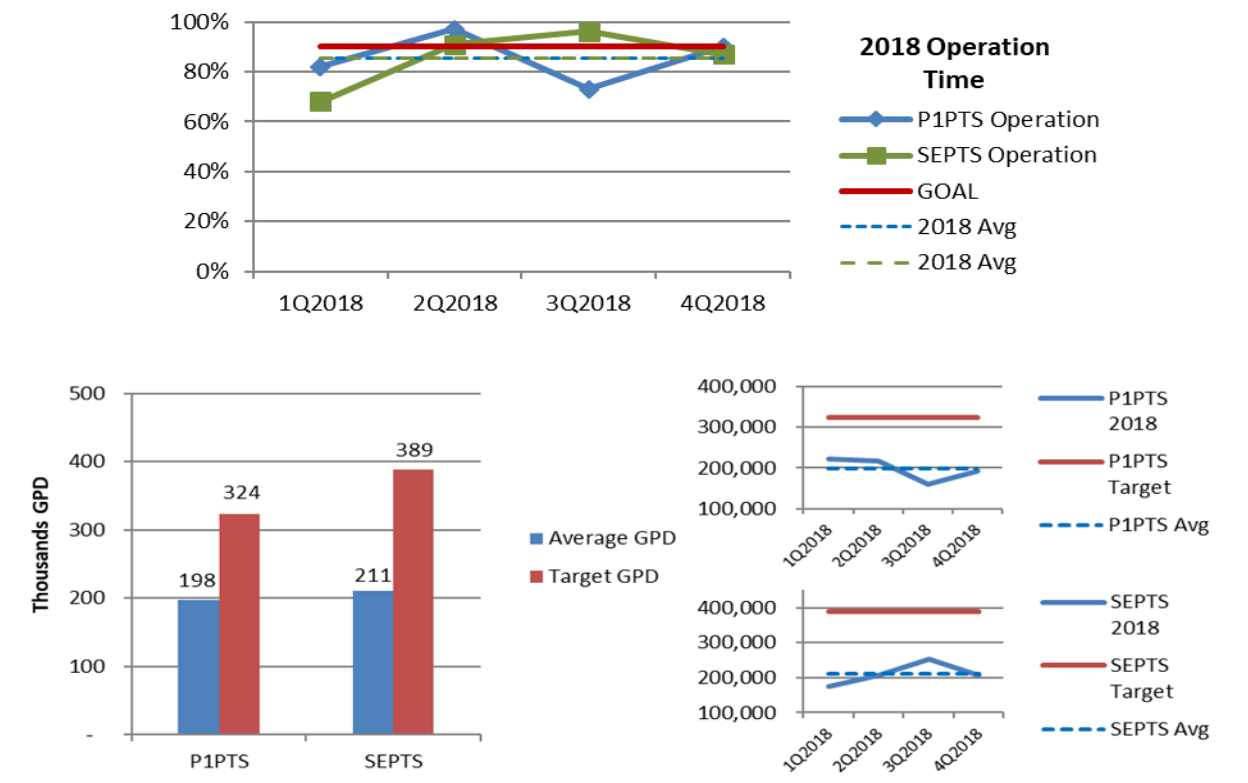
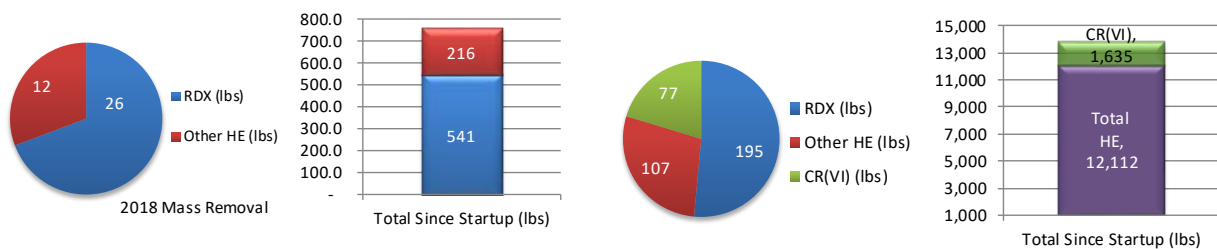


Figure 3.9 – Pump and Treat Systems Performance



P1PTS Mass Removal

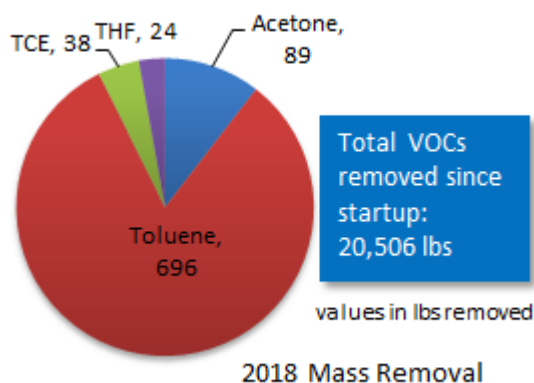
SEPTS Mass Removal

Figure 3.10 – Pump and Treat Systems Mass Removal

**In-Situ Bioremediation (ISB) Systems:** Two ISB systems (Zone 11 ISB and Southeast ISB) are in operation at Pantex where pump and treat technology is not effective. These systems are designed with closely spaced wells to set up a treatment zone in areas of the perched groundwater to control plumes migrating to TTU property south of Zone 11 or where the area is sensitive to vertical migration of contaminants of concern (COCs) to the underlying aquifer. Amendment is injected into the treatment zone to provide a food source for naturally occurring bacteria that break down the COCs. Monitoring wells were installed downgradient of the groundwater flow from the treatment systems to monitor whether the system is effectively degrading the COCs. During 2018, Pantex evaluated the use of a different amendment, molasses, for use in the ISBs. This more soluble carbon amendment provides better distribution of amendment away from the injection wells, so Pantex plans to primarily change to this type of amendment. Injection schedules are being changed to adjust for the molasses injection as injections will be required at the Zone 11 ISB at least once per year and every two years at the Southeast ISB. A discussion of treatment zone effectiveness and downgradient performance monitoring well information is included in Chapter 6. Pantex injected a newer portion of the Zone 11 ISB during 2018. A mixed amendment injection was performed using molasses and emulsified soybean oil that has been used in the system previously. Studies conducted during the injection indicates that the molasses is distributing more widely between wells, while the soybean oil did not reach a point between the wells. To ensure more consistent distribution and treatment across the ISB, Pantex plans to move to use of molasses in the systems and evaluate future performance based on this change.

**Burning Ground Soil Vapor Extraction**

**(SVE):** An SVE system was installed and has been operating at the Burning Ground since February 2002. After a large-scale system remediated a significant area at the Burning Ground, a small-scale activated carbon system was installed in late 2006 after the large-scale system became inefficient at continued removal of remaining soil gas and residual NAPL. The current system, consisting of a small-scale catalytic oxidizer and wet scrubber, was installed in early 2012 to replace the activated carbon system. The current system continues to focus on treating residual soil gas and NAPL at a single well (SVE-S-20) where soil gas concentrations continue to remain high. As depicted in Figure 3.11, the SVE system removed about 847 lbs of volatile organics during 2018.



**Figure 3.11 – 2018 SVE Mass Removal**

**Soil Remedies and Institutional Controls:** Institutional controls are required as part of the LTS of soil remedial action units at Pantex. Deed restrictions have been placed on all soil units with the exception of the active units. All SWMUs at Pantex are restricted to industrial use. To support the deed restrictions, Pantex maintains long-term control of any type of soil disturbance in SWMUs to protect human health and to prevent spread of contaminated soils. Pantex also regularly inspects and maintains soil covers on landfills to prevent infiltration of water into the landfill contents and migration of impacted water to groundwater.

**Second Five-Year Review:** The five-year review is conducted to ensure that Remedial Actions for soils and groundwater at the Pantex Plant remain protective of human health and the environment. Pantex started the second five-year review in May 2017 and regulatory approval for the final report was received in

September 2018. The results of the review indicate that the selected remedy is performing as intended and is protective of human health and the environment in the short-term because there are no completed exposure pathways to human or environmental receptors for soil or perched groundwater. In order to achieve long-term protectiveness of human health and the environment, operation and maintenance of the remedial action systems must continue and enhancements to existing systems and institutional controls need to be evaluated, planned, and implemented. Pantex is currently working towards completing the actions items included in the approved five-year review.

### 3.7.2 Long-Term Groundwater Monitoring

Pantex transitioned to the Long-Term Monitoring (LTM) network in July 2009. The groundwater monitoring network was developed to evaluate the effectiveness of the remedial actions. The evaluation is conducted to ensure that the remedial system is effective in stabilizing plumes and meeting cleanup goals, detecting any new COCs from source areas or in the drinking water aquifer, and to evaluate the presence and amount of natural attenuation that may be occurring in the groundwater plumes. The monitoring information collected is evaluated and reported in annual and quarterly progress reports and is summarized in Chapter 6 of this report. The quarterly and annual reports can be found at [www.pantex.energy.gov](http://www.pantex.energy.gov).

### 3.8 Environmental Monitoring

DOE Order 458.1 *Radiation Protection of the Public and Environment*, requires the performance of monitoring that is integrated with the general environmental surveillance<sup>7</sup> and effluent monitoring<sup>8</sup> program to:

- assess impacts and characterize exposures and doses to individual members of the general public, to the population, and to biota in the vicinity of the Pantex Plant,
- detect, characterize and respond to releases from DOE activities, and
- and demonstrate compliance with applicable regulatory and permit limits.

The monitoring program with its constituent planning, implementation and assessment phases was designed based upon the system described in the EPA's *EPA QA/G-1, Guidance for Developing Quality Systems for Environmental Programs (EPAb)*. Another document which was useful in continuous improvement of the design of the Pantex monitoring program was National Council on Radiation Protection (NCRP) Report No. 169 (NCRPa) published by the National Council on Radiation Protection and Measurements. Although this document specifically addresses radiological effluent monitoring and surveillance, the authors of the report note that many of the concepts described are appropriate for non-radiological contaminants that must also be monitored.

Planning for the environmental monitoring program begins with the development of (or revision of previously existing) monitoring requirements by the various environmental subject matter experts (for environmental media including but not limited to air, water, soil, and biota) by a process based upon that described in *EPA QA/G4, Guidance for Data Quality Objective Process (EPAa)*. This process requires subject matter experts to consider several factors including the purpose of the monitoring program, the trend of historical results from previous sampling, the predominant wind direction, and the presence of a sufficient quantity of a target species for analysis when planning sample collection locations and frequencies for the various environmental media. Specification of sampling locations and frequencies by

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<sup>7</sup> Environmental surveillance refers to measurements performed throughout the environment where it is assumed that a particular substance (sometimes referred to as a "contaminant") is well-mixed in the environment and the concentration of the substance in a collected sample is representative of its actual concentration in the environment.

<sup>8</sup> Effluent monitoring refers to the collection and analysis of samples at or before their entry into the environment.

a regulatory body (such as TCEQ or EPA) in a permit issued to the Pantex Plant has also been used in the development of certain monitoring programs. When feasible, sample plans included taking samples at the same geographical location for several environmental media to allow an individual media scientist to compare results from the other media and determine the usability of his/her data. It should be noted that, due to the minimal number of points where measurable quantities of radiological and non-radiological contaminants can be directly measured and compared to some risk-based standard, the majority of planned sampling locations are best characterized as “surveillance” locations.

The implementation of these plans begins with the collection of samples by technicians using procedures contained within an “Environmental Sampling and Analysis Manual”. In addition to procedures common to all environmental media (such as those associated with completion of sampling “logs” and “Chain-of-Custody forms”), the aforementioned manual contains procedures specific to the several different environmental media. These several specific procedures are based upon the “collection” protocols included in several different national consensus standards.<sup>9</sup> The majority of the analyses of Pantex environmental samples are accomplished by independent laboratories under a scope of work which requires the analysis of Pantex samples by protocols which are equivalent to those in consensus standards.<sup>10</sup> In some instances analysis results were not available due to drought conditions or electrical power failures during sample collection or laboratory errors during analysis.

Several data assessment processes were employed by Pantex to verify that the data collected for all of the monitoring programs met the specified data acceptance criteria. These processes included evaluation of sampling quality assurance; laboratory technical performance and quality assurance; and data verification and validation. Chapter 13 in this document contains a discussion of the program used to ensure that the environmental monitoring data meet the appropriate data quality requirements.

The results of the data assessment processes described above and management reviews performed for the several monitoring programs are then used as “feedback” for periodic revisions of the monitoring requirements as described above. The revisions may include changes to the analytes being monitored as well as locations and frequencies of sample collection.

Media-specific descriptions of the sampling locations and the results of the monitoring program for samples collected during 2018 are contained in Chapters 4-12 of this report.<sup>11</sup>

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<sup>9</sup> Examples of consensus standards include “Standard Methods for the Examination of Water and Wastewater” published by the American Public Health Association with the assistance of other similar organizations and “Methods of Air Sampling and Analysis” compiled by an intersociety committee including the Air and Waste Management Association, the American Chemical Society, the Health Physics Society and other similar organizations.

<sup>10</sup> A limited number of analyses including those for preliminary analysis of certain water samples are performed on-site. In addition Radiation Safety Department personnel perform analyses of the environmental TLDs discussed in Chapter 4.

<sup>11</sup> Appendix A indicates (by environmental media) the analytes which were monitored during 2018. Frequency of monitoring varies from weekly to quarterly depending upon the objectives of the several environmental monitoring programs.

## Chapter 4 – Environmental Radiological Program

*Monitoring results for the environmental radiological pathways in 2018 indicated levels below relevant standards, similar to results from previous years, and consistent with background conditions.*

This chapter summarizes radiological emissions from normal Plant operations. There were no emissions due to unplanned releases during the reporting period. This section would evaluate these releases in the unlikely event an unplanned incident were to occur.

During 2018 the Pantex Plant's environmental radiological monitoring program was conducted according to the Department of Energy (DOE) Order 458.1, *Radiation Protection of the Public and the Environment* (DOEi). The program involved measuring radioactivity in environmental samples in addition to calculating the potential radiological dose to the off-site public. The program monitored for the principal radionuclides associated with Plant operations: tritium, uranium-234 (U-234), uranium-238 (U-238), and plutonium-239 (Pu-239) in air, groundwater, drinking water, surface water, flora, and fauna samples. The radionuclides U-234, U-238, and Pu-239 emit primarily alpha particles<sup>1</sup> although gamma radiation emissions from these radionuclides were also monitored and evaluated. Tritium emits beta particles. Monitoring results for the air pathway are discussed in detail in Chapter 5.

### 4.1 Radiological Discharges and Doses<sup>2</sup>

#### 4.1.1 Doses to Members of the Public

DOE Order 458.1 requires radiological activities to be conducted in a manner so that the exposure of members of the public to ionizing radiation from all DOE sources and exposure pathways shall not cause, in a year, a total effective dose greater than 100 mrem (1 mSv). At the Pantex Plant, demonstration of compliance with this limit is documented by a combination of measurements and calculations including the comparison of concentrations of radioactive material in air and water to “Derived Concentration Standards” (DCS) listed in DOE-STD-1196-2011, *DOE Derived Concentration Technical Standard* (DOEk).<sup>3</sup>

##### 4.1.1.1 External Radiation Pathways

DOE Order 458.1 requires evaluations to demonstrate compliance with the aforementioned dose limit. The evaluations consider several exposure pathways including direct external radiation from sources located on-site, external radiation from airborne radioactive material, and external radiation from radioactive material deposited on surfaces off-site. At Pantex, external gamma radiation is measured at several locations at or near the site to determine the magnitude of doses from these pathways. As will be discussed below, the results of these measurements are of the same magnitude as those measured at a background or control location in Bushland, Texas, 56 kilometers (km) (35 miles [mi]) west of the Plant. Accordingly,

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<sup>1</sup> The alpha energies of U-233 (4.82 MeV and 4.78 MeV) and U-234 (4.77 MeV and 4.72 MeV) are very similar. Alpha-spectroscopy techniques used to perform analyses cannot distinguish between the two isotopes. Accordingly a single analysis result will indicate both isotopes in the “pair” as U-233/234. Similarly, the alpha energies of Pu-239 (5.16 MeV and 5.11 MeV) and Pu-240 (5.17 MeV and 5.12 MeV) are not distinguishable by alpha-spectroscopy and analysis will indicate both isotopes in a single analysis result as Pu-239/240.

<sup>2</sup> Radiological results are reported in units that are specific to different types of exposure and environmental media (i.e., air, water, etc.). See Appendix D.

<sup>3</sup> The DCS values listed in the technical standard represent the concentration of a given radionuclide in either air or water that would result in a member of the public receiving an effective dose of 100 mrem following continuous exposure for one year for each of the following pathways: ingestion of water, air contact, and inhalation. The DCS values were derived in accordance with dose limitation systems recommended by the International Commission on Radiological Protection (ICRP) in its several publications (ICRPa) and used by the Environmental Protection Agency (EPA), the Nuclear Regulatory Commission, and other regulatory bodies including DOE in establishing standards for radiological protection. The regulatory limits are purposely set at levels well below those known to cause any adverse effects on the public and/or the environment.

DOE radiological activities at Pantex do not cause any dose above that due to background radiation and thus do not contribute significantly to the exposure of members of the public to ionizing radiation.

#### 4.1.1.2 Air Pathway

DOE Order 458.1 further requires that internal doses<sup>4</sup> to members of the public from inhalation of airborne effluents be evaluated using the EPA’s CAP-88 model (or another EPA-approved model or method) to demonstrate compliance with applicable subparts of Title 40 of the Code of Federal Regulations (CFR), Chapter 61, *National Emission Standards for Hazardous Air Pollutants*. Compliance with the limit for emissions to the airborne pathway of radionuclides other than radon established by the EPA in 40 CFR 61.92 is demonstrated at the Pantex Plant by calculating the effective dose equivalent received by the maximally exposed individual (MEI)<sup>5</sup> member of the general public by the use of the CAP-88-PC (EPAC) model.

Since 1994, the meteorological data used in this modeling effort have been obtained from the meteorological tower at the Pantex Plant. Sensors at the tower automatically record average wind speed and direction, and several other parameters, every 15 minutes. Information about average tropospheric mixing height is obtained from the Amarillo National Weather Service station at the Rick Husband International Airport. The source term for releases to air was calculated based on process knowledge of the releases of radionuclides from the routine operations at Pantex (e.g., calibration of radiation detection instrumentation, sanitization<sup>6</sup> of components at the Burning Ground and Firing Sites, etc.), the number of operations conducted during the year, and other modifying factors. In estimating the emissions, conservative assumptions concerning the form of the radioactive material and the presence or absence of engineering controls such as High-Efficiency Particulate Air (HEPA) filters were made to maximize the potential emissions. A small percentage (0.24 percent) of these calculated emissions is due to emissions of U-238 and other radionuclides from various routine Plant activities, while the balance is due to emissions of tritium.<sup>7</sup> These emissions are summarized in Table 4.1 below.

**Table 4.1 – Pantex Radiological Atmospheric Emissions in Curies (Bq)**

Tritium	Total Uranium	Total Plutonium	Total Other Actinides	Other
5.31 x 10 <sup>-4</sup> (1.96 x 10 <sup>7</sup> )	1.19 x 10 <sup>-6</sup> (4.40 x 10 <sup>4</sup> )	None	6.68 x 10 <sup>-11</sup> (2.47)	None

Based on the 2018 operational data, the results of the CAP-88-PC modeling indicate that the maximally exposed individual (MEI) for 2018 (located approximately 1.14 km [0.71 mi] northeast [NE] of the Burning Ground) would have received a dose of 1.70 x 10<sup>-6</sup> mrem (1.70 x 10<sup>-8</sup> mSv). This dose is significantly below (is 1.7 x 10<sup>-5</sup> percent of) the EPA’s maximum permissible exposure limit to the public of 10 mrem/yr specified in 40 CFR 61, Subpart H. The indicated dose is also equivalent to 1.7 x 10<sup>-6</sup> percent of the DOE Public Dose Limit for all pathways. Based upon the same CAP-88-PC modeling results, the collective population dose equivalent received by those living within 80 km (50 mi) of the Pantex Plant would have

<sup>4</sup> Internal doses to organs or tissues of an organism which are due to the intake of radionuclides by ingestion, inhalation, or dermal absorption (NCRPd).

<sup>5</sup> The MEI is a person who resides near the Pantex Plant, and who would receive, based on theoretical assumptions about lifestyle, the maximum exposure to radiological emissions and therefore, the highest effective dose equivalent from Plant operations.

<sup>6</sup> See the definition of this term in the glossary.

<sup>7</sup> The overwhelming majority (86.9 percent) of these emissions arose from activities conducted within the southern portion of Zone 12. The balance of the emissions arose from sanitization activities conducted at the Burning Ground and Firing Sites.

been  $2.41 \times 10^{-6}$  person-rem/year ( $2.41 \times 10^{-8}$  person-sievert/year) in 2018. The majority of this collective population dose equivalent is contributed by tritium.

The effective dose equivalent for the MEI is less than that calculated for CY 2017, but is roughly equivalent to those over the last 5 years as illustrated in Table 4.2 below. Variation in the doses between years is due to changes in the emissions of tritium (and isotopes of uranium) as operations such as instrument calibration, sanitization of certain high explosive (HE) components and waste treatment operations may not necessarily have been conducted at the same rates during the period under consideration. The collective population dose equivalent for the same years displays the same general trend as that for the MEI dose.

**Table 4.2 – Effective Dose Equivalent for Maximally Exposed Individual Member of General Public During CYs 2014-2018**

Year	Maximally Exposed Individual Dose (mrem)	Population Dose (Person-rem/yr)
2014	$2.62 \times 10^{-7}$	$3.40 \times 10^{-6}$
2015	$1.35 \times 10^{-7}$	$3.21 \times 10^{-6}$
2016	$2.70 \times 10^{-5}$	$9.94 \times 10^{-4}$
2017	$7.60 \times 10^{-6}$	$1.04 \times 10^{-5}$
2018	$1.70 \times 10^{-6}$	$2.41 \times 10^{-6}$

#### 4.1.1.3 Water Pathway

In addition to promulgating the dose limit mentioned above, DOE Order 458.1 requires operators of DOE facilities discharging or releasing liquids containing radionuclides from DOE activities to conduct such activities in such a manner as to: protect groundwater resources; not cause private or public drinking water systems to exceed the drinking water maximum contaminant limits outlined in 40 CFR 141, *National Primary Drinking Water Regulations*; and comply with other limitations as applicable. Current Pantex Plant policy does not allow the discharge of radioactive material in liquid effluent discharges to groundwater (or to sanitary sewers), thus eliminating any future potential impact to groundwater from those sources. Compliance with 40 CFR 141.66 maximum contaminant level (MCL) limitations for individual radionuclides potentially released from Pantex activities, with the exception of tritium, is demonstrated by comparing measured concentrations of radionuclides in drinking water to four percent of the DCS values for ingested water.<sup>8</sup> The results of these measurements as well as those for other water monitoring programs did not indicate releases to any water pathway and thus no contribution to the total effective dose from Pantex activities during 2018.

#### 4.1.1.4 Other Pathways

The Pantex Plant has considered doses which might arise from radioactive materials ingested with food from terrestrial crops, animal products, and aquatic food products (including plant as well as animal species). The results of the faunal monitoring measurements<sup>9</sup> and monitoring of native vegetation and crops<sup>10</sup> did not indicate releases to either pathway from Pantex activities during 2018.

As will be discussed in more detail below, the current program concerning the release of property containing residual material has been designed to ensure that such releases are as low as reasonably achievable (ALARA). Public doses from this pathway are negligible.

<sup>8</sup> The current average annual concentration of tritium tabulated in 40 CFR 141.66 which is assumed to produce the same four mrem dose equivalent is 20,000 pCi/L (or  $2.0 \times 10^{-5}$   $\mu$ Ci/mL) equal to 1 percent of the ingested water DCS for tritiated water listed in DOE-STD-1196-2011[DOEk].

<sup>9</sup> See Chapter 11

<sup>10</sup> See Chapter 12

**4.1.1.5 Public Doses from All Pathways**

The dose equivalent received by the MEI during 2018, the 2018 collective population dose, and the 2018 natural background population dose are presented in Table 4.3. Because there were no releases from the Pantex Plant to the water or other pathways, the air pathway dose represents the public dose from all pathways.

**Table 4.3 – Pantex Radiological Doses in 2018**

Dose to Maximally Exposed Individual from Pantex Operations (mrem) (mSv)		Percent of DOE 100-mrem Limit	Estimated Population Dose from Pantex Operations (person-rem)( person-Sv)		Population within 80 km (50 mi)	Estimated Background Radiation Population Dose at Pantex Plant (person-rem)
1.70 x10 <sup>-6</sup>	(1.70 x10 <sup>-8</sup> )	1.70 x10 <sup>-6</sup>	2.41 x 10 <sup>-6</sup>	2.41 x 10 <sup>-8</sup>	296,000	29,600

**4.2 Release of Property Containing Residual Radioactive Material**

DOE Order 458.1 provides requirements for the clearance of potentially contaminated material and equipment (M&E) from the Pantex Plant to the public. The order distinguishes real property (land and structures) from personal or non-real property (any materials not land and structures) in its discussion of clearance. To implement the requirements of the Order, DOE requires that the property that has been or is suspected of being contaminated with radioactive material be adequately surveyed (radiologically characterized) to ensure that the property meets pre-approved DOE authorized limits prior to clearance to the public. DOE Order 458.1 specifically indicates that previously approved guidelines and limits (such as those developed for compliance with DOE Order 5400.5) may continue to be applied and used as pre-approved authorized limits until they are replaced or revised by pre-approved authorized limits issued under the new order. Clearance of potentially radioactive contaminated M&E to the public is managed with the consistent and appropriate application of one set of clearance criterion based upon the surface activity guidelines established in DOE Order 5400.5. Table 4.4 presents the DOE Order 5400.5 pre-approved clearance limits.

**Table 4.4 – Surface Activity Limits -Allowable Total Residual Surface Activity (dpm/100 cm<sup>2</sup>)**

Radionuclides	Average	Maximum	Removable
Group 1 – Transuranics, Iodine-125, Iodine-129, Actinium-227, Radium-226, Radium-228, Thorium-228, Thorium-230, Protactinium-231	100	300	20
Group 2 - Thorium-natural, Strontium-90, Iodine-126, Iodine-131, Iodine-133, Radium-223, Radium-224, Uranium-232, Thorium-232	1,000	3,000	200
Group 3 - Uranium-natural, Uranium-235, Uranium-238 and associated decay products, alpha emitters	5,000	15,000	1,000
Group 4 - Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except Strontium-90 and others noted above	5,000	15,000	1,000
Tritium (applicable to surface and subsurface)	NA	NA	10,000



Since 1993 the Pantex Plant’s clearance process, as stated in the *Pantex Radiological Control Manual* (PRCM) (PANTEK), requires the Radiation Safety Department’s (RSD’s) evaluation of any potentially contaminated M&E using process and forms including:

- RSD approval for M&E that is to be excessed;
- PX-4008, “Waste Operations Department Scrap Metal Disposition Form,” for disposition of any scrap metal (in compliance with Secretary Richardson’s moratorium on recycling certain metals);
- PX-2643, “Material Evaluation Form,” for release of all waste;
- PX-691, “Shipment Request,” for release of outbound non-weapon shipments; and/or
- PX-2189, “Radiation Safety Material Clearance,” for M&E not covered by one of the preceding methods.
- PX-3134, “Process Knowledge” for non-radioactive M&E having no potential for radioactive contaminated surfaces.

The application of the Pantex clearance process has resulted in no releases of personal property with surface contamination in excess of the indicated levels.

DOE Order 458.1 requires that verification be performed by personnel independent of contractor personnel conducting property clearance activities. At Pantex, a Waste Characterization Official (WCO) who is independent from organizations producing, accumulating, transporting, or performing radiological characterizations and/or surveys of weapons components and certain categories of mixed low-level waste destined for burial at the Nevada National Security Site, performs the verification.

The volume of radiological waste generated at Pantex during 2018 is discussed in Chapter 2. As there were no releases of real property containing residual radioactive material during 2018, those values represent the quantities of personal property released from the Pantex Plant in 2018.

### 4.3 Radiation Protection of Biota

While DOE Order 458.1 contains no specific limits for radiation doses to aquatic animals, terrestrial plants, and terrestrial animals, it requires the use of DOE-STD-1153-2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (DOEa) or equivalent methodologies, to demonstrate that radiological activities are conducted in a manner that protects these populations from adverse effects due to radiation and radioactive material released from DOE operations. This requirement has the effect of limiting the dose to 1 rad/day (10 mGy/day) for aquatic animals and terrestrial plants and to 0.1 rad/day (1 mGy/day) for terrestrial animals<sup>11</sup>.

During 2018, there was sufficient precipitation in the vicinity of Playa 1, in addition to discharge from the Wastewater Treatment Facility (WWTF), for the collection of surface water and/or sediment samples. These samples were analyzed for tritium, U-234, U-235, U-238, and Pu-239/240. To implement the aforementioned standard, DOE-STD-1153-2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (DOEa), the radionuclide concentrations obtained were entered into the calculation tool (RAD-BCG) provided by the DOE with the standard and compared to biota concentration guide (BCG) limits for aquatic and terrestrial systems in the technical standard. Estimated concentrations of the indicated radionuclides in the sediment were obtained by multiplying the measured aqueous concentrations by isotope-specific solid/solution distribution coefficients tabulated for the measured radionuclides in the standard. The value for each radionuclide was automatically divided by the BCG for

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<sup>11</sup> These dose limits have been developed and/or discussed by the NCRP (in *Effects of Ionizing Radiation on Aquatic Organisms*, Report No. 109 [NCRPb]) and the International Atomic Energy Agency (IAEA) (in *Effects of Ionizing Radiation on Plants and Animals at Levels Implied by Current Radiation Protection Standard*, Technical Report Series No. 332) (IAEAa).

that radionuclide to calculate a partial fraction for each nuclide for each medium. Partial fractions for each medium were added to produce a sum of fractions.

The dose limit for aquatic animals would not be exceeded if the sum of fractions for the water medium plus that for the sediment medium is less than 1.0. Similarly, the dose limits for both terrestrial plants and animals would not be exceeded if the sum of fractions for the water medium plus that for the soil medium is less than 1.0. The maximum site concentrations for each medium, applicable BCGs, partial fractions, and sums of fractions are listed in Tables 4.5a and 4.5b. As the sum of fractions for the aquatic system and the terrestrial system are  $8.65 \times 10^{-3}$  and  $2.95 \times 10^{-4}$  respectively, applicable BCGs were met for both evaluations. It can, therefore, be concluded that populations of aquatic and terrestrial biota on and near the Pantex site are not being exposed to doses in excess of the existing DOE dose limits.

**Table 4.5a – Evaluation of Dose to Aquatic Biota in 2018**

Nuclide	Water Conc. (pCi/L)	BCG (Water) (pCi/L)	Partial Fraction (Water)	Sediment Concentration (pCi/g)	BCG (Sediment) (pCi/g)	Partial Fraction (Sediment)	Sum of Fractions (Water & Sediment)
Tritium	23.4	$2.6 \times 10^8$	$8.83 \times 10^{-8}$	0.00343	$4.0 \times 10^5$	$9.16 \times 10^{-9}$	$9.75 \times 10^{-8}$
U-234	2.86	$2.0 \times 10^2$	$1.42 \times 10^{-2}$	0.31	$5.0 \times 10^3$	$5.94 \times 10^{-5}$	$1.42 \times 10^{-2}$
U-235	0.08	$2.2 \times 10^2$	$3.68 \times 10^{-4}$	0.01	$4.0 \times 10^3$	$2.68 \times 10^{-6}$	$3.71 \times 10^{-4}$
U-238	1.59	$2.2 \times 10^2$	$7.12 \times 10^{-3}$	0.35	$2.0 \times 10^3$	$1.39 \times 10^{-4}$	$7.26 \times 10^{-3}$
Pu-239	0.00843	$1.9 \times 10^2$	$4.52 \times 10^{-5}$	0.00205	$6.0 \times 10^3$	$3.50 \times 10^{-7}$	$4.55 \times 10^{-5}$
Sum of Fractions			$2.17 \times 10^{-2}$			$2.01 \times 10^{-4}$	$8.65 \times 10^{-3}$

**Table 4.5b – Evaluation of Dose to Terrestrial Biota in 2018**

Nuclide	Water Conc. (pCi/L)	BCG (Water) (pCi/L)	Partial Fraction (Water)	Soil Concentration (pCi/g)	BCG (Soil) (pCi/g)	Partial Fraction (Soil)	Sum of Fractions (Water & Soil)
Tritium	23.4	$2.31 \times 10^8$	$1.01 \times 10^{-7}$	0.00343	$1.71 \times 10^5$	$2.01 \times 10^{-8}$	$1.21 \times 10^{-7}$
U-234	2.86	$4.04 \times 10^5$	$7.07 \times 10^{-6}$	0.31	$5.13 \times 10^3$	$6.10 \times 10^{-5}$	$6.81 \times 10^{-5}$
U-235	0.08	$4.19 \times 10^5$	$1.91 \times 10^{-7}$	0.0117	$2.83 \times 10^3$	$4.13 \times 10^{-6}$	$4.32 \times 10^{-6}$
U-238	1.59	$4.06 \times 10^5$	$3.92 \times 10^{-6}$	0.345	$1.58 \times 10^3$	$2.19 \times 10^{-4}$	$2.23 \times 10^{-4}$
Pu-239	0.00843	$2.00 \times 10^5$	$4.21 \times 10^{-8}$	0.00205	$6.11 \times 10^3$	$3.35 \times 10^{-7}$	$3.77 \times 10^{-7}$
Sum of Fractions			$5.14 \times 10^{-6}$			$2.84 \times 10^{-4}$	$2.95 \times 10^{-4}$

#### 4.4 Unplanned Releases

No unplanned releases of radioactive material occurred at the Pantex Plant during 2018.

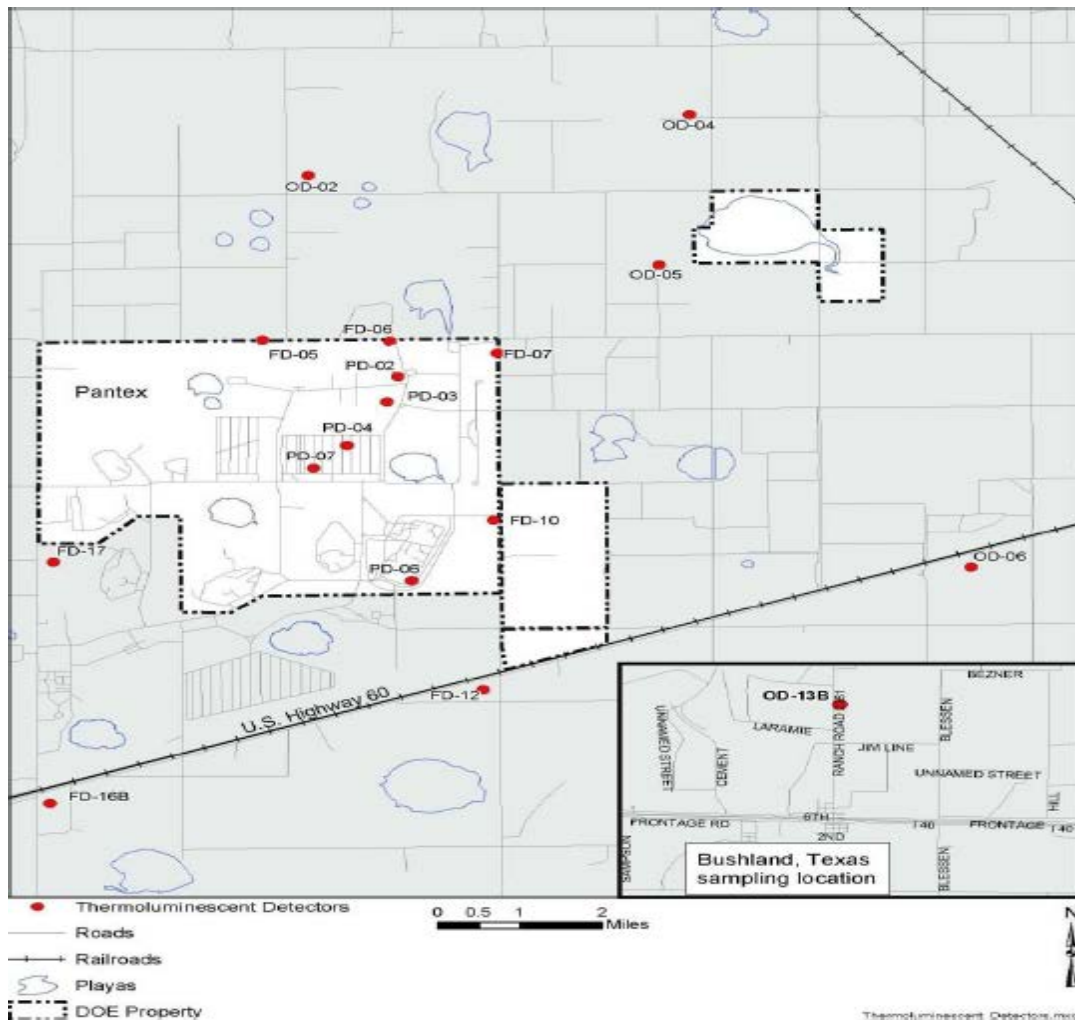
### 4.5 Environmental Radiological Monitoring

With the exception of the environmental dosimetry program discussed herein, media-specific descriptions, as well as the results of any radiological surveillance monitoring for samples collected during 2018, are contained in Chapters 5-12 of this report.

#### 4.5.1 Environmental Dosimetry

The environmental dosimetry program uses thermoluminescent dosimeters (TLDs) to measure gamma radiation on and around the Pantex Plant. This program has been conducted at several locations in parallel with monitoring conducted by the Texas Department of State Health Services (TDSHS)<sup>12</sup> since the early 1980s. Figure 4.1 shows the locations of the Plant’s dosimeters during 2018.

The Pantex Plant’s TLDs are generally placed at the same locations where Pantex Plant operates air monitors, as discussed further in Chapter 5. Pantex Plant’s TLDs are analyzed and replaced at the end of each calendar quarter. This data provides the cumulative radiation exposure received while exposed to the environment over approximately 90 days of uninterrupted deployment at each location.



**Figure 4.1 – Locations of Pantex Plant TLDs**

<sup>12</sup> The TDSHS used optically stimulated luminescence devices similar in function to the TLDs used by Pantex.

Table 4.6 lists results for 2018 and reflects the dose that an individual would have received at the TLD location if the person were present continuously for a full quarter. The average quarterly dose for all on-site locations during 2018 was approximately 23.6 mrem. The equivalent average annual dose is 94.2 mrem/year (0.94 mSv/year). The average quarterly dose at the TLD monitoring locations which are located in the direction of the predominant wind direction at the Pantex Plant was 25.3 mrem (equivalent to 101.2 mrem/year or 1.01 mSv/year), while the quarterly dose at upwind locations averaged 25.5 mrem (equivalent to 102 mrem/yr or 1.02 mSv/year). These average quarterly measurements are less than but of the same magnitude as the quarterly average dose of 29.0 mrem (equivalent to 116 mrem/year or 1.16 mSv/year) measured at the background or control location at Bushland, Texas, for the same period. The quarterly measurements indicate evidence of seasonality as the measurements taken during the winter quarters (in the Northern Hemisphere) when the earth is closest to the sun in its orbit and levels of cosmic radiation are highest) are generally higher than those taken during the summer quarters. However, all measured doses are similar to those obtained during previous years (see Figure 4.2), and the equivalent average annual doses are of the same magnitude as the sum of the external components of ubiquitous background.<sup>13</sup>

**Table 4.6 – Environmental Doses Measured by TLDs in 2018 in Millirem<sup>14</sup>**

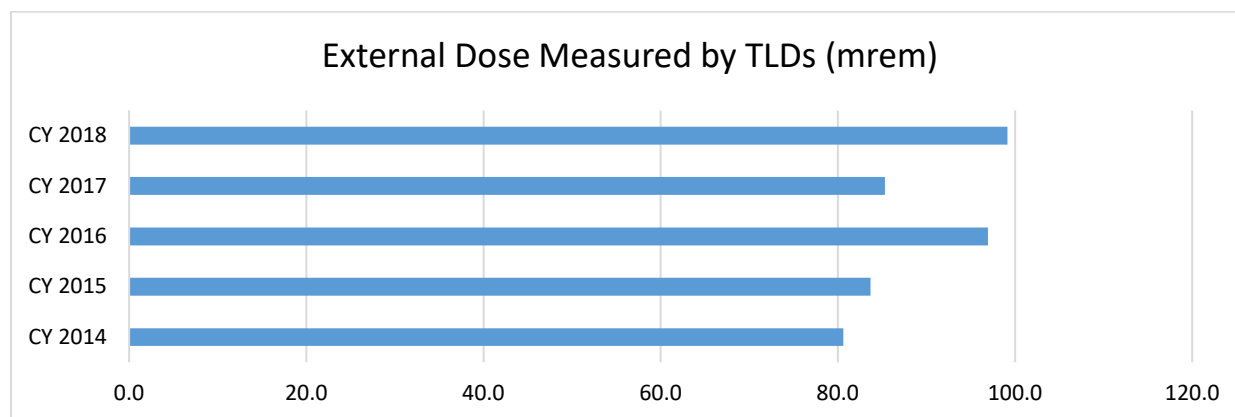
Location	1 <sup>st</sup> Qtr	2nd Qtr	3rd Qtr	4th Qtr	Avg. Qtr
<b>On-site</b>					
PD-02	24.0	19.0	24.0	24.0	18.2
PD-03	22.0	19.0	23.0	22.0	21.5
PD-04	27.0	23.0	26.0	29.0	26.2
PD-06 <sup>a</sup>	27.0	24.0	27.0	30.0	27.0
PD-07	26.0	21.0	28.0	24.0	24.8
<b>“Upwind”</b>					
FD-02	27.0	21.0	26.0	24.0	24.5
FD-12 <sup>a</sup>	27.0	24.0	27.0	29.0	26.8
FD-16B <sup>a</sup>	26.0	21.0	26.0	24.0	24.2
FD-17 <sup>a</sup>	27.0	24.0	28.0	26.0	26.2
OD-06	27.0	23.0	27.0	26.0	25.8
<b>“Downwind”</b>					
FD-06 <sup>a</sup>	28.0	N/S <sup>b</sup>	28.0	28.0	28.0
FD-07 <sup>a</sup>	27.0	21.0	24.0	24.0	24.0
OD-02	26.0	23.0	26.0	24.0	24.8
OD-04 <sup>a</sup>	25.0	23.0	25.0	23.0	24.0
OD-05	26.0	23.0	26.0	28.0	25.8
<b>Control</b>					
OD-13B	30.0	26.0	30.0	30.0	29.0
Blank Correction	3.0	1.0	1.0	7.0	

<sup>a</sup> Locations co-sampled with TDSHS.

<sup>b</sup> N/S indicates that TLD was damaged and no valid analysis result was obtained.

<sup>13</sup> Although on the average, these sources are of approximately equal magnitude, soil concentrations of the principal sources of terrestrial radiation are variable (NCRPb).

<sup>14</sup> All measurements have been “blank corrected.” This is accomplished by measuring the residual doses on dosimeters which have been stored in a location where they receive no exposure during the same period as those dosimeters which have been deployed at the indicated locations. The residual dose (the blank correction for each quarter) which was subtracted from the raw data of the deployed dosimeters is indicated in the table.



**Figure 4.2 – Environmental Doses Measured by TLDs CY 2014-2018**

#### 4.5.2 Future Radiological Monitoring

As discussed herein, media-specific subject matter experts periodically make revisions to the Pantex Environmental Monitoring Program based on process changes and potential impacts. The revisions are highly controlled via procedures that force evaluation of any new process thoroughly prior to construction of new facilities and again prior to operation using a very disciplined and tiered readiness review/assessment process to assess impacts and characterize exposures and doses to individual members of the general public, to the population, and to biota in the vicinity of the Pantex Plant. The subject matter experts develop (or revise previously existing) monitoring requirements using a process based upon EPA guidance documents and consider potential releases from current DOE activities at the site. However, the subject matter experts also consider planned new activities identified in the National Environmental Policy Act (NEPA) process discussed in Chapter 2. Based upon pathway analyses the subject matter experts make adjustments to the monitoring program for their individual environmental media.

#### 4.6 Conclusions

The calculated doses to the public and to the environment from Plant operations discussed above are minute when compared to those from naturally occurring sources and those from other man-made sources. The estimated total average annual effective dose equivalent to any individual member of the U.S. population and the collective effective dose from these several sources are presented in Table 4.7. Pantex measured and/or calculated effective doses are several orders of magnitude smaller than the smallest doses indicated. Additionally, the measured doses are of the same order of magnitude as the external components of national ubiquitous<sup>15</sup> background.

The environmental radiological monitoring program at the Pantex Plant continues to provide information that supports the hypothesis that current Plant operations do not have a detrimental effect on the quality of the environment at or near Pantex. The Pantex Plant’s monitoring results for the environmental radiological pathways in 2018 indicated levels below relevant standards, similar to results from previous years, and consistent with background conditions<sup>16</sup>.

<sup>15</sup> The external components of ubiquitous radiation include radiation from space incident on the earth’s atmosphere and radiation from radionuclides in the environment (primarily the earth).

<sup>16</sup> In a similar manner, analysis performed by TDSHS laboratories for samples obtained by the TDSHS on or around the Pantex facility during 2018 indicated no exceedances of any regulatory limits (TDSHS).

**Table 4.7 – Effective Dose per Individual in the US. Population and Collective Effective Dose for Population Located within 50 Miles of the Pantex Plant**

Exposure Category	Effective Dose per Individual (mrem)	Collective effective dose (person-rem)
National ubiquitous background	311	9.33x10 <sup>4</sup>
Medical procedures	300	8.99x10 <sup>4</sup>
Consumer	13	3.99x10 <sup>3</sup>
General public exposure to industrial, security, medical, educational, and research	0.30	1.00x10 <sup>2</sup>

Modified from a table in NCRP Report No. 160 “Ionizing Radiation Exposure of the Population of the United States” (NCRP).

## Chapter 5 – Air Monitoring

*The Pantex Plant implements a radiological air monitoring program to ensure Plant operations are not having an impact on ambient air quality. All of the radiological air monitoring data for 2018 indicated that results were not distinguishable from background.*

### 5.1 The Scope of the Program

Monitoring and sampling to detect possible airborne emissions of radiological material or hazardous pollutants at the Pantex Plant is conducted at on-site and off-site locations as a part of an environmental surveillance program. The monitoring program at the Pantex Plant has been described in several documents (e.g., the *Environmental Information Document* [PANTEXC]). Some Pantex Plant operations are sources or potential sources of airborne emissions. Monitoring of ambient air<sup>1</sup> for releases of airborne emissions from the Pantex Plant facilities has historically been done at fixed remote locations, primarily because of the lack of discrete release points at the facilities.

During current operations at the Pantex Plant, various radioactive materials including tritium, plutonium, uranium, and miscellaneous sources (e.g., thorium, cobalt and cesium) may be present in the components of nuclear weapons being managed. However, in normal operating situations, the nature of the work at the Pantex Plant and the physical form of the material are such that there is very little potential for the public or the environment (in addition to Pantex Plant personnel) to be affected by releases of radioactive materials as a result of Plant operations. As shown in Table 4.1, most of the small numbers of radionuclide releases during normal operations at the Pantex Plant are tritium releases. Very small amounts of tritium escape as gas or vapor during normal operations (as well as from the area of the accidental release that occurred in 1989. {described in the *Environmental Information Document* (PANTEXC)}).

### 5.2 Non-Radiological Monitoring

As noted in previous annual reports, Pantex has not routinely operated non-radiological monitors since 2003. However, a qualitative monitoring system has continued to operate at the Pantex Plant. During CY 2018 no Visual Emission Evaluations (VEEs) were conducted.

### 5.3 Routine Radiological Air Monitoring

During 2018, air monitors were operated according to the schedule shown in Table 5.1, wherein several monitors were operated continuously (the four on-site locations as well as the control location), others operated less frequently, and a few were not operated at all during the year. See Figures 5.1 and 5.2 for the location of all air monitoring stations. The figures include those locations which have been used historically, but have been discontinued as a result of revisions to the air monitoring program discussed in Chapter 3.8.

#### 5.3.1 Collection of Samples

A total of 17 air monitoring stations were used to monitor for radionuclides in the air in 2018. Three on-site monitoring stations designated as PA-AR-XX (for Plant air) in the tables and as PA on the figures, are placed near the several operating areas where radiological material is used and/or stored. Stations PA-AR-03 and PA-AR-04 are located near the firing sites where testing and sanitization of nuclear weapons components contaminated with tritium are conducted. Station PA-AR-04 is adjacent to the north fence of Zone 4 East. Since the predominant wind direction is from the south-southwest, this station is also used to monitor ambient air near the shipping and receiving operations conducted in Zone 4. Station PA-AR-06 is located near an area where operations involving the disassembly of nuclear weapons, the calibration of portable radiation detection instruments, and the packaging of radiological waste occur.

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<sup>1</sup> Ambient air monitoring refers to the monitoring of air at remote locations where it is assumed that the material (either radioactive material or hazardous pollutants) being measured and compared to some risk-based standard is well mixed in the atmosphere and that any concentration present represents what might be inhaled by an individual.

**Table 5.1 – 2018 Schedule for Air Sampling and Analysis**

Location	Month											
	1	2	3	4	5	6	7	8	9	10	11	12
<b>On-site</b>												
PA-AR-03	X	X	X	X	X	X	X	X	X	X	X	X
PA-AR-04	X	X	X	X	X	X	X	X	X	X	X	X
PA-AR-06	X	X	X	X	X	X	X	X	X	X	X	X
<b>Fence line</b>												
FL-AR-01	X	X	X	X	X		X	X				
FL-AR-02		X	X		X	X		X			X	
FL-AR-04	X	X	X			X		X			X	X
FL-AR-05		X	X		X		X	X	X	X	X	
FL-AR-07			X	X	X	X	X	X	X	X	X	
FL-AR-08	X	X		X	X			X	X	X	X	X
FL-AR-09		X	X		X	X		X			X	
FL-AR-10	X	X	X			X	X	X	X	X	X	
FL-AR-14	X	X		X	X		X	X	X	X	X	X
FL-AR-16		X	X		X			X			X	
FL-AR-17			X			X			X	X	X	X
<b>Off-site</b>												
OA-AR-02	X	X			X		X	X	X			X
OA-AR-04		X	X	X	X	X		X	X			X
<b>Control</b>												
OA-AR-13B	X	X	X	X	X	X	X	X	X	X	X	X



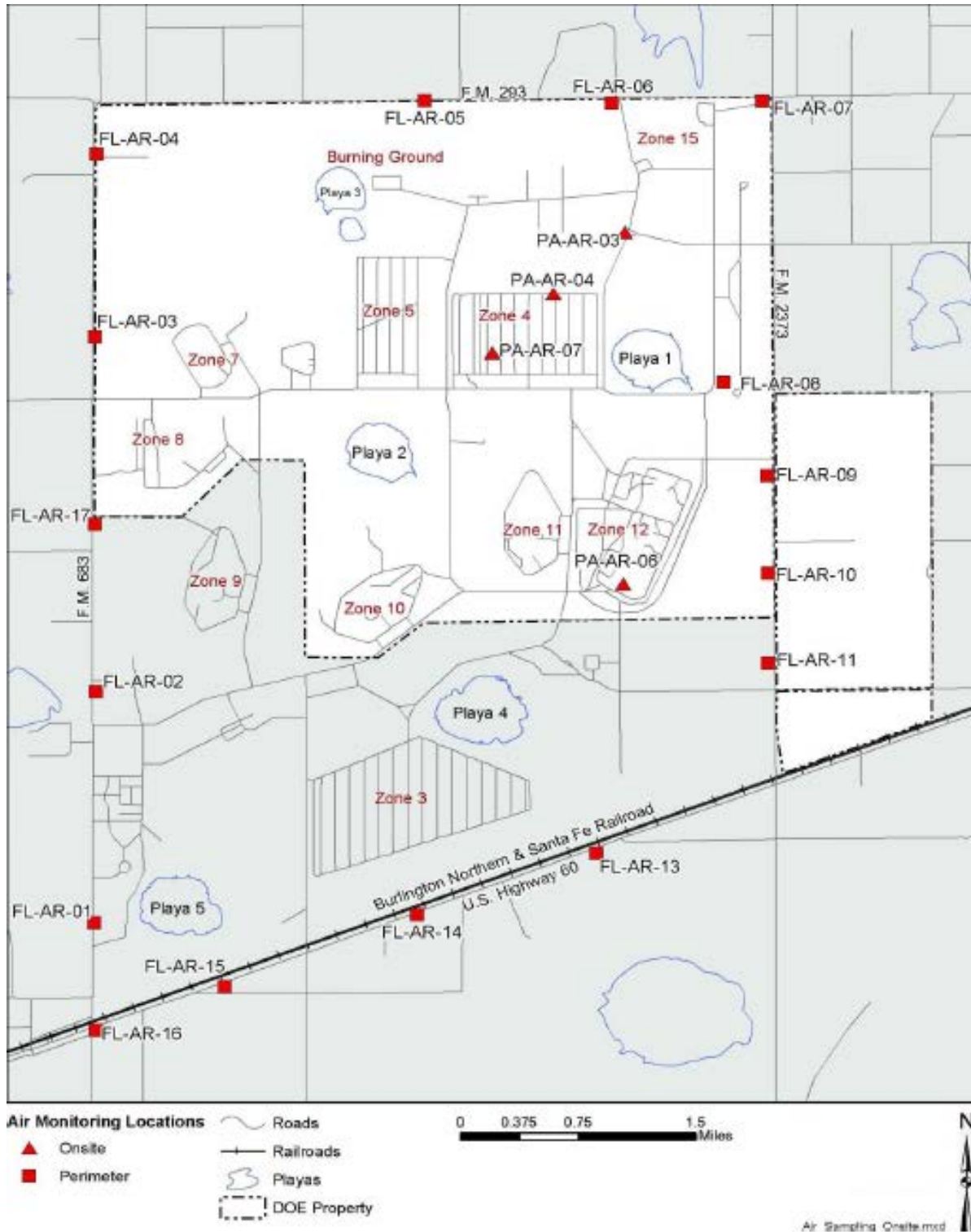


Figure 5.1 – Locations of On-site and Fence Line Air Monitoring Stations

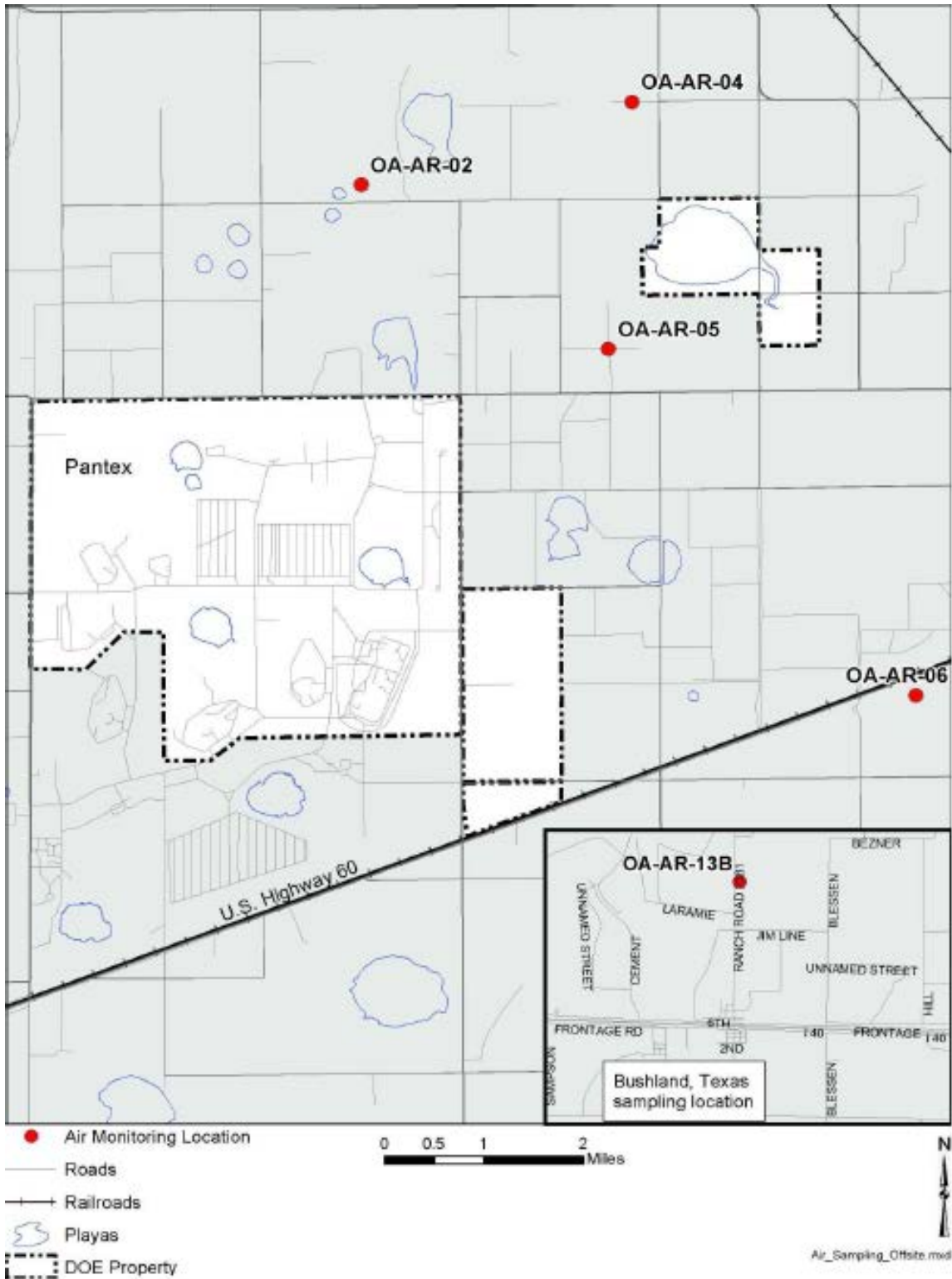


Figure 5.2 – Off-site Air Sampling Stations

The 17 available fence line radiological monitoring stations designated as FL-AR-XX (for Fence line), are located along the Plant perimeter (as it existed prior to the purchase of property east of FM 2373 in the latter part of 2008) in the principal compass directions and in directions where residences are located. The concerns of the Texas Department of State Health Services (TDSHS) and other stakeholders were considered in establishing the locations. The fence line samplers at the southern end of the Plant are located south of U.S. Highway 60. These locations were chosen for convenient access, to avoid the collection of dust generated by activities on the railroad (which is located adjacent to the southern boundary of the Plant), and to better represent air quality near actual residences. Eleven of these stations were operated at various times during 2018.

The off-site air monitoring stations are designated as OA-AR-XX. (Figure 5.2). Stations OA-AR-02 and OA-AR-04 are about 8 kilometers (5 miles) from the center of the Pantex Plant. The third off-site station, designated as OA-AR-13B, is a control station and is located upwind at Bushland, Texas. Stations OA-AR-02, OA-AR-04, and OA-AR-13B were used in monitoring activities in 2018. Stations OA-AR-05 and OA-AR-06 illustrated on the map were not used in the 2018 monitoring activities.

The air monitoring schedule shown in Table 5.1 was designed to reduce costs associated with environmental monitoring while still ensuring that any hypothetical releases of radiological material to the atmosphere from operations at the Pantex Plant could still be adequately characterized<sup>2</sup>. Several fence line monitoring stations (those designated as FL-AR-04, -05, -07, -08, and -09) in addition to those designated as OA-AR-02 and -04 are located in the downwind direction of the predominant wind at the Pantex Plant (the expected direction in which hypothetical releases of radiological material from Pantex would be expected to travel) and were operated more frequently than those located opposite the predominant wind direction (i.e., those located upwind from the Pantex Plant). Monitoring stations designated as FL-AR-01, -02, -10, -14, -16, and -17 are included in the latter category.

Each monitoring station was equipped with a high-volume air sampler and a low-volume air sampler (Figure 5.3). At far-left in this figure is a container for the co-located thermoluminescent dosimeters (TLD) discussed in Chapter 4. The high-volume sampler is located on the left and a “doghouse” containing the low-volume sampler is on the right. The samplers (when operated) ran continuously, and filters or silica gel samples were collected from the samplers on a weekly basis. Operational characteristics of the samplers, such as the length of the sample collection period (known as the “run time”), the beginning and ending flow rates, and other parameters were recorded by the sampling technicians at the initiation and/or at the completion of the sampling activity. The high-volume samplers operated at a flow rate of approximately 1.13 cubic meters per minute (40 ft<sup>3</sup> per minute [ft<sup>3</sup>/min or more commonly cfm]). During sampling, particles were collected on 20×25-centimeter (8×10-inch) filters. Each air filter sample included particulate matter from about 11,400 cubic meters of air (~ 403,000 ft<sup>3</sup>). Weekly<sup>3</sup> samples for a given month<sup>4</sup> were combined as one sample for later analysis for uranium-234 (U-234), uranium-238 (U-238), and plutonium-239 (Pu-239) by a radiological analysis laboratory.

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<sup>2</sup> This schedule has for the last several years been modified annually in a manner to ensure that each location other than on-site locations and the control location is scheduled for sample collection at least once every three years.

<sup>3</sup> The sample collection period is nominally one week. However in some cases due to the inability of the sampling technician to access a monitoring location due to weather, or due to modifications of the sampling schedule due to holidays or periods where no activities which could cause releases of radiological material to the atmosphere were occurring, samples were collected for longer periods.

<sup>4</sup> A sample collection “month” might commence several days prior to the designated month or extend into the following month. For example, the sampling period denoted as “July” represents samples collected during the period from June 27 through August 2 wherein the majority of the period of collection (31 of 36 days) occurred during July.



**Figure 5.3 – Typical Air Monitoring Site**

Nominal airflow through the low-volume air samplers was much smaller than that for the high-volume samplers, being 42.5 liters per minute (1.5 ft.<sup>3</sup>/min). Each low-volume sampler contained silica gel within the “U-tube” illustrated in Figure 5.4. The silica gel acted as a desiccant, removing water vapor from air as it flowed through the sampler. The silica gel samples were collected at the same time as the individual filters were collected from the high-volume samplers. Any tritiated water vapor present in the sampled air was recovered and quantified during analysis of the silica gel by a radiological analysis laboratory.



**Figure 5.4 – Low-Volume Sampling Apparatus**

### 5.3.2 Sample Analysis Results

All analytical results obtained from the laboratory were converted to concentrations in air by dividing the quantity of radionuclide collected in the sample by the volume of air sampled. This quantity was calculated using the operational characteristics recorded and (when necessary) temperature, pressure, and relative humidity data obtained from the meteorological tower described in Chapter 1. Table 5.2 summarizes values for the several analytes in four categories of monitoring stations (on-site, upwind, downwind, and control [or background]). The values indicated are: the mean and the standard deviation; the maximum value and its associated counting error; the historical background<sup>5</sup> and the Derived Concentration Standard (DCS)<sup>6</sup> for comparison.

**Table 5.2 – Concentrations of Radionuclides in Air for 2018 at (a) On-site Locations; (b) Upwind Locations; (c) Downwind Locations; and (d) Background Location (μCi/mL)**

a.

Radionuclide	Number of Samples Analyzed/Planned	Mean ±Std. Dev.	Max ± Counting Error	Historical Background	DCS
Tritium <sup>a</sup>	131/145	0.10±0.39	2.77±0.51	1.32	14,000
U-234 <sup>b</sup>	35/36	16.55± 8.05	38.80±6.33	30.40	400,000
U-238 <sup>b</sup>	35/36	15.67 ±7.57	37.28±6.16	28.96	470,000
Pu-239 <sup>b</sup>	35/36	-0.004 ±0.43	1.02±1.63	0.93	240,000

b.

Radionuclide	Number of Samples Analyzed/Planned	Mean ±Std. Dev.	Max ±Counting Error	Historical Background	DCS
Tritium <sup>a</sup>	104/122	0.09±0.29	1.77±0.46	1.32	14,000
U-234 <sup>b</sup>	24/27	23.13±13.53	65.85±14.52	30.40	400,000
U-238 <sup>b</sup>	24/27	22.71 ±13.82	65.27±13.58	28.96	470,000
Pu-239 <sup>b</sup>	24/27	-0.06±0.46	0.80±0.84	0.93	240,000

c.

Radionuclide	Number of Samples Collected/Planned	Mean ±Std. Dev.	Max ±Counting Error	Historical Background	DCS
Tritium <sup>a</sup>	155/169	0.07±0.28	2.18 ±0.49	1.32	14,000
U-234 <sup>b</sup>	39/41	25.41 ±17.26	93.38 ±18.55	30.40	400,000
U-238 <sup>b</sup>	39/41	25.11 ±19.81	113.31 ±19.80	28.96	470,000
Pu-239 <sup>b</sup>	39/41	0.09 ±0.42	1.04±0.97	0.93	240,000

<sup>5</sup> This parameter is the upper confidence limit (UCL) for a population consisting of all data for the specified radionuclide from the control location during the period from 2013-2015.  $UCL = \bar{x} + sK$ , where  $\bar{x}$  is the mean of the population,  $s$  is the standard deviation and  $K$  is a statistical parameter (approximately equal to 3) tabulated for specific numbers of samples, and the percent confidence that a user of the data is willing to accept (usually 95 percent) for statistical conclusions drawn from the data. When used to compare non-control results to the “historical background”, a user will have 95 percent confidence that any single analysis result from a non-control location which is greater than the derived value is “different than background”.

<sup>6</sup> DCSs represent the concentration of a given radionuclide in either water or air that results in a member of the public receiving 100 millirem (mrem) effective dose following continuous exposure for one year for either the ingestion of water, submersion in air, and air inhalation pathways. DOE-STD-1196-2011 (DOEk) lists several values of DCS for air inhalation for each radionuclide based upon the chemical form or the absorption class of the isotope. Since information concerning the chemical form is not available, the most restrictive (i.e. smallest in magnitude) of the several values is used in accordance with guidance in the technical standard. The values for the isotopes for which analysis is conducted as discussed in 5.3.1 above are: tritium:  $1.4 \times 10^{-8}$  μCi/mL; U-234:  $4.0 \times 10^{-13}$  μCi/mL; U-238:  $4.7 \times 10^{-13}$  μCi/mL; and Pu-239:  $2.4 \times 10^{-13}$  μCi/mL.

d.

Radionuclide	Number of Samples Collected/Planned	Mean ±Std. Dev.	Max ±Counting Error	Historical Background	DCS
Tritium <sup>a</sup>	39/48	0.06±0.19	1.04±0.39	1.32	14,000
U-234 <sup>b</sup>	11/12	25.98 ±8.65	38.30 ±5.39	30.40	400,000
U-238 <sup>b</sup>	11/12	24.31 ±7.58	36.19 ±4.53	28.96	470,000
Pu-239 <sup>b</sup>	11/12	-0.16±0.53	0.77 ±0.78	0.93	240,000

<sup>a</sup> Units in all tables are x 10<sup>-12</sup> µCi/mL (or aCi/mL) for tritium.

<sup>b</sup> Units in all tables are x 10<sup>-18</sup> µCi/mL (or yCi/mL) for α-emitting radionuclides (U-233/234, U-238, and Pu-239/240).

Figure 5.5 below illustrates the average concentrations in air of tritium during 2014 through 2018. When compiling the data used to produce this graph, the category of monitoring station described above has been ignored and the average of all tritium monitoring data collected during the indicated year calculated. A similar process was used for determining the average concentrations in air of U-234, U-238, and Pu-239 during the same period. When preparing Figure 5.6, the calculated annual averages for each of the aforementioned radionuclides has been divided by their respective DCSs and expressed as a percentage.

During CY 2018, as in most previous years, Pantex collected and analyzed approximately 90 percent of the planned samples at all locations. Intermittent power losses or motor failures caused the non-collection of a large number of high-volume and low-volume samples and resulted in non-representative sampling volumes.

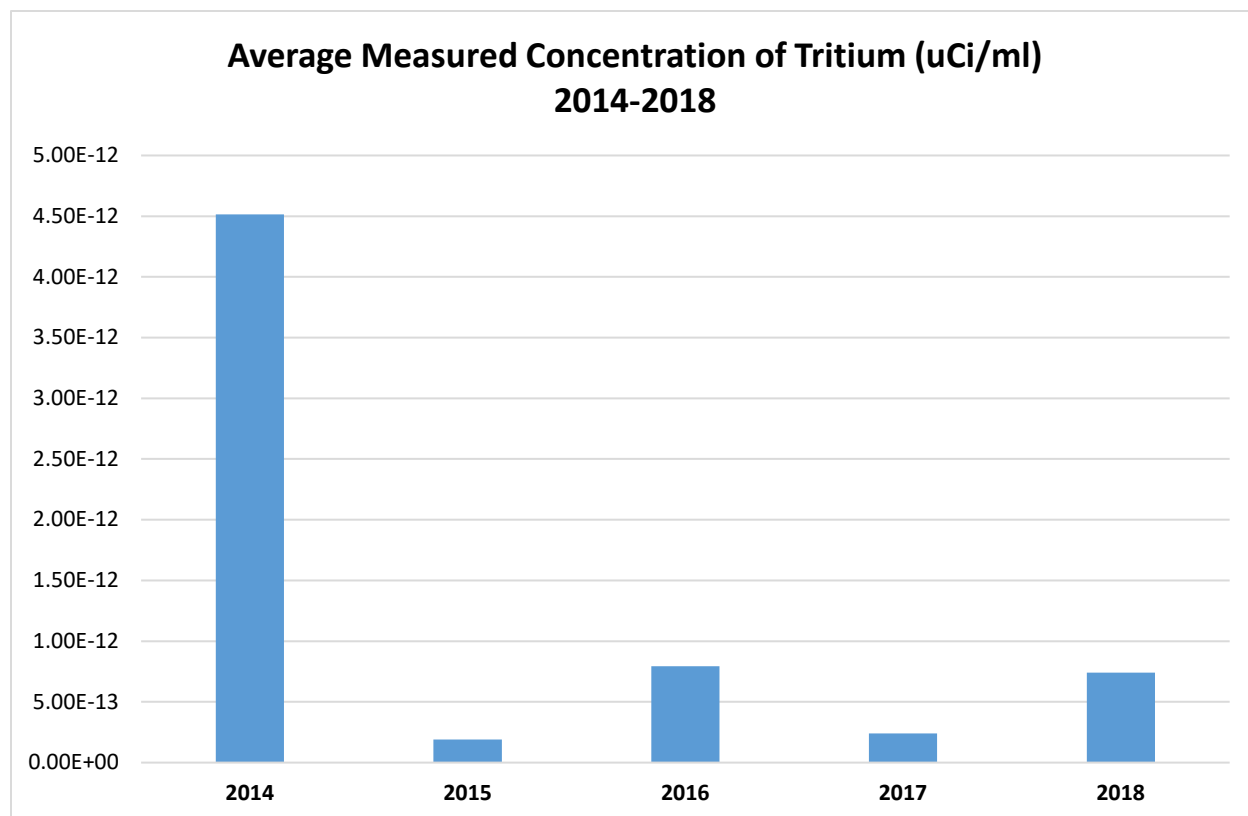
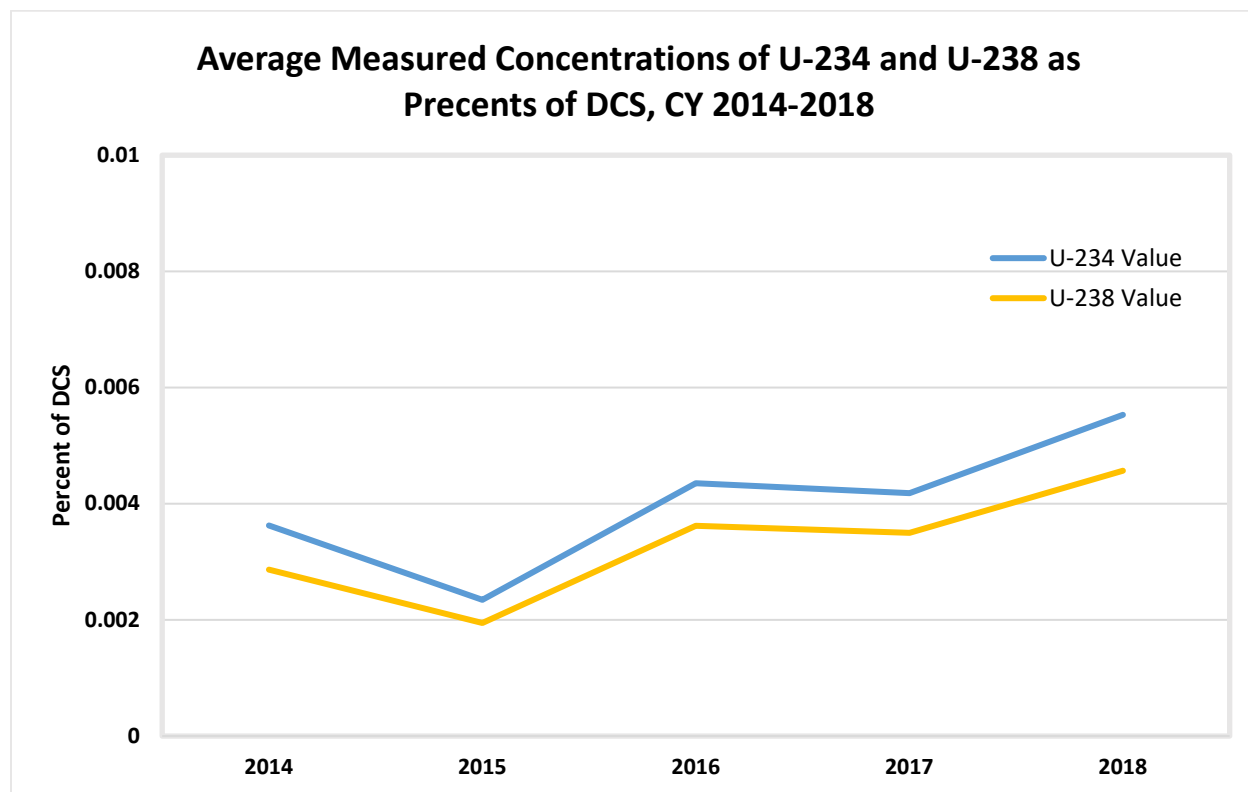


Figure 5.5 – Average Measured Concentration of Tritium (uCi/mL), CY 2014-2018



**Figure 5.6 – Average Measured Concentrations of U-234 and U-238, CY 2014-2018**

### 5.3.3 Data Interpretation

During 2018, the maximum measurements for the  $\alpha$ -emitting radionuclides (U-234, U-238, and Pu-239) during the year occurred during periods in the spring and summer when high wind speeds were observed in the Texas Panhandle and increased re-suspension of dust into the atmosphere. Because the relative maxima were observed to be occurring both upwind and downwind from the Pantex Plant, it is likely that many of the maximum measurements represent the collection of increased quantities of naturally occurring radioactive material during these periods.

A review of the ratio of the mean values of the concentrations of U-234 and U-238 in each of the four categories of locations as well as the same statistical parameter for all results during CY 2014 through 2018 shows good correlations between the calculated means for CY 2018 and for CY2014 through CY 2018 as illustrated in Figure 5.6. The fact that the ratio of the activities of U-234 and U-238 is not much different from unity indicates radiological equilibrium between the two radionuclides and is another indication of the absence of any discharges of uranium during Pantex operations.

Statistical comparison of the U-234 and U-238 sampling data for each of the several categories of monitoring stations (on-site, upwind, downwind, and control (or background)) during CY 2018 indicates that all results are of the same magnitude (i.e., results from areas potentially affected by Pantex operations are not distinguishable from background). The Pu-239 measurement data is of such low magnitude (more than 80 percent is indicated as “below detection” by the analysis laboratory) that apparent statistical differences between the “on-site” and “up-wind” categories and the other two categories during CY 2018 may be the result of the use of this “uncensored” data set. Average concentrations for all three alpha-emitting radionuclides are a very small fraction of levels that would cause a 100 mrem effective dose.

A similar equivalency to that noted for U-234 and U-238 sampling data exists for comparisons between categories of the tritium data collected during 2018. Variations in mission activities over the last several years may have resulted in various rates of emission of tritium and resulted in the apparent variations in measured concentrations of tritium during the period from CY 2014 through CY 2018. No tritium concentration in ambient air during 2018 (or any of the indicated years) exceeded the DCS. In fact, no radiological concentration in ambient air exceeded the applicable DCS for the radiological materials analyzed.

### **5.4 Conclusions**

Results indicate that the air monitoring program at the Pantex Plant continues to provide information that supports the hypothesis that current Plant operations do not have a detrimental effect on the quality of the environment at or near the Pantex Plant.



## Chapter 6 – Groundwater Monitoring

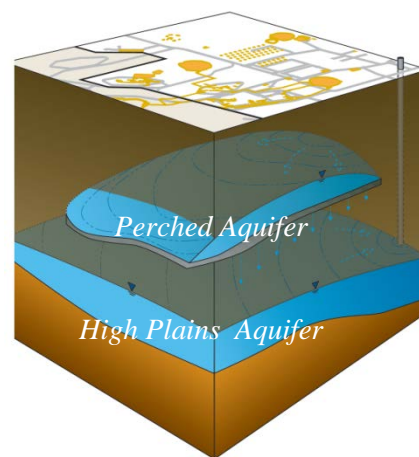
*Groundwater monitoring at the Pantex Plant began in 1975 when the first investigative wells were installed. Pantex completed its investigations in 2005 with the identification of contaminant plumes in the perched groundwater beneath the Pantex Plant and Texas Tech University (TTU) property. Monitoring wells in the perched groundwater are being used to monitor two remedial actions: two pump and treat systems, with 70 operating extraction wells and two injection wells and three in situ bioremediation (ISB) systems consisting of a total of 115 active treatment zone wells. Pantex also monitors 24 wells in the deeper drinking water aquifer (Ogallala Aquifer) to verify the remedial actions remain protective of this resource. Groundwater data collected in 2018 demonstrated that current remedial actions continue to progress toward cleanup of perched groundwater contaminants and that constituent levels found in the deeper drinking water resource are below Environmental Protection Agency (EPA) drinking water standards or cleanup standards established for the Pantex Remedial Action.*

### 6.1 Groundwater at Pantex

Groundwater beneath the Pantex Plant and vicinity occurs in the Ogallala and Dockum Formations at two intervals (Figure 6.1). The first water-bearing unit below the Pantex Plant in the Ogallala Formation is a discontinuous zone of perched groundwater located at approximately 61 to 91 meters (m) (200 to 300 feet [ft]) below ground surface and 30 to 61 m (100 to 200 ft) above the drinking water aquifer. A zone of fine-grained sediment (consisting of sand, silt, and clay) that created the perched groundwater is found between the perched groundwater and the underlying drinking water aquifer. The fine-grained zone (FGZ) acts as a significant barrier to downward migration of contaminated water. The perched groundwater ranges in saturated thickness from less than a foot at the margins to more than 23 m (75 ft) beneath Playa 1. Perched groundwater is formed by surface water in the playas that initially migrates down to the fine-grained zone. It then flows outward in a radial manner away from the playa lakes and becomes influenced by the regional south to southeast gradient. The largest area of perched groundwater beneath Pantex is associated with natural recharge from Playas 1, 2, and 4, treated wastewater discharge to Playa 1, historical releases to the ditches draining Zones 11 and 12, and storm water runoff that drains to the unlined ditches and playas. Two hydraulically separate, relatively small, perched zones occur around Playa 3 (near the Burning Ground in the north central portion of the Plant) and near the Old Sewage Treatment Plant in the northeast corner of Pantex.

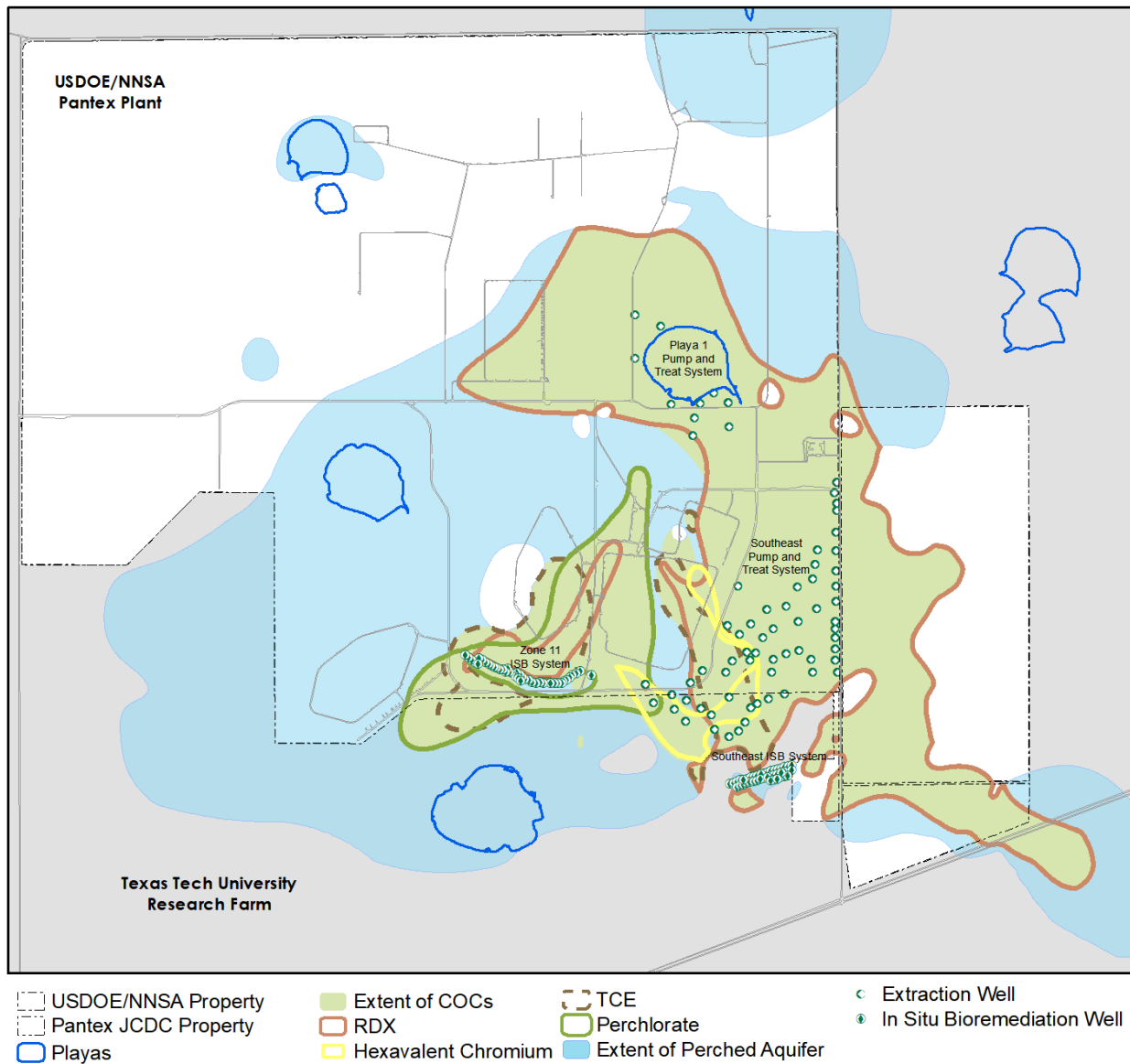
The second water-bearing zone, the High Plains Aquifer (also known as and referred to herein as the Ogallala Aquifer), is located below the fine-grained zone in the Ogallala and Dockum Formations. The Ogallala Aquifer is a primary drinking and irrigation water source for most of the High Plains. The groundwater surface of the Ogallala Aquifer beneath the Plant is approximately 122 to 152 m (400 to 500 ft) below ground surface with a saturated thickness of approximately 0.3 to 30 m (1 to 100 ft) in the southern regions of the Plant and approximately 76 to 122 m (250 to 400 ft) in the northern regions. In the vicinity of the Plant, the primary flow direction of the Ogallala Aquifer is north to northeast due to the influence of the City of Amarillo's well field located north of the Plant.

Historical operations at the Pantex Plant resulted in contamination of the larger perched groundwater area, and the contaminant



**Figure 6.1 – Groundwater Beneath Pantex**

plume has migrated past the Plant boundaries and beneath the adjacent property to the south and east. Most of the impacted property to the east was purchased in 2008 to allow better access for monitoring and control of perched groundwater. The primary contaminants of concern (COCs) in the perched aquifer are the explosives RDX and TNT and related breakdown products, perchlorate, hexavalent chromium, and trichloroethene (Figure 6.2). With the exception of one domestic well north of the Pantex Plant, no public or private water supply wells are completed in the perched groundwater in the immediate vicinity of the Pantex Plant. The domestic well north of the Plant is in an area that has not been impacted by historic operations.



**Figure 6.2 – Major Perched Groundwater Plumes and Remediation Systems**

Perched groundwater is not used for industrial purposes at Pantex, although the treated perched groundwater is routed through the Wastewater Treatment Facility (WWTF) and is beneficially used for subsurface irrigation of crops. Because concentrations of contaminants in the perched groundwater beneath the Plant’s property and off-site to the south and east currently exceed drinking water standards, the water is not safe

for domestic or industrial use. On-site use of perched groundwater is restricted by the Pantex Plant. TTU and one off-site property owner to the east have placed a deed restriction on their property to control use of perched groundwater and restrict drilling through the perched groundwater in areas that are impacted. Due to the expansion of the plumes to the southeast, Pantex is currently working with offsite landowners to the southeast to gain agreements for cleanup and ensure water use is restricted.

### 6.2 Long-Term Monitoring (LTM) Network

The purpose of the LTM network is to ensure that Remedial Action Objectives (RAOs) are being achieved. The RAOs and the corresponding LTM Network Monitoring Objectives are provided in the highlight box below.

Remedial Action Objectives	LTM Network Monitoring Objectives
<ul style="list-style-type: none"> <li>❖ Reduce risk of exposure to perched groundwater through contact prevention</li> <li>❖ Achieve cleanup standard for perched COCs</li> <li>❖ Prevent growth of perched groundwater contaminant plumes</li> <li>❖ Prevent COCs from exceeding cleanup standards in the drinking water aquifer</li> </ul>	<ul style="list-style-type: none"> <li>❖ Remedial action effectiveness</li> <li>❖ Plume stability</li> <li>❖ Uncertainty management</li> <li>❖ Early detection</li> </ul>

To ensure that the RAOs are achieved, wells and monitoring information were chosen with respect to specific objectives developed for the LTM network. The objectives are applied to perched and drinking water aquifer wells, as appropriate. Pantex developed an *LTM System Design Report* (PANTEXh) and a Sampling and Analysis Plan (SAP) (PANTEXi) to detail the LTM network and monitoring. The network monitoring information is evaluated quarterly, annually, and on a 5-year basis, with evaluations increasing in detail and complexity for each type of report.

### 6.3 The Scope of the Groundwater Monitoring Program

Groundwater is monitored at the Pantex Plant in accordance with requirements of the TCEQ HW-50284 (TCEQa). Pantex is also subject to requirements in the Interagency Agreement (IAG), signed jointly by the EPA and TCEQ, and issued effective in 2008. The *LTM System Design Report* and a new SAP, approved by the EPA and TCEQ in July 2009, identified the final monitoring well network and the parameters to be monitored. An update to the *LTM System Design Report* and revised SAP were submitted to and approved by the TCEQ and EPA in 2014. Table 6.1 summarizes the number of wells, by function, sampled in 2018 that are currently used in monitoring of the remedial actions and the total number of analytes assessed.

**Table 6.1 – Summary of Well Monitoring in 2018**

Well Type	Drinking Water Aquifer		Perched Groundwater	
	# Wells	# Analytes Assessed	# Wells	# Analytes Assessed
<b>Long-Term Monitoring Well</b>	24	1,569	90	7,277
<b>Other Wells</b>	4	152	1	65
<b>Pump &amp; Treat Extraction Well</b>	--	--	68	1,145
<b>ISB Treatment Zone Monitoring Wells</b>	--	--	45	3,527
<b>Total</b>	28	1,721	204	12,014

#### **6.4 Remedial Action Effectiveness and Plume Stability**

The purpose of the remedial action evaluation is to determine the effectiveness of remedial measures, indicate when remedial action objectives for perched groundwater have been achieved, and validate groundwater modeling results or provide data that can be used to refine modeling. The expected conditions for the remedial action effectiveness wells are that, over time, indicators of the reduction in volume, toxicity and mobility of constituents will be observed. These indicators include stable or decreasing concentrations of constituents or declining water levels in areas where pump and treat remedies have been implemented.

The purpose of plume stability wells is to determine if impacted areas (plumes) of perched groundwater are expanding and affecting uncontaminated perched groundwater and to monitor the changes occurring within the perched groundwater plumes. The expected conditions for the plume stability wells are that, over time, a reduction in the toxicity and mobility of constituents will be observed.

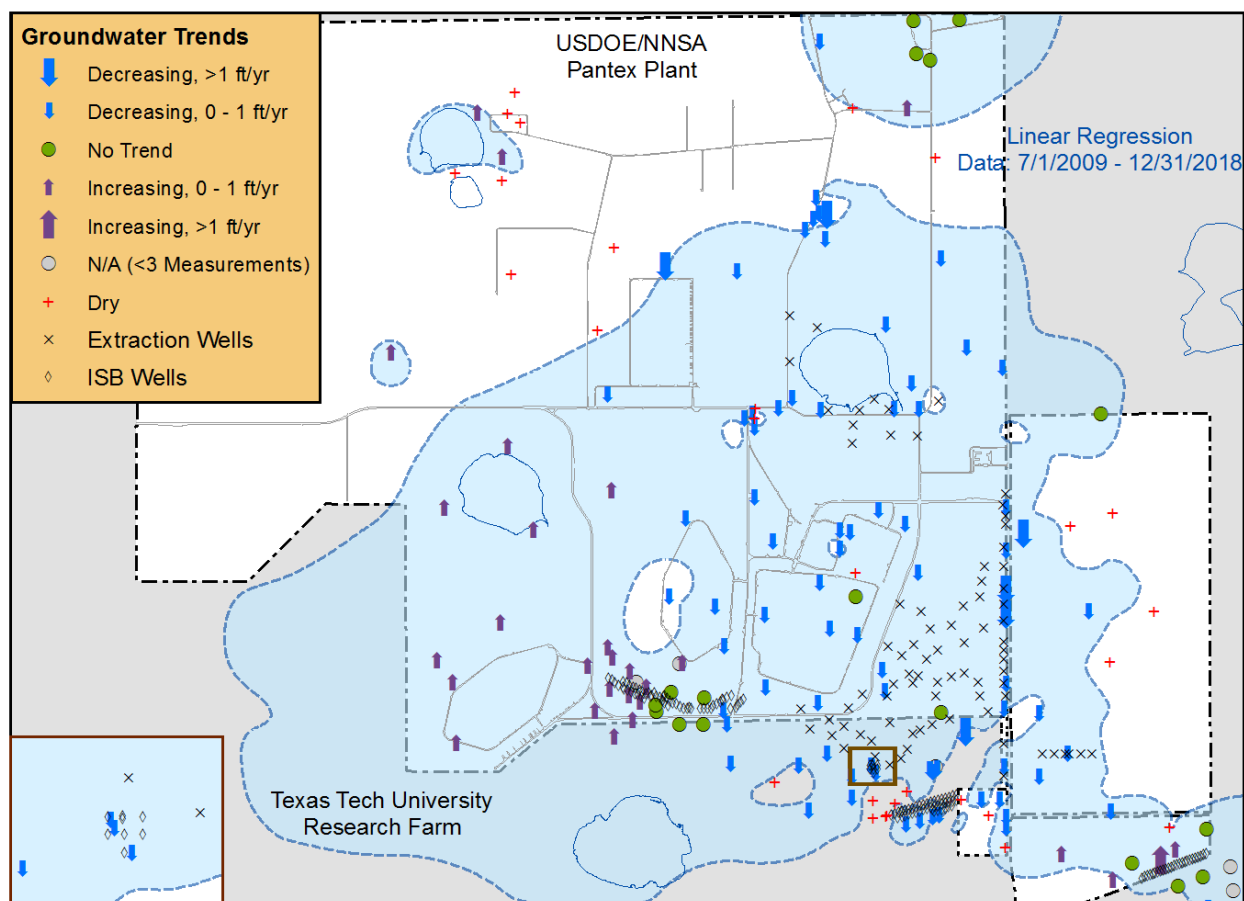
##### **6.4.1 Pump and Treat Systems**

The two pump and treat systems are designed to remove and treat perched groundwater, provide hydraulic control of plume movement away from Pantex, and reduce its saturated thickness to lessen the potential for impacted perched groundwater to migrate to the drinking water aquifer below it. The systems were designed to remove and treat perched groundwater and reuse the treated water for beneficial use. The Southeast Pump and Treat System (SEPTS) has the capability to inject the treated water back into the perched aquifer when beneficial use is not possible. Operational priorities for the pump and treat systems emphasize beneficial use of water.

The pump and treat systems' operation and throughput were variable in 2018. The Playa 1 Pump and Treat System (PIPTS) annual average operation was 85%. The monthly system operation was primarily affected by repairs at the WWTF early in the year and a break at the irrigation filter bank that occurred in 2017. The irrigation system is expected to be offline until late 2019. Further evaluation of the irrigation tapes is expected following startup of the system and repairs will be made if necessary. PIPTS operation was heavily affected by the break as the only method for release of treated water is through the WWTF. The SEPTS annual average operation in 2018 was 86% with system operation affected by various repairs, various repair issues at the WWTF, and the filter bank break at the irrigation system. WWTF treated water is now being routed to Playa 1 until repairs are completed at the irrigation system. SEPTS operation now continues, but primarily at lower flow rates due to the need to inject into the perched aquifer or release to Playa 1. SEPTS operations focused on removing water in high priority locations that help control migration of the plume to the southeast. PIPTS operations continue at a lower flow rate but can be interrupted when the flows to Playa 1 are restricted.

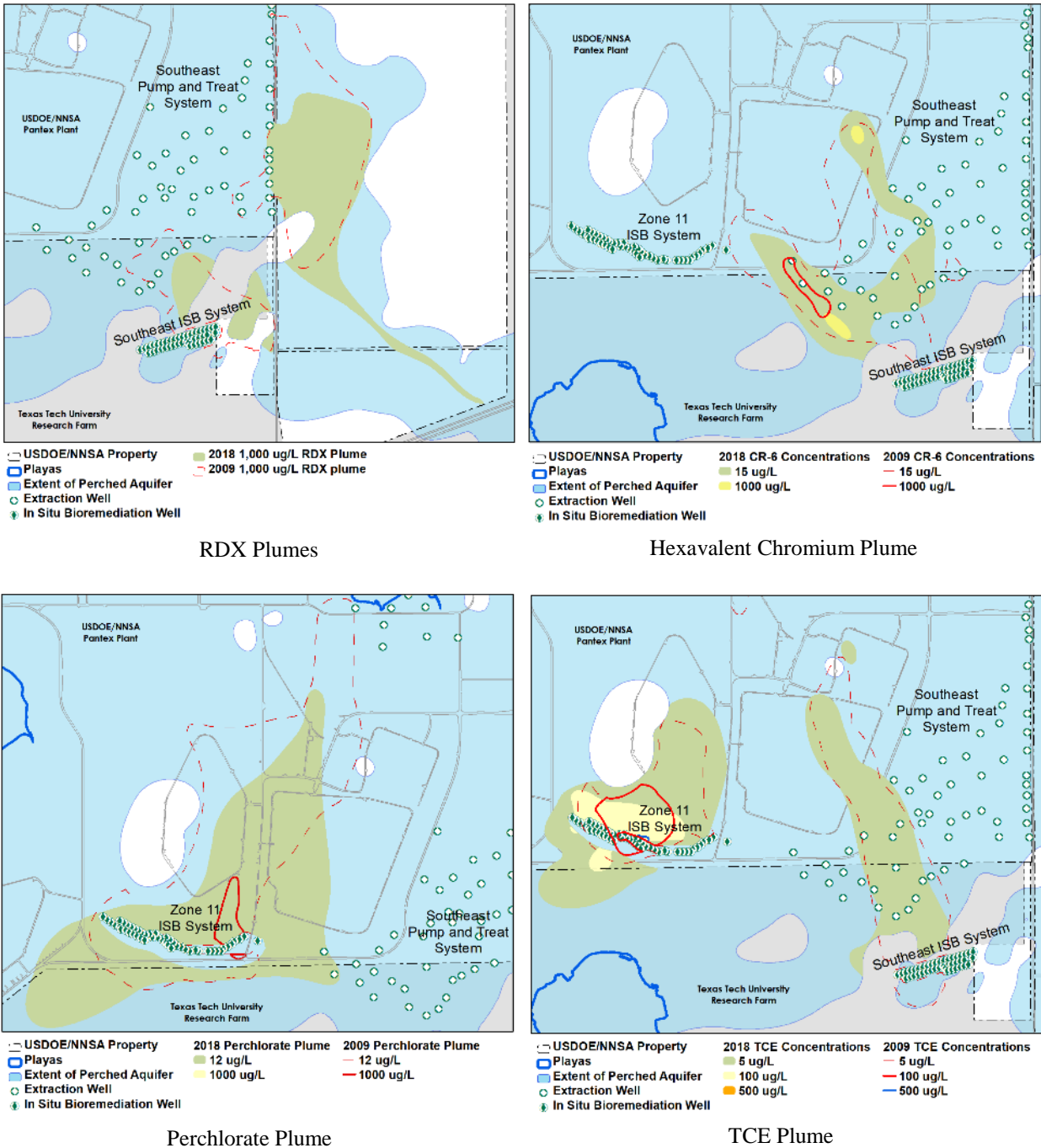
During the long operational history of the SEPTS, much of the treated water has been injected back into the perched zone, as the system was not originally designed to meet the remedial goal of reducing saturated thickness in the perched aquifer. Pantex has focused on beneficial use of the treated water, to the extent possible, since the subsurface irrigation system operation began in May 2005. Water levels are continuing to decline in the areas downgradient of the pump and treat systems, with declines exceeding one foot per year in several wells as depicted in Figure 6.3.

New extraction wells were drilled east of FM 2373 to provide additional control of plume movement to the southeast. Pantex is constructing the tie-in of the new extraction wells east of FM 2373 to SEPTS, and construction is scheduled for completion in March 2019.



**Figure 6.3 – Water Level Trends in the Perched Aquifer**

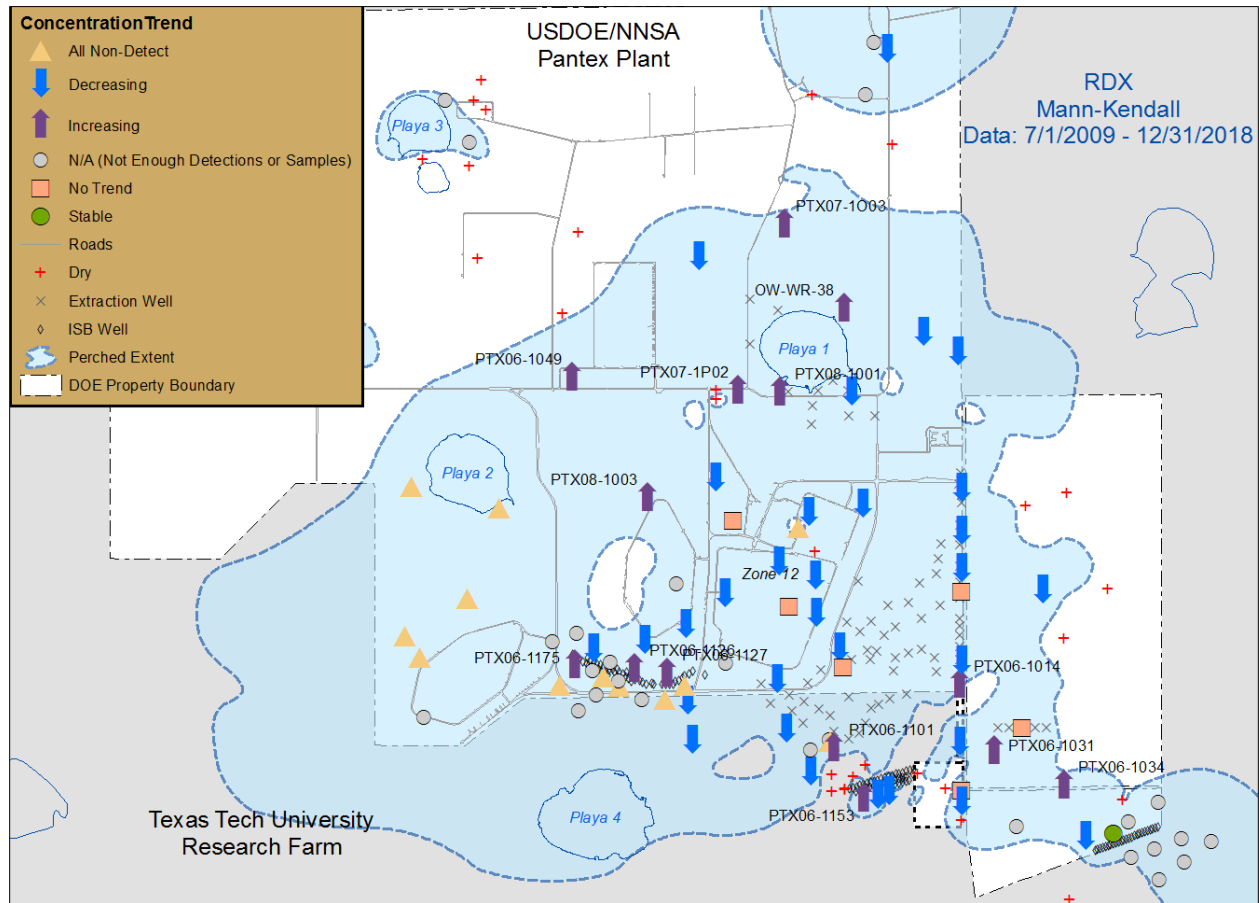
Plume stability is also evaluated to determine if the center of mass is still moving in the perched groundwater. Major perched aquifer COCs (RDX, hexavalent chromium, TCE, and perchlorate) were included in this evaluation. All plumes exhibit slight variations at their boundaries caused by minor variations in concentration over time, additional data from newly constructed or sampled wells, and the low values defining the plume boundaries. In addition, some plume expansion is expected as contaminants move and mix within the groundwater flow system. Because the RDX plume has expanded to the perched extent, the entire plume was not evaluated, but rather the two 1,000 microgram per liter ( $\mu\text{g/L}$ ) plume “hot spots” associated with the two source areas (Zone 12 east ditch and Playa 1) were evaluated. As depicted in Figure 6.4, the COC plumes had similar general shapes from 2009 to 2018; however, the eastern portion of the RDX plume has migrated further to the southeast. Movement of the plume in this area appears to be associated with faster groundwater flow paths along channel-type features in the top of the FGZ. After gaining access agreements with neighbors, Pantex installed fifteen new wells during 2018 and early 2019 to evaluate the extent of contamination to the south and southeast. Sampling indicates that RDX is now defined to the southeast.



**Figure 6.4 – 2009 - 2018 Plume Movement – Perchlorate, Hexavalent Chromium, RDX, and TCE in the Perched Aquifer**

RDX concentration trends since the start of remedial action in July 2009, depicted in Figure 6.5, generally indicate that RDX is decreasing or does not demonstrate a trend at the source areas (Playa 1 and the ditch along the eastern side of Zone 12). The SEPTS has affected the plume as the majority of COC concentrations are declining or not demonstrating a trend along the outer margins of the system. Although increasing trends are noted in four wells near Playa 1, recent data for these wells indicated decreasing concentrations or no trend. To the southeast, only one (PTX06-1153) of the five wells indicating a long-

term increasing trend currently exhibits an increasing trend based on recent data. PTX06-1153 is the only well downgradient of the Southeast ISB System that is not indicating effective treatment. Pantex continues to evaluate conditions in the area of this well; further recommendations will be made based on evaluation of data over time.



**Figure 6.5 – RDX Concentration Trends in the Perched Aquifer**

Concentration trends for the remaining major COCs (perchlorate, TCE, and hexavalent chromium) are discussed in the 2018 Annual Progress Report. Figure 6.6 shows the annual maximum concentrations of the major COCs observed in the perched aquifer since 2009. Continued declining trends are demonstrated for RDX and hexavalent chromium through 2018. However, perchlorate and TCE both showed an increase in annual maximum concentrations in 2018. This increase is associated with plume movement in the area southwest of Zone 11. Areas outside the influence of the remedial action systems are also monitored for high explosives (HE) and TCE breakdown products to gather data regarding natural attenuation and will be evaluated over time to attempt to estimate the rate of these processes.



**Figure 6.6 – Annual Maximum Concentration Trends in the Perched Aquifer**

### 6.4.2 In Situ Bioremediation Systems

The ISB systems treat the impacted groundwater as it moves through the bioremediation zone with the goal of reducing concentrations below the Groundwater Protection Standard (GWPS) established in the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) ROD. Creation of a bioremediation zone is achieved by injecting amendment and nutrients to stimulate resident bacteria. With complete reduction, the resident bacteria will reduce the COCs to less harmful substances. A new third system was installed in late 2017 with injection completed in early 2019. Treatment zone data will not be collected until the second quarter of 2019.

Overall, the Zone 11 and Southeast ISB have been effective in treating the primary COCs: RDX, hexavalent chromium, TCE, and perchlorate. Pantex continues to evaluate areas of the ISBs where an issue has been identified with treatment and has made adjustment to the treatment as needed based on the results of evaluation. Monitoring of conditions within the treatment zone and downgradient indicate that a reducing zone has been established at both ISB systems. The mild to strong reducing conditions found are expected for each ISB treatment zone. However, stronger reducing conditions may be required for the complete breakdown of TCE.

Downgradient monitoring at the Southeast ISB demonstrates that the system has been effective at reducing concentrations of RDX and hexavalent chromium to levels below the GWPS across most of the treatment zone. Pantex will continue to monitor wells in the area to determine groundwater flow patterns, mass flux, and treatment conditions in the western side of the treatment zone where RDX concentrations persist above the GWPS. In addition, water levels in the area of the Southeast ISB are declining as the pump and treat systems continue to remove water causing persistent low water levels or dry conditions across the system.



As a result, the future need for injections at the Southeast ISB will be reduced or eliminated after the 2019 injection event.

Evaluation of data collected downgradient of the Zone 11 ISB treatment zone indicates that a very mild to strong reducing zone has been established and maintained over time with conditions favorable for reduction of perchlorate and reductive dechlorination of TCE. Overall, perchlorate has been reduced to concentrations below the GWPS, and TCE concentrations continue to trend downward in downgradient wells. Although *Dehalococcoides* spp. (DHC) counts indicate that bioaugmentation was successful, reductive dechlorination will only occur at low rates due to the low counts.

The ninth injection event for the Zone 11 ISB was completed in October 2018, with only the expansion area injected. Pantex continues to evaluate the expansion area to determine the appropriate timing for bioaugmentation with DHC to potentially boost the treatment efficiency for TCE. The entire system is scheduled to be injected in 2019.

### 6.5 Uncertainty Management and Early Detection

Because the evaluation of uncertainty management and early detection well types is similar, they are evaluated together for unexpected conditions. The purpose of uncertainty management wells in perched groundwater is to confirm expected conditions identified in the Resource Conservation and Recovery Act (RCRA) Facility Investigations and ensure there are not any deviations, fill potential data gaps, and fulfill LTM requirements for soil units evaluated in the baseline risk assessment. The purpose of early detection wells is to identify breakthrough of constituents to the drinking water aquifer from overlying perched groundwater, if present, or from potential source areas in the unsaturated zone, before potential points of exposure have been impacted.

Figure 6.7 depicts the perched and Ogallala aquifer wells used in this evaluation for 2018. Pantex monitors for the most widespread and leachable contaminants at the uncertainty management and early detection wells. The monitoring lists for these wells are included in the *SAP* (PANTEXI) and consist of all HEs found in perched groundwater, degradation products of RDX, PCE, and TCE, as well as chloroform and boron. The data for each well in each aquifer were evaluated for unexpected conditions. Discussions of unexpected conditions are provided in the following sections.

#### 6.5.1 Perched Groundwater Uncertainty Management

New perched groundwater wells installed outside the previously defined extent of the southeast lobe of the perched aquifer indicates that water and contamination have migrated further to the southeast. Results indicate the presence of the HEs 4-amino-2,6-DNT and RDX at concentrations exceeding the practical quantitation limit (PQL) and GWPS (up to 8.6 and 1,280 µg/L and GWPS of 1.2 and 2 µg/L, respectively). Movement of the plumes in this area appears to be associated with faster groundwater flow paths along channel-type features along the top of the FGZ. Pantex completed an electromagnetic geophysical study to attempt to identify the area with faster flow paths in the groundwater to assist in identifying the extent of contamination. The study indicated the possibility of channels extending through the ISB area with one primary channel leading offsite to the south and southwest. In addition to identifying a subtle preferential groundwater path, the investigation may also serve to rule out much of the area where preferential flow is not occurring. The reports states that although the technology can identify the approximate center of the preferential flow path within the tolerances described, it does not always identify the edges of the flow path as accurately. Following the results of the study, Pantex drilled six new wells on the property to the south. Data from one well drilled in the area of the identified channel did not confirm the presence of water as proposed by the electromagnetic survey results. However, sampling of the newly

installed wells indicates that the extent of HE contamination in this area of perched groundwater has been identified.

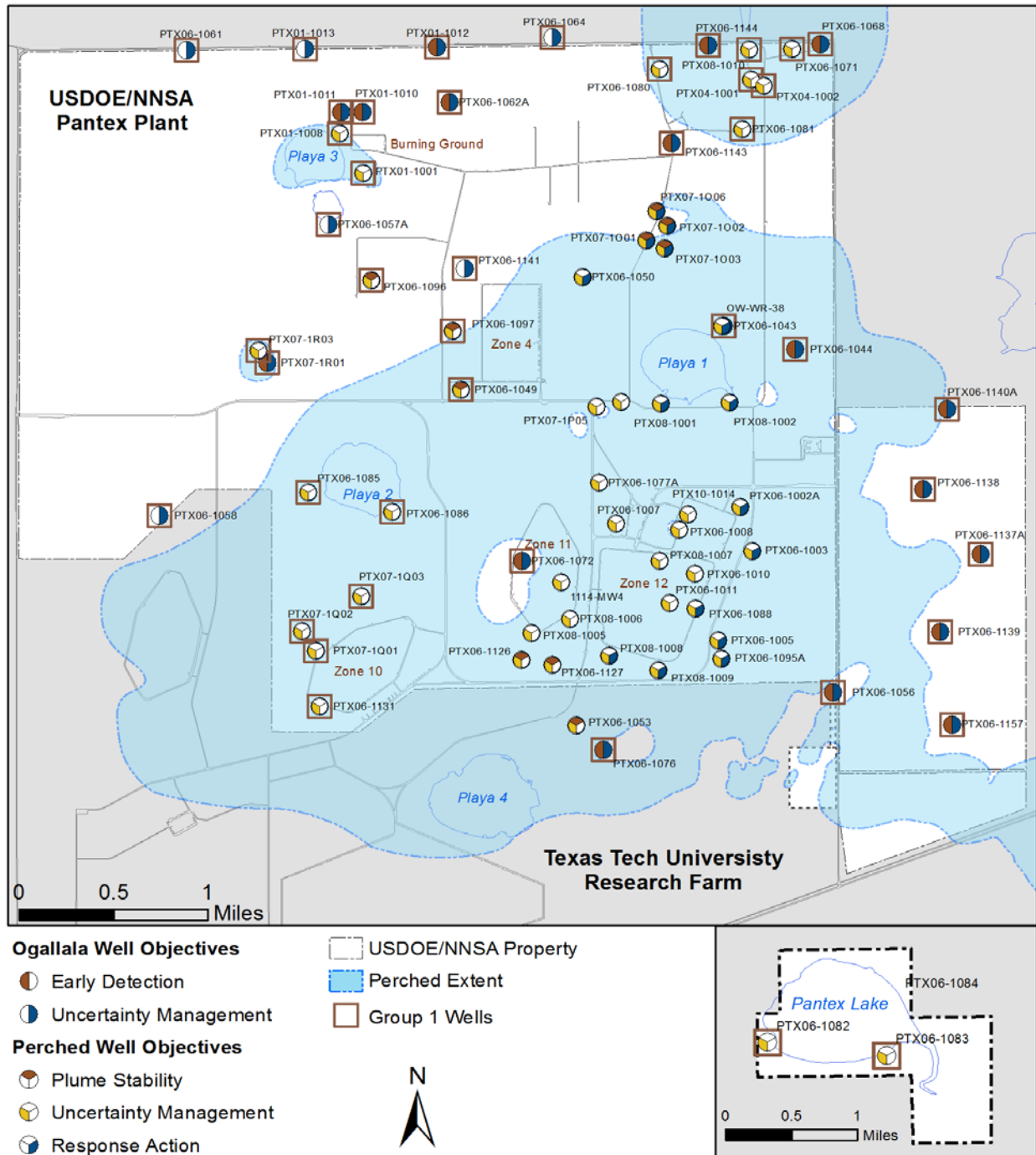


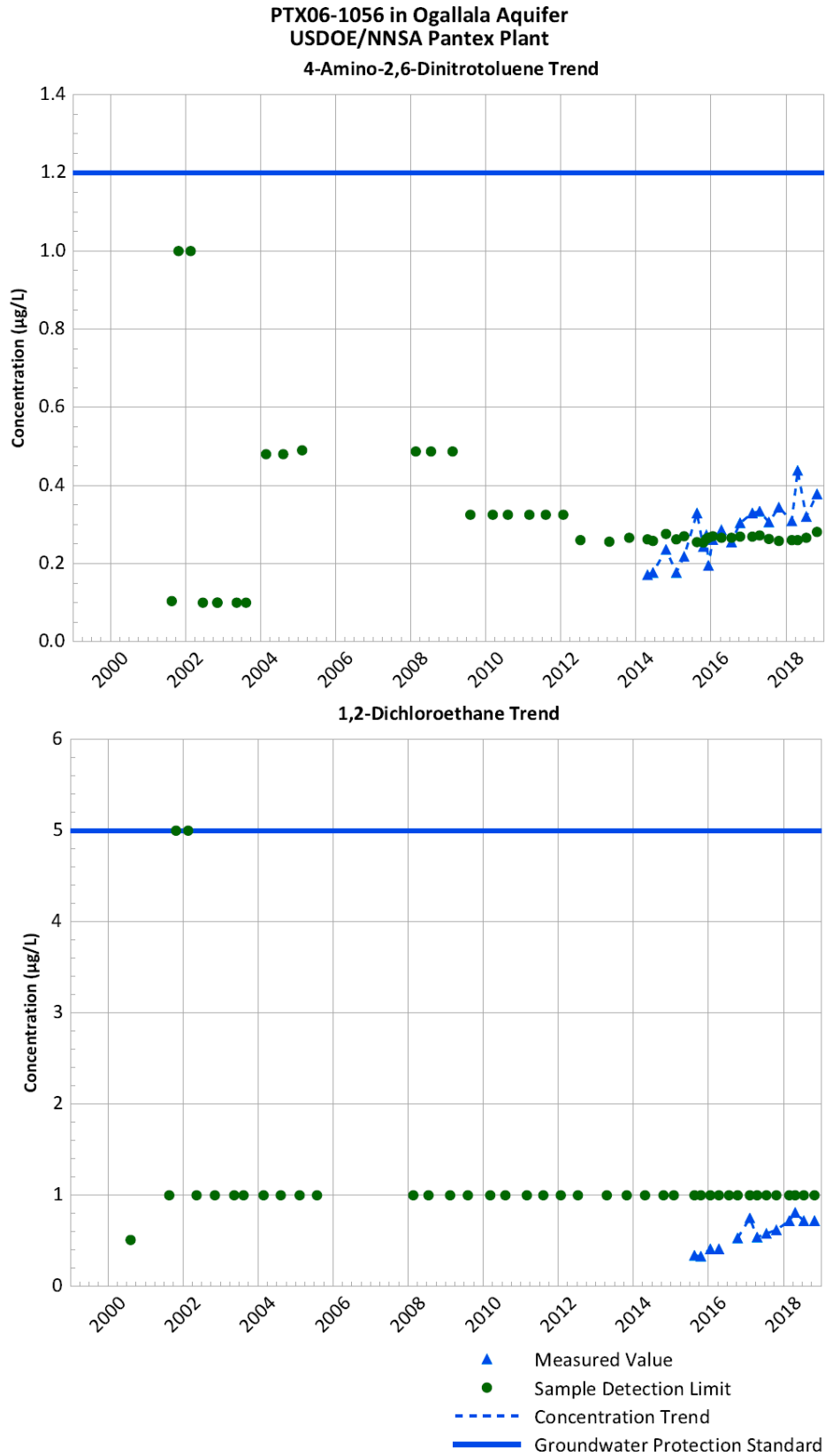
Figure 6.7 – Uncertainty Management and Early Detection Wells

### **6.5.2 Ogallala Aquifer Uncertainty Management and Early Detection**

Unexpected conditions in the Ogallala Aquifer primarily involve detections of organic constituents at one well, PTX06-1056. While boron and hexavalent chromium were also detected in Ogallala wells, these detections are related to background fluctuations or corrosion. Hexavalent chromium detections were not confirmed upon additional successive sampling. Other corrosion indicator metals were also detected in Ogallala wells above background. However, these detections are expected because of the use of stainless steel in Ogallala well construction. No detections exceeded the GWPS in the Ogallala Aquifer uncertainty management wells sampled during 2018.

PTX06-1056 continues to demonstrate detections of 4-amino-2,6-dinitrotoluene (DNT4A), a breakdown product of the HE 2,4,6-trinitrotoluene (TNT), and 1,2-dichloroethane, as shown in Figure 6.8. DNT4A was first detected in April 2014, and sample results collected since that time have been variable with a few values slightly exceeding the PQL. All values slightly exceeded the PQL in samples collected in 2018. 1,2-Dichloroethane has been variably detected since August 2015 but was not detected above the PQL in 2018. All detections were below the GWPS indicating that the water is still protective of human health.

Pantex has proactively evaluated potential sources for the contamination and has plugged a nearby perched well that was drilled deeply into the FGZ to address that potential source. An external independent review indicated that the perched well was the most likely source of the contamination, based on fate and transport modeling. A cement bond log was used to evaluate the competency of the concrete seal at the FGZ and indicated that the seal is competent. Therefore, PTX06-1056 is not likely acting as a preferential pathway for contamination to reach the Ogallala Aquifer. As agreed with regulatory agencies, Pantex will continue with quarterly sampling to evaluate trends in these detections. Further actions will be determined based on results of sampling and in accordance with the Ogallala Aquifer and Perched Groundwater Contingency Plan (PANTEXi).



**Figure 6.8 – Summary of Unexpected Conditions in Ogallala Aquifer Well PTX06-1056**

## 6.6 Natural Attenuation

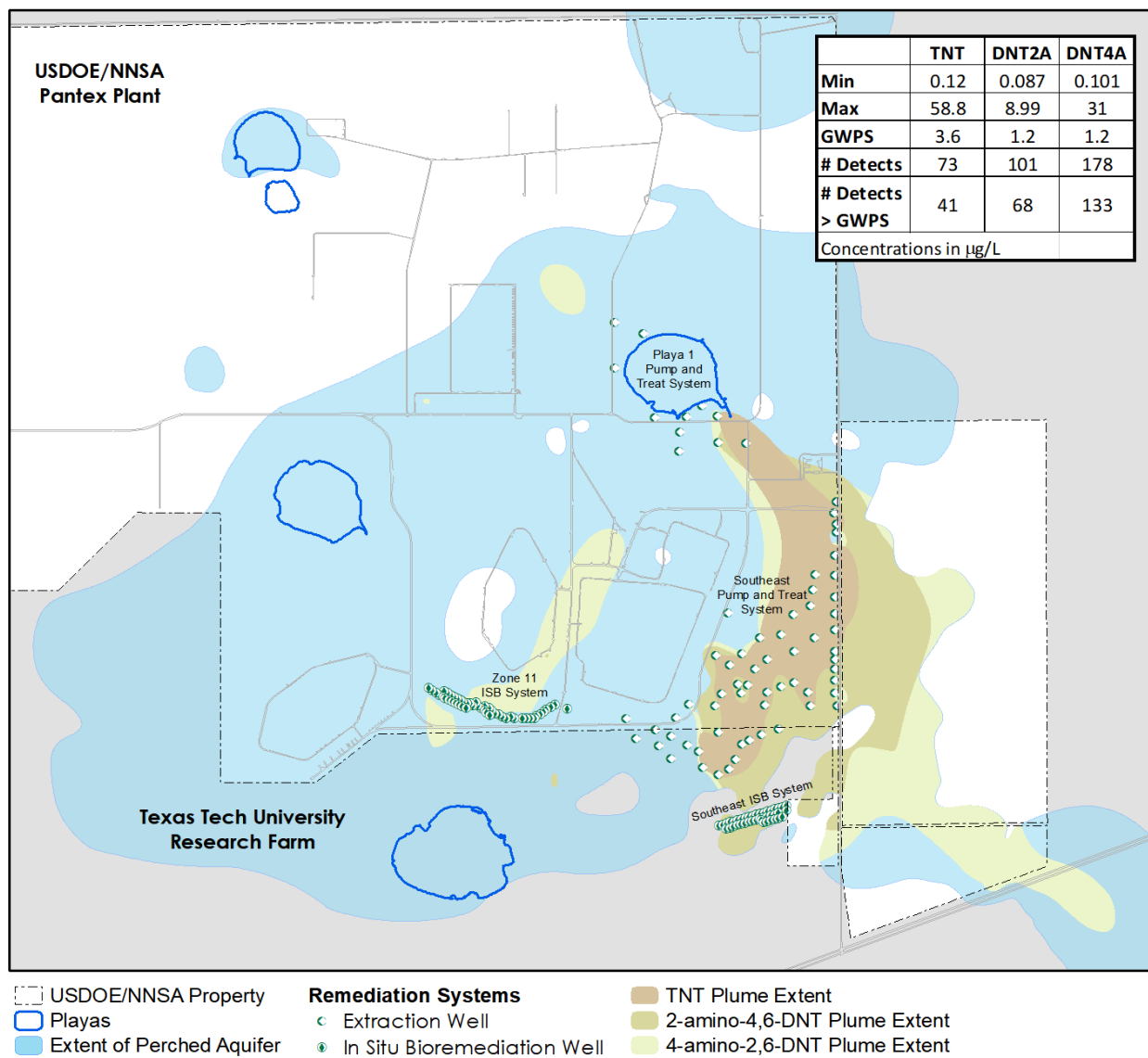
Natural attenuation is the result of processes that naturally lower concentrations of contaminants over time. This process is monitored at Pantex to help determine where natural attenuation is occurring, under what conditions it is occurring, and to eventually determine rates of attenuation for various constituents.

Pantex routinely monitors for breakdown products of the primary COCs. Groundwater conditions that may affect attenuation, such as dissolved oxygen and redox potential, are also monitored in each well. For example, RDX can degrade under aerobic and anaerobic conditions, but achieves faster reduction under anaerobic conditions. Trending of concentrations is also performed at each well to determine if concentrations are declining as expected.

Based on monitoring results for TNT and its breakdown products (2-amino-4,6-DNT and 4-amino-2,6-DNT), TNT continues to naturally attenuate over time (Figure 6.9). TNT has been manufactured at Pantex since the 1950s yet is only present in the central portion of the overall southeastern plume – within the SEPTS well field and near Playa 1. Its first breakdown product, 2-amino-4,6-DNT, occurs near the TNT plume and extends slightly beyond. The plume for the final breakdown product, 4-amino-2,6-DNT, extends to the eastern edge of the perched saturation at low concentrations. Only TNT breakdown products are present in perched groundwater beneath Zone 11 and north of Playa 1. Concentrations of the breakdown products are still above GWPS, but most wells with detections are recently showing a decreasing or stable trend.

Perched groundwater sampling results for RDX and breakdown products (MNX, DNX, and TNX) indicate that the breakdown products are present throughout most of the RDX plume, with TNX being the most widespread. TNX, the final degradation product, is a better indicator of degradation because the other intermediate products (MNX, DNX) degrade rapidly and do not accumulate in the environment (SERDP, 2004). If complete biodegradation of RDX is occurring, RDX and all breakdown products would be expected to decrease over time. As depicted in Figure 6.10, the TNX plume is similar in size and in extent to the RDX plume, but at much lower concentrations. Pantex contracted for a project to evaluate lines of evidence for natural attenuation of RDX at the Pantex Plant. The study included both aerobic and anaerobic degradation with evidence of both occurring. Biodegradation rates of 0.016 to 0.168 / year were calculated translating to RDX half-lives of approximately 5 to 50 years. The project found that the rates of RDX biodegradation are likely limited by the available labile organic carbon in the groundwater. The predominant attenuation process is aerobic biodegradation by bacterial strains. The study found several lines of evidence for natural attenuation of RDX as well as the potential to enhance aerobic biodegradation of RDX with introduction of low levels of labile organic carbon. Recommendations for further study were presented for additional treatability studies, bioaugmentation, and additional proteomics analyses for the degrading bacterial strains.

Pantex has monitored for breakdown products of TCE for many years; however, a strong indication of natural attenuation of TCE has not been observed in perched groundwater. TCE has started degrading in the Zone 11 ISB treatment zone. The TCE plumes at Pantex are being actively treated by the SEPTS and the ISB treatment zones.

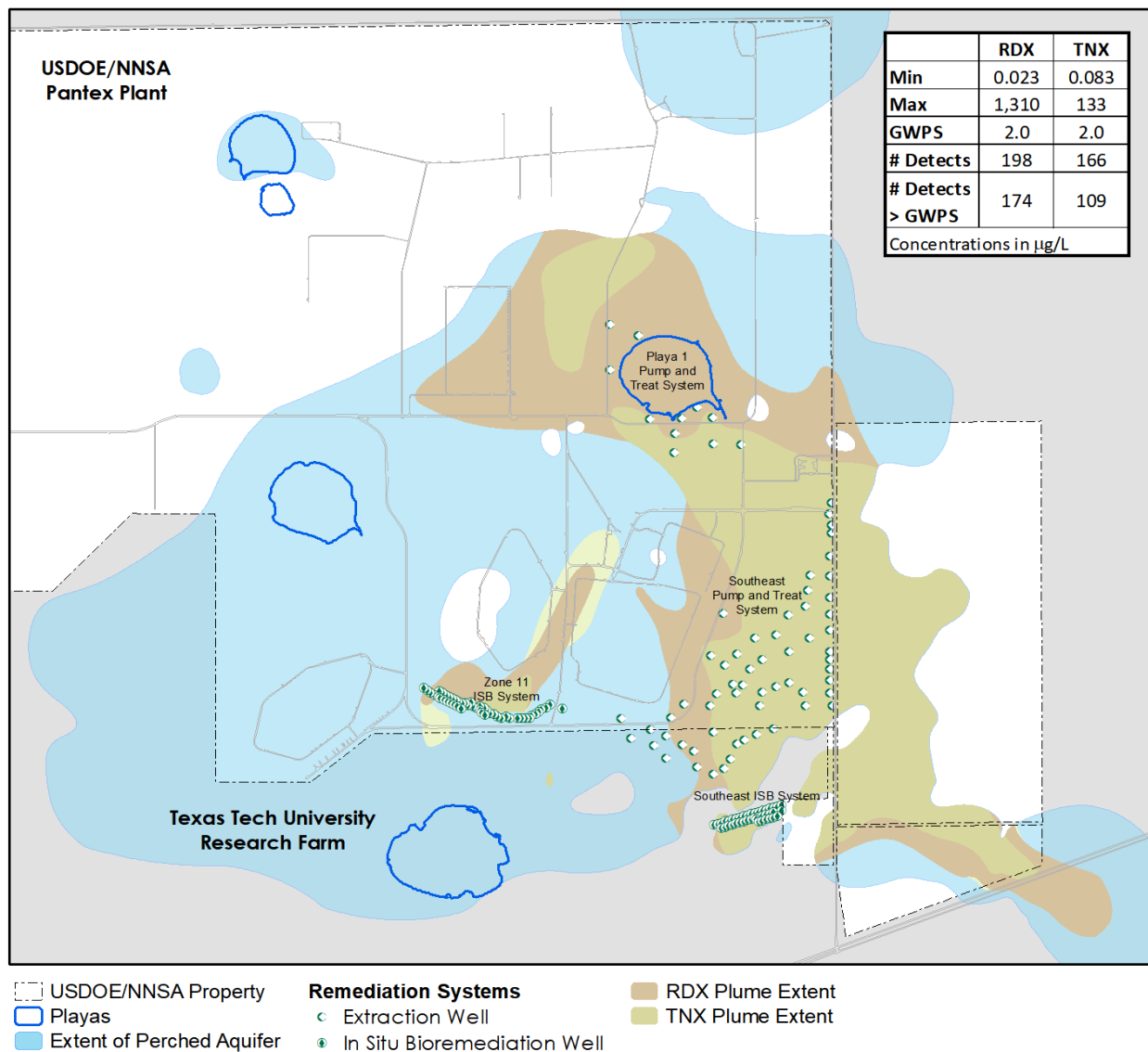


**Figure 6.9 – TNT and Degradation Product Plumes**

### 6.7 Groundwater Monitoring Conclusions

Overall, the groundwater remedial actions continued to be effective in 2018. The remedial actions continue to operate and meet short-term expectations for cleanup of the perched groundwater in areas under the influence of the remediation systems. As a whole, perched water levels continue to decline. Perched aquifer wells near Playa 2 reported a slight increase in groundwater levels attributable to rainfall and infiltration. COC mass is being removed or reduced, and institutional controls provide protection for use of impacted groundwater, while the remedial actions continue to operate to meet long-term goals. The influence of both pump and treat systems will continue to expand as the saturated thickness is reduced in the perched aquifer.

New perched groundwater wells installed outside the previously defined extent of the southeast lobe of the perched aquifer indicate that water and contamination have migrated further to the southeast and to offsite property. Pantex has extended the Southeast ISB remedy to that area at the Pantex boundary. Pantex completed an electromagnetic geophysical study to attempt to identify the area with faster flow paths in the



**Figure 6.10 – RDX and Degradation Product Plumes**

groundwater. The study was not conclusive; however, additional wells recently installed have identified the extent of HE contamination in this area of perched groundwater.

One Ogallala Aquifer well had continued COC detections slightly above the laboratory PQL, but below the GWPS, indicating possible migration of perched groundwater to the Ogallala Aquifer. In response to these detections, Pantex has fully implemented the conditions specified in the *Pantex Plant Ogallala Aquifer and Perched Groundwater Contingency Plan (PANTEXi)* and will continue quarterly sampling for HEs and VOCs at this well. Pantex has proactively evaluated potential sources for the contamination and plugged a nearby well that may have served as a migration pathway for perched groundwater.

Pantex contracted with APTIM and Dr. Mark Fuller to evaluate lines of evidence for natural attenuation of RDX at the Pantex Plant. The study included both aerobic and anaerobic degradation with evidence of both occurring. The project found that the rates of RDX biodegradation are likely limited by the available labile organic carbon in the groundwater.

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## Chapter 7 – Drinking Water

*Results from the routine drinking water compliance monitoring in 2018 confirmed that the drinking water system at the Pantex Plant met water quality regulatory requirements. All analytical results for bacteria, chemical compounds, lead & copper, and disinfection by-products were below regulatory limits, and adequate levels of disinfectant were maintained in the distribution system. The Pantex Public Water System (PWS) continues to be recognized by the Texas Commission on Environmental Quality (TCEQ) as a “Superior” supply system.*

### 7.1 The Scope of the Program

The Pantex Plant’s drinking water system (State of Texas Public Water System I.D. No. 0330007) is considered a non-transient, non-community public water system (NTNC-PWS) under the Safe Drinking Water Act (SDWA) regulations. The Environmental Protection Agency (EPA) created this category to identify private systems that continuously supply water to small groups of people (for example, in schools and factories). Water supplied by such systems is consumed daily by the same group of people over long periods of time.

The Plant’s drinking water is obtained from the Ogallala Aquifer. The drinking water production wells supply all of the Plant’s water needs. Before being transferred to the distribution system, all water is treated to provide disinfection protection throughout the system. In addition, the system provides water to adjacent Texas Tech University-owned property for domestic and agricultural use.

Samples from the drinking water system were collected and analyzed monthly for biological contaminants. The drinking water system is also sampled annually and triennially for various chemical contaminants as required by the SDWA and its implementing regulations (Title 40 of the Code of Federal Regulations (CFR), Chapter 141 and 143, and Title 30 of the Texas Administrative Code (TAC), Chapter 290). Analytical results were compared to regulatory guidelines for drinking water. Sampling locations were chosen to meet regulatory requirements and to provide system operators with data that would assist their evaluation of the system’s integrity.

### 7.2 New Requirements and Program Changes

There were no new regulatory requirements or changes implemented in 2018.

### 7.3 Water Production and Use

During 2018, the Pantex Plant produced/pumped approximately 421 million liters (L) (111 million gallons [gal]) of water from the Ogallala Aquifer. This was a decrease of 79 million L (21 million gal) compared to water produced in 2017.

The Pantex Plant remains committed to reducing the amount of produced water by implementing a water reuse and recycling program. Examples of the water conservation and reuse initiatives include the procurement of more efficient industrial cooling equipment (such as water re-circulating systems) and beneficial reuse of treated wastewater. Typically, Pantex beneficially reuses 100 percent of its treated wastewater to grow crops in the northeast portion of the Plant and continues to investigate other reuse opportunities. In July 2017, Pantex began discharging treated wastewater to an on-site playa lake, due to a system failure associated with the subsurface fluid distribution system. Surface discharge continued for the remainder of the year and throughout 2018. Efforts are underway to restore the beneficial reuse of treated wastewater.

### 7.4 Sampling

Pantex collected routine drinking water samples at 31 locations. Nine locations were sampled for biological indicators and residual disinfectant levels, two locations were monitored for chemical and water quality constituents, and 20 locations were monitored for lead and copper. The sampling locations are representative of drinking water at the Pantex Plant and are listed in Tables 7.1 and 7.2. Sample locations are periodically changed to assure there is adequate Plant coverage.

**Table 7.1 – Drinking Water Sampling Locations, 2018**

Description	Location
<b>Chemical &amp; Water Quality Monitoring</b>	Building 15-27 (Entry Point to the Distribution System)
	Building 16-12 (TTHM2 site <sup>1</sup> )
<b>Biological and Disinfectant Level Monitoring</b>	Building 12-103
	Building 18-1
	Building 12-6
	Building 16-12
	Building 12-70
	Building 11-2
	Building 15-27
	Building 16-1
	Building 10-9

**Table 7.2 – Water Quality Results for Copper and Lead, 2018**

ANALYTE	LOCATION	MEASURED VALUE (mg/L)	DETECTION LIMIT (mg/L)	ACTION LEVEL (mg/L)
<b>Copper</b>				
(Results are listed from highest concentration to lowest)	12-2-FTN	0.24	0.001	1.3
	09-9059-BR	0.17	0.001	1.3
	16-1-UHS	0.16	0.001	1.3
	12-132-FTN	0.16	0.001	1.3
	12-104-JC	0.15	0.001	1.3
	16-12-JC	0.15	0.001	1.3
	16-24-JC	0.14	0.001	1.3
	12-70-FTN	0.13	0.001	1.3
	18-1-BR	0.11	0.001	1.3
	12-61-FTN	0.11	0.001	1.3
12-121-FTN	0.09	0.001	1.3	

<sup>1</sup> The TTHM2 site is the location within the distribution system with the potential for high disinfection byproducts (Total Trihalomethanes (TTHM) and Haloacetic Acids (HAA5)) formation. Samples were collected for TTHMs and HAA5s at the Entry Point to the Distribution System, but these constituents are not regulated at this location. All sample results were below applicable regulatory limits.

ANALYTE	LOCATION	MEASURED VALUE (mg/L)	DETECTION LIMIT (mg/L)	ACTION LEVEL (mg/L)
	12-15-FTN	0.09	0.001	1.3
	11-2-JC	0.08	0.001	1.3
	12-103-FTN	0.07	0.001	1.3
	12-36-FTN	0.06	0.001	1.3
	Texas Tech-SINK	0.06	0.001	1.3
	11-51-BR	0.05	0.001	1.3
	12-84-MR	0.04	0.001	1.3
	12-5-RAMP-FTN	0.04	0.001	1.3
	12-39-BR	0.02	0.001	1.3
<b>Lead</b>				
(Results are listed from highest concentration to lowest)	11-2-JC	0.011	0.002	0.015
	12-5-RAMP-FTN	0.003	0.002	0.015
	16-12-JC	0.003	0.002	0.015
	09-9059-BR	0.003	0.002	0.015
	12-15-FTN	0.002	0.002	0.015
	16-24-JC	0.002	0.002	0.015
	12-2-FTN	0.002	0.002	0.015
	12-104-JC	0.001	0.002	0.015
	18-1-BR	0.001	0.002	0.015
	12-39-BR	0.001	0.002	0.015
	Texas Tech-SINK	0.001	0.002	0.015
	12-103-FTN	0.001	0.002	0.015
	12-36-FTN	<0.002	0.002	0.015
	12-61-FTN	<0.002	0.002	0.015
	16-1-UHS	<0.002	0.002	0.015
	12-121-FTN	<0.002	0.002	0.015
	12-84-MR	<0.002	0.002	0.015
12-132-FTN	<0.002	0.002	0.015	
11-51-BR	<0.002	0.002	0.015	
12-70-FTN	<0.002	0.002	0.015	

### 7.5 Results

In 2018, the TCEQ sampled the water system at Pantex. Results for this drinking water sampling were within regulatory limits for chlorine (disinfectant) and below regulatory limits for disinfection by-products, microbial contaminants, inorganic contaminants, nitrate, pesticides, and volatile organic compounds. Table 7.3 shows water quality results from the Pantex water system as measured by the TCEQ.

**Table 7.3 – Water Quality Results, 2018**

CONTAMINANT CATEGORY	ANALYTE	MEASURED VALUE	ACTION LEVEL
<b>DISINFECTANT</b>	Residual Chlorine	1.3 mg/L	4.0 mg/L
<b>TRihalOMETHANES</b> (Individual disinfection by-products are not regulated) TTHM2.	Bromodichloromethane	4.28 µg/L	N/A
	Dibromochloromethane	4.33 µg/L	N/A
	Bromoform	2.27 µg/L	N/A
	Chloroform	2.85 µg/L	N/A
<b>TOTAL TRIHALOMETHANES</b> (Only Total Trihalomethanes are regulated.)		<b>13.7 µg/L</b>	<b>80 µg/L</b>
<b>HALOACETIC ACIDS</b>	Bromochloroacetic acid	1.70 µg/L	N/A
	Dibromoacetic acid	1.00 µg/L	N/A

CONTAMINANT CATEGORY	ANALYTE	MEASURED VALUE	ACTION LEVEL
(Individual disinfection by-products are not regulated) TTHM2	Dichloroacetic acid	1.40 µg/L	N/A
	Monobromoacetic acid	<1.00 µg/L	N/A
	Monochloroacetic acid	1.40 µg/L	N/A
	Trichloroacetic acid	<1.00 µg/L	N/A
<b>TOTAL HALOACETIC ACIDS</b> (Only Total Haloacetic Acids are regulated.)		<b>3.8 µg/L</b>	<b>60 µg/L</b>
<b>VOLATILE ORGANIC COMPOUNDS</b>	Vinyl chloride	<1.00 µg/L	2 µg/L
	1,1-Dichloroethene	<5.00 µg/L	7 µg/L
	Methylene chloride	<5.00 µg/L	5 µg/L
	trans-1,2-Dichloroethene	<5.00 µg/L	100 µg/L
	cis-1,2-Dichloroethene	<5.00 µg/L	70 µg/L
	1,1,1-Trichloroethane	<5.00 µg/L	200 µg/L
	Carbon tetrachloride	<5.00 µg/L	5 µg/L
	1,2-Dichloroethane	<2.50 µg/L	5 µg/L
	Benzene	<5.00 µg/L	5 µg/L
	Trichloroethene	<2.50 µg/L	5 µg/L
	1,2-Dichloropropane	<5.00 µg/L	5 µg/L
	1,1,2-Trichloroethane	<5.00 µg/L	5 µg/L
	Chlorobenzene	<5.00 µg/L	100 µg/L
	<b>VOLATILE ORGANIC COMPOUNDS</b>	Ethyl Benzene	<5.00 µg/L
m,p-Xylene		<5.00 µg/L	N/A
Styrene		<5.00 µg/L	100 µg/L
1,2-Dichlorobenzene		<5.00 µg/L	600 µg/L
1,2,4-Trichlorobenzene		<5.00 µg/L	70 µg/L
o-Xylene (total)		<5.00 µg/L	10000 µg/L
Chloromethane		<10.00 µg/L	N/A
Bromomethane		<10.00 µg/L	N/A
Chloroethane		<10.00 µg/L	N/A
Acetone		<20.00 µg/L	N/A
Carbon disulfide		<5.00 µg/L	N/A
Acrylonitrile		<50.00 µg/L	N/A
1,1-Dichloroethane		<5.00 µg/L	N/A
Vinyl acetate		<5.00 µg/L	N/A
2,2-Dichloropropane		<5.00 µg/L	N/A
Bromochloromethane		<5.00 µg/L	N/A
Tetrahydrofuran		<25.00 µg/L	N/A
1,1-Dichloropropene		<5.00 µg/L	N/A
Methyl methacrylate		<10.00 µg/L	N/A
Dibromomethane		<5.00 µg/L	N/A
Bromodichloromethane	2.60 µg/L	N/A	

CONTAMINANT CATEGORY	ANALYTE	MEASURED VALUE	ACTION LEVEL
	cis-1,3-Dichloropropene	<5.00 µg/L	N/A
	Trans-1,3-Dichloropropene	<5.00 µg/L	N/A
	Ethyl methacrylate	<5.00 µg/L	N/A
	1,3-Dichloropropane	<5.00 µg/L	N/A
	2-Hexanone	<20.00 µg/L	N/A
	1,1,1,2-Tetrachloroethane	<5.00 µg/L	N/A
	Isopropylbenzene (Cumene)	<5.00 µg/L	N/A
	Bromobenzene	<5.00 µg/L	N/A
	1,2,3-Trichloropropane	<5.00 µg/L	N/A
	n-Propylbenzene	<5.00 µg/L	N/A
	1,3,5-Trimethylbenzene	<5.00 µg/L	N/A
	tert-Butylbenzene	<5.00 µg/L	N/A
	1,2,4-Trimethylbenzene	<5.00 µg/L	N/A
	sec-Butylbenzene	<5.00 µg/L	N/A
	1,3-Dichlorobenzene	<5.00 µg/L	N/A
	4-Isopropyltoluene	<5.00 µg/L	N/A
	1,2-Dibromo-3-chloropropane	<10.00 µg/L	0.2 µg/L
<b>VOLATILE ORGANIC COMPOUNDS</b>	n-Butylbenzene	<5.00 µg/L	N/A
	1,2,3-Trichlorobenzene	<5.00 µg/L	N/A
	1,2,4-Trichlorobenzene	<5.00 µg/L	N/A
<b>INORGANICS</b>	Nitrate (as N)	1.36 mg/L	10 mg/L

### 7.5.1 Inorganic Contaminants

Monitoring for inorganic contaminants in the PWS is required under the SDWA and the TAC. The State of Texas regulates the amount of these contaminants in drinking water to protect public health. Consumption of these contaminants may cause health problems if present in public water supplies in amounts greater than the drinking water standard set by the EPA. All inorganic contaminant results from monitoring conducted in 2018 were below regulatory levels.

### 7.5.2 Biological (Microbial) Monitoring

Water distribution systems may contain naturally occurring microorganisms and other organic matter that could enter a system through leaks, cross-connections, back-flow events, or disinfection system failures. Bacterial growth may occur within the water itself, at or near the pipe surfaces (bio-film), or from suspended particulates. Factors that influence bacterial growth include water temperature, flow rate, and chlorination. During 2018, all microbial sample results were negative for coliform and E. coli bacteria.

### 7.5.3 Radiological Monitoring

Radiological monitoring is not required for the non-transient, non-community public water supply at Pantex. During 2018, no radiological monitoring was conducted.

#### **7.5.4 Disinfection By-Products**

All drinking water at Pantex is chlorinated prior to entry into the distribution system. Disinfection By-products (DBPs) are produced by the reaction between the disinfectant (chlorine) and organic matter in the water. Reducing the amount of organic matter in the source water before disinfection can help control the quantity of DBPs produced. In addition, limiting the amount of disinfectant introduced in the system reduces the formation of these byproducts. All PWSs where chlorine is used are required to maintain residual levels between 0.2 and 4.0 milligrams per liter (mg/L) throughout the distribution system. These levels provide assurance that the water is safe from most water-borne pathogens while minimizing any adverse health risks to the population from DBPs or the higher concentrations of chlorine.

DBPs are broken into two groups: total trihalomethanes (TTHMs) and haloacetic acids (HAA5). TTHMs are reported as the sum of the chloroform, dibromochloromethane, bromo-dichloromethane, and bromoform concentrations in milligrams per liter. Haloacetic acids are reported as the sum of the monochloroacetic acid, dichloroacetic acid, trichloroacetic acid, monobromoacetic acid, and dibromoacetic acid concentrations in milligrams per liter. All tests for DBPs were at or below SDWA MCLs.

#### **7.5.5 Water Quality Parameters**

Water quality parameter testing was not conducted in 2018. These include constituents such as alkalinity and specific conductivity. Typically, detection of these constituents does not indicate that the water is unsafe to drink; rather they may have aesthetic effect on the water such as salty tasting water.

#### **7.5.6 Synthetic Organic Contaminants**

Synthetic organic chemicals (SOCs) are products derived from naturally occurring materials (petroleum, natural gas, and coal), which have undergone at least one chemical reaction, such as oxidation, hydrogenation, or other process. The TCEQ did not monitor the water system for SOCs during 2018.

#### **7.5.7 Volatile Organic Contaminants**

Volatile organic compounds (VOCs) include a variety of chemicals, some of which may have short and long term adverse health effects. VOCs are released by a wide array of products numbering in the thousands. Organic chemicals are widely used as ingredients in household products such as; fuels, paints, varnishes, and wax which contain organic solvents, as do many cleaning, disinfecting, cosmetic, degreasing, and hobby products. All of these products can release organic compounds while being used, and to some degree, when they are stored. Because of the vast number of products on the market that contain VOCs, it is possible that some of these constituents may find their way into drinking water supplies. The TCEQ did monitor the water system for VOCs during 2018. All sample results were below any regulatory limits established in federal or state regulations, and within the ranges observed in previous years.

#### **7.5.8 Lead and Copper Monitoring**

The Lead and Copper Rule under the SDWA requires that concentrations of lead and copper remain below action levels (0.015 and 1.3 mg/L, respectively) for the 90th percentile of the sampling locations. These regulations establish requirements for monitoring, reporting, corrosion control studies and treatment, source water treatment, lead service line replacement, and public education. Public water systems must control the levels of lead and copper in drinking water by controlling the corrosivity of the water. Pantex is on a triennial monitoring schedule for lead and copper. Compliance monitoring for lead and copper was conducted during 2018. Table 7.2 shows the water quality results from the Pantex water system.

#### **7.5.9 Contaminant Candidate Monitoring**

The drinking water Contaminant Candidate List (CCL) is a list of contaminants that are currently not subject to national primary drinking water regulations, but are known or anticipated to occur in public water systems. Contaminants listed on the CCL may require future regulation under the SDWA. The EPA is

required to publish the CCL every five years. The SDWA directs the EPA to consider the health effects and occurrence information for unregulated contaminants as the agency makes decisions to place contaminants on the list. The SDWA further specifies that the EPA place those contaminants on the list that present the greatest public health concern related to exposure from drinking water. The EPA uses the CCL to identify priority contaminants for regulatory decision making and information collection. The TCEQ did not monitor for select contaminants on the CCL during 2018.

#### **7.6 Inspections**

The TCEQ monitors the water supply in accordance with the drinking water standards. In August 2018, a TCEQ-contractor collected samples from the Pantex Plant public water supply system. The report generated from that event indicated that Pantex met or exceeded all requirements for operating a Public Water Supply. The TCEQ did not perform a Comprehensive Compliance Inspection of the Pantex Drinking Water system in 2018.

#### **7.7 Conclusions**

All sample results were below applicable regulatory limits under the SDWA. Monitoring results demonstrate that Pantex continues to provide safe drinking water while the water supply system maintains a “Superior Rating.”

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## Chapter 8 – Wastewater

*Pantex operates an on-site wastewater treatment facility. The wastewater treatment system consists of a facultative lagoon and two wastewater storage lagoons. This facility is permitted by the Texas Commission on Environmental Quality (TCEQ) to treat and dispose of domestic and industrial wastewater. During 2018, the Pantex Plant discharged more than 644 million liters (L) (170 million gallons [gal]) of treated wastewater to the on-site playa lake.*

### 8.1 The Scope of the Program

Domestic and industrial wastewaters generated at the Pantex Plant are treated at an on-site wastewater treatment facility (WWTF). Industrial effluents from Plant operations are generally pre-treated and are directed into the WWTF for further treatment. All such effluents are collected in the sanitary sewer, managed in the WWTF, and are either discharged through a permitted outfall to an underground irrigation system or discharged through a permitted outfall to an on-site playa lake. The playa is an ephemeral lake and is not connected to any other lakes, rivers, or streams (Figure 8.1).



**Figure 8.1 – Playa 1**

The WWTF (Figure 8.2) is a clay-lined, facultative lagoon that covers approximately 1.58 hectares (ha) (3.94 acres [ac]) and has a capacity of 42 million L (11 million gal). Pantex also has two storage lagoons used for storage and retention of treated wastewater. The east lagoon is a storage lagoon with a polyethylene liner with similar dimensions and capacity as the facultative lagoon and can serve as the facultative lagoon should the need arise (Figure 8.3). In addition to the treated domestic and industrial wastewater, this lagoon receives treated groundwater from environmental remediation projects.



**Figure 8.2 – Wastewater Treatment Facility, Facultative Lagoon**



**Figure 8.3 – East Wastewater Storage Lagoon**

The northern storage lagoon is a clay-lined lagoon, which covers approximately 1.05 ha (2.6 ac) and has a capacity of 25.4 million L (6.7 million gal). This lagoon is used only for the storage of treated wastewater (Figure 8.4).



**Figure 8.4 – Wastewater Storage Lagoon**

The treatment process in the facultative lagoon involves a combination of aerobic, anaerobic, and facultative bacteria. At the surface, aerobic bacteria and algae exist in a symbiotic relationship. Oxygen is provided by natural aeration processes, algal photosynthesis, and by solar-powered mechanical aerators. Bacteria use the oxygen for the aerobic degradation of organic matter. Nutrients and carbon dioxide released in the degradation process are used by the algae. Below the surface and above the bottom of the lagoon, treatment and degradation of organic matter is accomplished with facultative bacteria. At the bottom of the facultative lagoon, organic matter is deposited in a sludge layer and is decomposed by anaerobic bacteria. The wastewater treatment process in a facultative lagoon is complex and nearly all treatment is provided by biological activity.

### **8.2 Operational Description and Metrics**

The TCEQ is the permitting authority for wastewater discharges. During 2018, Pantex had three authorizations for wastewater disposal. These authorizations require analytical monitoring and periodic reporting to the TCEQ.

Pantex is permitted to dispose of treated wastewater by means of a subsurface irrigation system into agricultural fields for beneficial reuse. This permit is referred to as a Texas Land Application Permit (TLAP), WQ0004397000. This permit was modified and reissued on April 5, 2012, and will expire on December 1, 2020.

During periods when the agricultural fields are fallow, Pantex is authorized to apply limited quantities of wastewater to the irrigation area under an Underground Injection Control (UIC) Authorization 5W2000017. There is no expiration date on this authorization.

Finally, Pantex maintains a Texas Water Quality Permit (TWQP) that allows it to discharge treated wastewater to an on-site playa (WQ0002296000). This permit was renewed by the TCEQ on August 10, 2016 and will expire on December 1, 2020. Through compliance with these three authorizations, Pantex manages and discharges treated effluent in a manner that is beneficial to the environment.

When discharging to the subsurface irrigation system, water is distributed through manifold pipes to individual zones located within four tracts of land that are each approximately 41 ha (100 ac) in size. The irrigation area consists of agricultural land owned by the Department of Energy (DOE) and farmed by Texas Tech University (TTU). Crops grown in this area may include winter wheat, sorghum, soybeans, cotton, corn, oats, and opportunity wheat. Crops will vary from field to field, depending on the cropping needs of TTU. During 2018, the subsurface irrigation system was not utilized due to ongoing repairs. However, all four tracts were planted as dry land crops with winter wheat (Figure 8.5).



**Figure 8.5 – Irrigation Tract 101**

### **8.3 Sampling Locations**

Sampling was conducted at the incoming weir of the lagoon system (before treatment) and at the permitted discharge point for surface water discharge, Outfall 001A. Monitoring the water quality at the incoming weir was done to determine the effectiveness of the wastewater treatment system. Results of these efforts showed that the treatment system adequately treated the wastewater to comply with all effluent limitations.

### **8.4 Analytical Results**

During 2018, Pantex discharged approximately 644 million L (170 million gal) of treated wastewater through Outfall 001A. Water quality results through this outfall are shown in Table 8.1.

Although the subsurface irrigation system did not operate in 2018, TLAP-required analyses were reported to the TCEQ in September 2018. Results from the required soil monitoring in the irrigation application area are provided in Chapter 10 of this report.

**Table 8.1 – Water Quality Results from Outfall 001A, 2018**

Analyte	Maximum Discharge Limits <sup>b</sup> (mg/L)	Minimum Detected Concentration (mg/L)	Maximum Detected Concentration (mg/L)	Permit Exceedance/ Violation <sup>c</sup>	Percent Compliance
Copper	1.0	0.004	0.049	0/0	100
Manganese	2.0	0.004	0.010	0/0	100
Zinc	2.0	0.004	0.012	0/0	100
HMX	Report	<0.001	<0.001	0/0	100
RDX	Report	<0.001	<0.001	0/0	100
PETN	Report	<0.001	<0.001	0/0	100
TNT	Report	<0.001	<0.001	0/0	100
BOD	70	2.7	16.8	0/1	92
COD	150	14.2	73.5	0/0	100
TSS	90	1.5	35.6	0/0	100
Oil/Grease	15	2.7	3.9	0/0	100
pH <sup>a</sup>	6.0 Min. 10.0 Max.	7.2	9.4	0/0	100

<sup>a</sup> pH is measured in standard units and not in mg/L.  
<sup>b</sup> The maximum discharge limits are based on the daily maximum levels stated in the permit.  
<sup>c</sup> An exceedance is defined as a measured value above or below a permit limit. A violation is defined as a missing permit parameter such as failure to obtain a sample required by the permit.

### 8.5 Permit Violations

An unauthorized discharge is defined as either a discharge of untreated wastewater prior to treatment or a discharge to the environment at any location other than through a permitted outfall. During 2018, Pantex had no unauthorized discharges. However, Pantex did receive a monitoring violation in January for failing to report one weekly biochemical oxygen demand (BOD) effluent concentration. The BOD sample that Pantex collected and shipped to the laboratory exceeded the required hold time for that analysis. This issue occurred as the result of an extreme weather event that delayed the laboratory from analyzing the collected sample.

### 8.6 Conclusions

At Outfall 001A, the 2018 results for explosives, metals, BOD, chemical oxygen demand (COD), total suspended solids (TSS), and oil/grease were all within expected ranges and did not exceed permit limits. These values are consistent with the previous year. Prior to 2017, discharge to the on-site playa had not occurred in more than 10 years and therefore no long-term comparisons could be made.

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## Chapter 9 – Surface Water

*Data from the surface water program collected during 2018 were consistent with historical data from past monitoring activities, indicating that operations at the Pantex Plant did not adversely affect the surface water environment at Pantex. No significant changes were made to the surface water sampling program during the 2018 calendar year.*

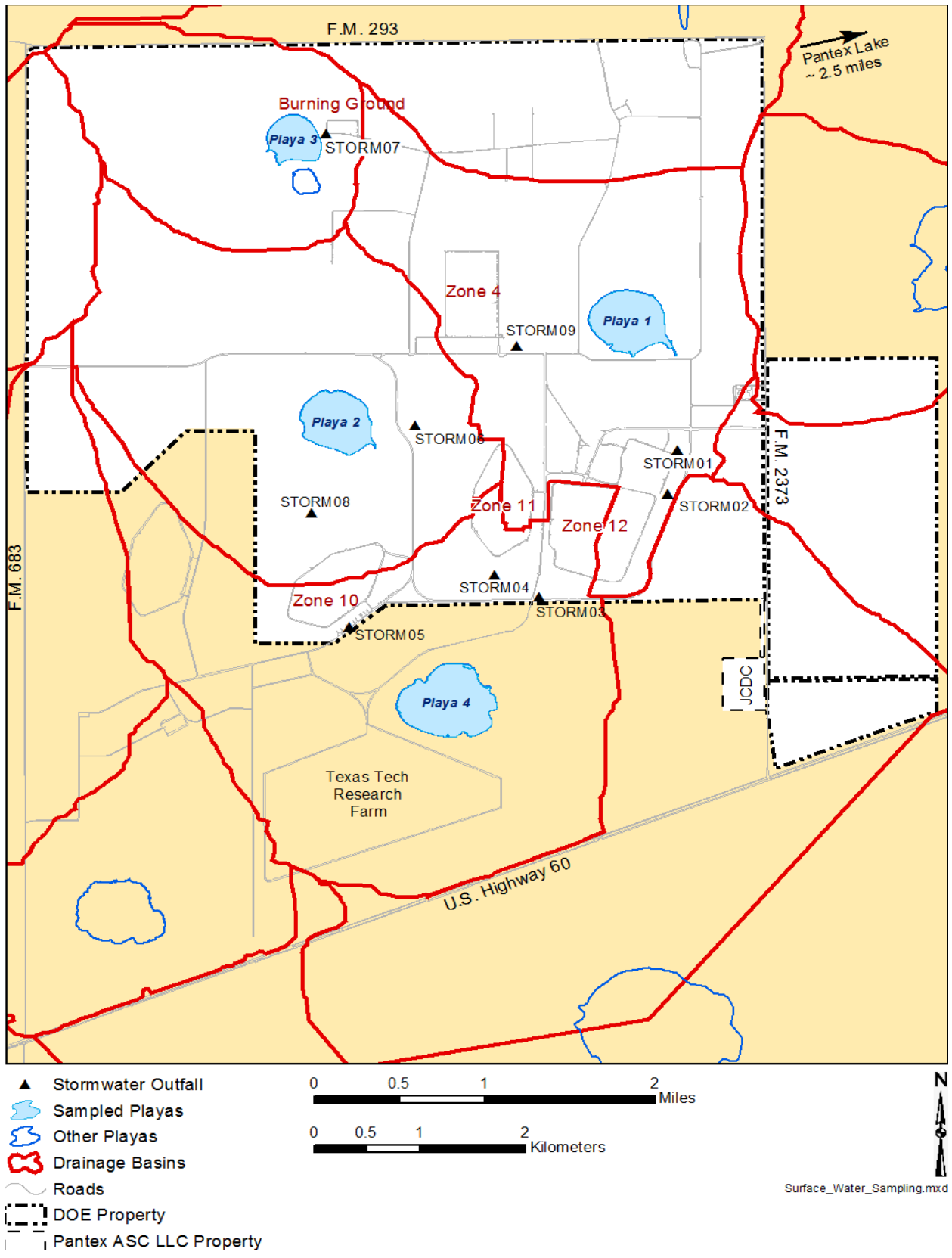
### 9.1 The Scope of the Program

The Pantex Plant is located in a region of relatively flat topography and with a semi-arid climate. Surface water represented by rivers or streams does not exist around the facility site and all surface water drains to isolated playa lakes. Playa lakes are shallow, ephemeral lakes that have clay-lined basins that fill periodically with surface water runoff (Figure 9.1). There are approximately 20,000 of these playas on the Southern High Plains. Playa lakes are extremely important hydrologic features that provide prime habitat for wildlife, especially waterfowl that winter in the Southern High Plains. Playas are also believed by most authorities to be an important source of recharge for the Ogallala Aquifer, the area's primary source of groundwater.

At Pantex, six playas are located on Department of Energy (DOE) property that is either owned or leased. Two of these are on property owned by Texas Tech University (TTU). Most of the surface drainage on the DOE lands flows via man-made ditches, natural drainage channels, or by sheet-flow to these on-site playa basins. Playa basins consist of the ephemeral lakes themselves and their surrounding watersheds. Figure 9.2 is a map of the Pantex Plant that shows the locations of the six playas at the facility site with their respective drainage basins (watersheds). Some storm water flows to off-site playas. These areas are at the outer periphery of the site and, for the most part, are a considerable distance from most Plant operations.



**Figure 9.1 – Mule Deer Grazing at a Playa Lake at Pantex Plant**



**Figure 9.2 – Drainage Basins, Playas, and Storm Water Outfalls at Pantex Plant**



Effluent from the wastewater treatment facility (WWTF) and storm water runoff from Zones 4, 12, and the northeastern portion of Zone 11 are permitted to discharge through ditches to Playa 1. Storm water runoff from northwestern portions of Zone 11 is channeled to Playa 2 via the ditch system. Storm water runoff from the Burning Ground flows, primarily as sheet-flow, into Playa 3. Storm water runoff from southern portions of Zones 10, 11, and 12 discharge into Playa 4 on TTU property. There are no Plant discharges to Pantex Lake, which is located on DOE property to the northeast of the main Plant property, or to Playa 5, which is on TTU property to the southwest. Both of these playas receive storm water runoff from surrounding pastures and agricultural operations.

## 9.2 Sampling Locations and Monitoring Results

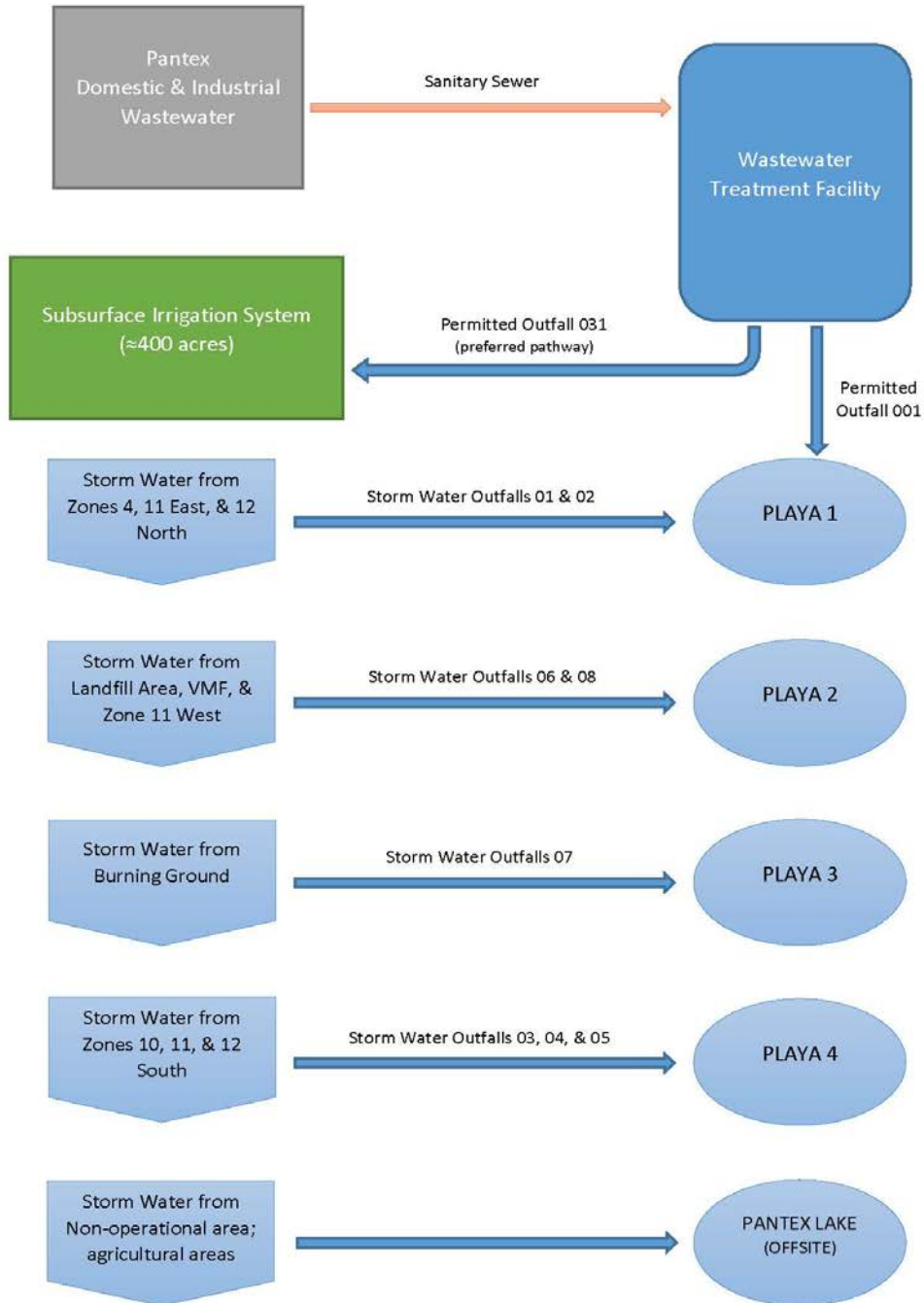
Surface water sampling occurs as a result of precipitation or discharge events. During 2018, sampling was conducted in accordance with permits issued by the Texas Commission on Environmental Quality (TCEQ) and the Data Quality Objective documents developed by Pantex media scientists. The TCEQ is the permitting authority for storm water discharges for waters in the state of Texas.

Storm water runoff at the Pantex Plant is sampled in accordance with the Texas Pollutant Discharge Elimination System (TPDES) Multi-Sector General Permit (MSGP) TXR050000 for storm water. During 2018, Pantex performed sampling in compliance with the MSGP issued in 2016. Pantex filed for coverage under the MSGP on November 7, 2016. General permits are typically for five years and the most recent MSGP expires in August of 2021. Storm water sampling locations, known as “outfalls,” are conveyances in which storm water accumulates and discharges. Locations have been selected based on their proximity to operational areas of the Plant.

The TCEQ has issued a five-year general permit (TPDES General Permit No. TXR150000), relating to storm water discharges associated with construction activities. The most recent general permit expires in March of 2023. There were two construction projects filed under the general permit in effect at Pantex at the end of 2018. These permits do not require analytical monitoring, but rely on best management practices, such as storm water pollution prevention plans, erosion controls, soil stabilization controls, and routine field inspections.

Pantex conducted storm water monitoring during 2018 at designated sampling locations in accordance with permit requirements. Environmental surveillance monitoring was also conducted at the playas as a best management practice. Appendix A lists the 2018 surface water analytes. In addition to routine sampling at four on-site playas, the Pantex Plant has eight storm water outfalls (shown on Figure 9.2). The flow diagram in Figure 9.3 depicts how storm water and treated industrial effluents discharge through the outfalls, and ultimately to the playas or the subsurface drip irrigation system on the Pantex site.

During 2018, sampling was conducted at seven storm water outfalls and three playas. Based on data from the National Weather Service – Amarillo, located northeast of Amarillo and southwest of the Pantex Plant, rainfall during 2018 was below normal with approximately 34.5 centimeters (cm) (13.6 inches [in]) for the year. The average annual rainfall for Amarillo is typically 50.1 cm (19.7 in).



**Figure 9.3 – Pantex Surface Water Schematic, 2018**

Storm water monitoring required by the TPDES MSGP in 2018 consisted of both visual monitoring and analytical monitoring. Both are required each year for the duration of the MSGP. Visual monitoring involves the examination of the physical properties of storm water including color, clarity, odor, oil sheen, solids, and foam. Visual samples taken and examined in 2018 appeared to be of good quality, and none showed any abnormalities based on the criteria specified in the MSGP. Analytical monitoring consisted of metals (Inland Water Quality Parameters [IWQPs]) listed in Title 30 of the Texas Administrative Code (TAC), Chapter 319 and sector-specific analytes required by the MSGP. Metal concentrations were compared with IWQPs. Sector-specific analytes are compared to benchmarks listed in the MSGP. Table 9.1 lists the results for metals from the storm water outfalls in 2018 and compares them with the IWQPs.

**Table 9.1 – Annual Storm Water Results (metals), 2018 (mg/L)**

	Outfall STORM01	Outfall STORM02	Outfall STORM03	Outfall STORM04	Outfall STORM05	Outfall STORM06	Outfall STORM07	Outfall STORM08	IWQP
<b>Arsenic</b>	<0.010	0.004	0.004	<0.010	<0.010	0.005	NA	0.011	<b>0.3</b>
<b>Barium</b>	0.095	0.200	0.210	0.130	0.033	0.435	NA	0.460	<b>4.0</b>
<b>Cadmium</b>	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	NA	0.0004	<b>0.2</b>
<b>Chromium</b>	0.006	0.011	0.013	0.009	<0.010	0.018	NA	0.040	<b>5.0</b>
<b>Copper</b>	0.009	0.009	0.012	0.010	0.006	0.020	NA	0.025	<b>2.0</b>
<b>Lead</b>	0.004	0.006	0.006	0.004	<0.003	0.012	NA	0.018	<b>1.5</b>
<b>Manganese</b>	0.078	0.130	0.140	0.150	0.015	0.340	NA	0.540	<b>3.0</b>
<b>Mercury</b>	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	NA	<0.0002	<b>0.01</b>
<b>Nickel</b>	0.005	0.008	0.010	0.010	<0.005	0.016	NA	0.029	<b>3.0</b>
<b>Selenium</b>	<0.005	<0.005	<0.005	<0.005	0.002	<0.005	NA	0.003	<b>0.2</b>
<b>Silver</b>	<0.002	0.003	<0.002	<0.002	<0.002	<0.002	NA	<0.002	<b>0.2</b>
<b>Zinc</b>	0.058	0.065	0.069	0.100	0.012	0.180	NA	0.110	<b>6.0</b>
IWQP = Inland Water Quality Parameter limits, 30 TAC 319.22 NA = Due to insufficient flow, a sample could not be collected and therefore data is not available. The values above are the average concentration from all samples, if more than one sample was collected during the year.									

### 9.2.1 Playa 1 Basin

Playa 1 is approximately 32 hectares (ha) (79.3 acres [ac]) in size and may receive treated wastewater effluent and storm water runoff from several small drainages. One of the drainages to the playa is associated with Plant operations (permitted Industrial Wastewater Outfall 001). The other drainages receive only storm water runoff from agricultural and operational areas. There are three drainages along the southern perimeter of Playa 1. All three include storm water from both agricultural and operational areas. Storm Water Outfalls 01 and 02 are located upstream in one of these drainages, which originates from some of the operational areas of Zone 12 North. The western edge of Playa 1 receives storm water runoff from the Zone 4 area. Two additional drainages transport storm water runoff from agricultural areas that are north of the playa. In 2018, playa monitoring was conducted at Playa 1 and both Storm Water Outfalls 01 and 02.

Technicians collected water samples from Playa 1 during the first and fourth quarters of 2018. Metal analyses were all consistent with historic levels found at the playa; all were below the IWQPs. All Volatile Organic Compounds (VOCs) and Semi-Volatile Organic Compounds (SVOCs) were below their respective Maximum Contaminant Levels (MCLs). Isotopic radiological analyses for uranium were below the Derived Concentration Standards (DCSs) for ingested water. Tritium was also below the DCS for ingested water and the more conservative MCL for drinking water standards. Explosives were detected in trace amounts. Both explosives (HMX and RDX) have been detected at these levels historically at Playa 1 and are legacy contaminants from operations conducted years ago.



**Figure 9.4 – Sampling Technicians at Playa 1**

**Storm Water Outfall 01 – Zone 12 North at BN5A.** BN5A is the Pantex Plant designation for the parking lot located north of operational areas, south of Playa 1, and west of agricultural areas. Flow through this outfall consists entirely of storm water and originates in the operational areas of Zone 12 North. Storm water flows northward from the outfall through the BN5A ditch and on northward, finally discharging into Playa 1.

MSGP-required monitoring at Storm Water Outfall 01 was conducted during the second, third, and fourth quarters of 2018. Activities included visual monitoring, pH evaluation, and metal analyses. Visual examinations showed no abnormalities based on the visual criteria described in the MSGP and pH was normal (6.0 – 9.0 s.u.). All metal concentrations were below IWQPs in 2018.

**Storm Water Outfall 02 – Zone 12 East at S. 15<sup>th</sup> Street.** Flow through this outfall includes storm water discharges from the eastern portions of Zone 12 South, which includes some of the operational areas of the Plant.

Permit-required monitoring at Storm Water Outfall 02 was conducted during the second quarter of 2018. Activities included visual monitoring, pH evaluation, and metal analyses. Visual examinations showed no abnormalities based on the visual criteria described in the MSGP and pH was normal. All metal concentrations were below IWQPs in 2018.

### **9.2.2 Playa 2 Basin**

Playa 2 is approximately 30 ha (74 ac) and receives only storm water runoff. Playa 2 receives runoff from the northwest side of Zone 11, the north side of Zone 10, and an area of agricultural fields that includes both pasture and cultivated fields. Two storm water outfalls, Outfalls 06 and 08, are within the Playa 2 basin. In 2018, monitoring was conducted at both Storm Water Outfalls 06 and 08. However, due to below average rainfall, monitoring was not conducted at Playa 2 during 2018.

**Storm Water Outfall 06 – Vehicle Maintenance Facility (VMF).** This outfall receives storm water runoff from an area that includes the VMF and portions of the parking lot around the VMF where vehicles awaiting maintenance are staged. The refueling stations for the Plant fleet are also located in this drainage area. The drainage area is primarily a paved lot utilized for parking and staging vehicles on the south side of the VMF.

Permit-required monitoring at Storm Water Outfall 06 was conducted during the second and fourth quarters of 2018. Activities included visual monitoring, pH testing, total petroleum hydrocarbons (TPHs) analysis, and metal analyses. Visual examinations showed no abnormalities based on the visual criteria contained in the MSGP and pH was normal. TPH results were below detection limits for all quarters, indicating that runoff from the VMF staging area and refueling operations is not contributing significant hydrocarbon pollutants to the environment. All metal concentrations were below IWQPs in 2018.

**Storm Water Outfall 08 – Landfill.** This outfall receives storm water runoff from an area within the Plant's active landfill. Runoff from active open landfill cells is retained within the cells. Storm water at this outfall consists of runoff over the landfill area, including runoff over closed cells. Storm water from this area eventually makes its way northward to Playa 2.

Permit-required monitoring at Storm Water Outfall 08 was conducted during the second, third, and fourth quarters of 2018. Activities included visual monitoring, pH evaluation, and metal analyses. Visual examinations showed no abnormalities based on the visual criteria described in the MSGP and pH was normal. All metal concentrations were below IWQPs in 2018. Sector-specific monitoring is required at this location and includes total suspended solids (TSS) and iron. TSS concentrations averaged 475.5 milligrams per liter (mg/L) for the year, which is above the benchmark level of 100 mg/L. Iron concentrations averaged 20.7 mg/L for the year, which is above the benchmark level of 1.3 mg/L. Both of these analytes have been above benchmark levels historically and are consistent with past results. These results are not indicative of a contaminant problem, but reflect the characteristics of storm water from this area. However, specific projects are planned for 2019 to reduce these levels. These projects include

reseeded less vegetated areas within the landfill area and replacing certain pieces of the sampling equipment that may be contributing to the total iron concentrations.

### 9.2.3 Playa 3 Basin

Playa 3, the smallest playa at the Pantex Plant, is approximately 22 ha (54 ac) and receives only storm water runoff from pastureland, cultivated fields, and portions of the Burning Ground. No well-defined ditches feed into the playa and runoff occurs primarily as sheet-flow. Storm Water Outfall 07 is located within the basin and is northeast of Playa 3 between the playa and the Pantex Burning Ground. In 2018, monitoring was conducted at Playa 3 during the first quarter.

Playa 3 was sampled for metals, VOCs, SVOCs, explosives, and radionuclides. Metal analyses during the year were all consistent with historic levels found at the playa and were all below the IWQPs. All VOCs and SVOCs were below their respective MCLs. Isotopic radiological analyses for uranium were below the DCSs for ingested water. Tritium was also below the DCS for ingested water and the more conservative MCL for drinking water standards. The explosive HMX was detected at trace amounts. This explosive has been detected at these levels historically at Playa 3 and is a legacy contaminant from operations conducted years ago.



**Figure 9.5 – Playa Sampling**

**Storm Water Outfall 07 – Burning Ground.** This outfall receives only storm water runoff from the Burning Ground operational area through a culvert under a circumferential road around the Burning Ground, a relatively small land area (Figure 9.6). For this reason, sampling at the outfall can be a challenge. Permit-required monitoring at Storm Water Outfall 07 was not conducted in 2018 due to insufficient discharge.



**Figure 9.6 – Storm Water Outfall 07; Playa 3 in the Background**

#### **9.2.4 Playa 4 Basin**

Playa 4 is approximately 46 ha (112.5 ac) and is located on property owned by TTU. The playa receives runoff primarily from pasture areas but does receive storm water runoff from portions of Zone 10 (through Storm Water Outfall 05), Zone 11 (through Storm Water Outfall 04), and Zone 12 South (through Storm Water Outfall 03). Discharges from Zone 12 are predominately storm water runoff; however, Fire Department personnel flush fire water storage tanks or test fire hydrants in sufficient volumes to reach Storm Water Outfall 03. In 2018, monitoring was conducted at Playa 4 and within the Playa 4 basin at Storm Water Outfalls 03, 04, and 05.

Playa 4 was sampled during the first quarter of 2018 for metals, VOCs, SVOCs, explosives, and radionuclides. Metal analyses during the year were all consistent with historic levels found at the playa and all were below the IWQPs. All VOCs, SVOCs, and explosives were below their respective MCLs. Isotopic radiological analyses for uranium were below the DCSs for ingested water. Tritium was also below the DCS for ingested water and the more conservative MCL for drinking water standards.

**Storm Water Outfall 03 – Zone 12 South.** Surface water monitored at this outfall is primarily storm water runoff from the west half of Zone 12 South. Periodically, water from the Plant’s fire protection system is discharged through this outfall. There are no industrial effluents discharged through this outfall. Permit-required monitoring at Storm Water Outfall 03 was conducted during the first and third quarters of 2018. Activities included visual monitoring, pH evaluation, and metal analyses. Visual examinations showed no abnormalities based on the visual criteria contained in the MSGP and the pH was normal. All metal concentrations were below IWQPs in 2018.

**Storm Water Outfall 04 – Zone 11 South.** Surface water monitored at this outfall is entirely storm water runoff from the southern half of Zone 11. Storm water from this area discharges southward through the outfall to Playa 4. There are no industrial effluents discharged through this outfall.

Permit-required monitoring at Storm Water Outfall 04 was conducted during the second, third, and fourth quarters of 2018. Activities included visual monitoring, pH evaluation, and metal analyses. Visual examinations showed no abnormalities based on the visual criteria described in the MSGP and pH was normal. All metal concentrations were below IWQPs in 2018.

**Storm Water Outfall 05 – Zone 10 South.** Surface water monitored at this outfall is entirely storm water runoff from the southern half of Zone 10. This area includes several contractor laydown yards. Some of the laydown yards contain double-walled aboveground storage tanks utilized for equipment refueling, material staging, and waste bins utilized primarily for scrap metal. Drainage in this vicinity is very flat and there are no industrial effluents discharged through this outfall.

Permit-required monitoring at Storm Water Outfall 05 was conducted during the second, third, and fourth quarters of 2018. Monitoring included visual monitoring, pH evaluation, and metal analyses. Visual examinations showed no abnormalities based on the visual criteria contained in the MSGP and pH was normal. All metal concentrations were below IWQPs in 2018.

#### **9.2.5 Pantex Lake**

Pantex Lake is the largest playa controlled by the DOE and is approximately 136 ha (337 ac) in size. The playa is located approximately 4 kilometers (2.5 miles) to the northeast from the main Plant site. Playa monitoring at Pantex Lake was discontinued in 2003, as it does not receive any runoff or discharges from the Pantex Plant.

### **9.3 Historical Comparisons**

Sampling results from storm water outfalls during 2018 showed no significant changes from the results of prior years. All monitoring results for metals are within the IWQP established by the State of Texas. TPH results are consistent with samples taken in the past. Sampling continues to indicate that storm water discharges at Pantex are of relatively good quality and that current operations at the Plant are not degrading storm water quality.

Playa lake sample results obtained during 2018 were very similar with past monitoring results. The playa data continues to support the premise that operations at the Pantex Plant are not negatively affecting the water quality of the playas.

### **9.4 Conclusions**

Monitoring storm water runoff at the Pantex Plant is performed as required by the TCEQ's general permits. The playa lakes at Pantex are monitored as a best management practice, but monitoring is often limited due to the semi-arid climate of the Texas Panhandle. Based on the data collected in 2018, surface water monitoring continues to support the premise that continuing operations are having no detrimental effect to the quality of the surface waters at the Pantex Plant.



## Chapter 10 – Soils

*Results of permit required soil monitoring are reported in this chapter. Results of soil monitoring conducted at the Pantex Burning Ground in 2018 were within established background comparison values. Results of soil monitoring conducted at the subsurface irrigation site were consistent with previous year's results.*

### 10.1 The Scope of the Program

This chapter presents the results of permit required soil sampling at the Pantex Plant during 2018. Surface soil samples were collected at the Pantex Burning Ground and analyzed for metals and explosives in accordance with Provision VI.C of the Pantex Plant Hazardous Waste Permit HW-50284 (Permit HW-50284) (TCEQa). Subsurface soil samples were also collected from four subsurface irrigation tracts and analyzed for various parameters in accordance with Provision V.O of the Pantex Plant Texas Land Application Permit (TLAP) WQ0004397000 (TCEQb). All samples were analyzed by off-site contract laboratories that meet Environmental Protection Agency (EPA) requirements as discussed in Chapter 13, Quality Assurance. Specific analytes are listed in Appendix A.

### 10.2 Burning Ground Surface Soil Sampling and Analysis

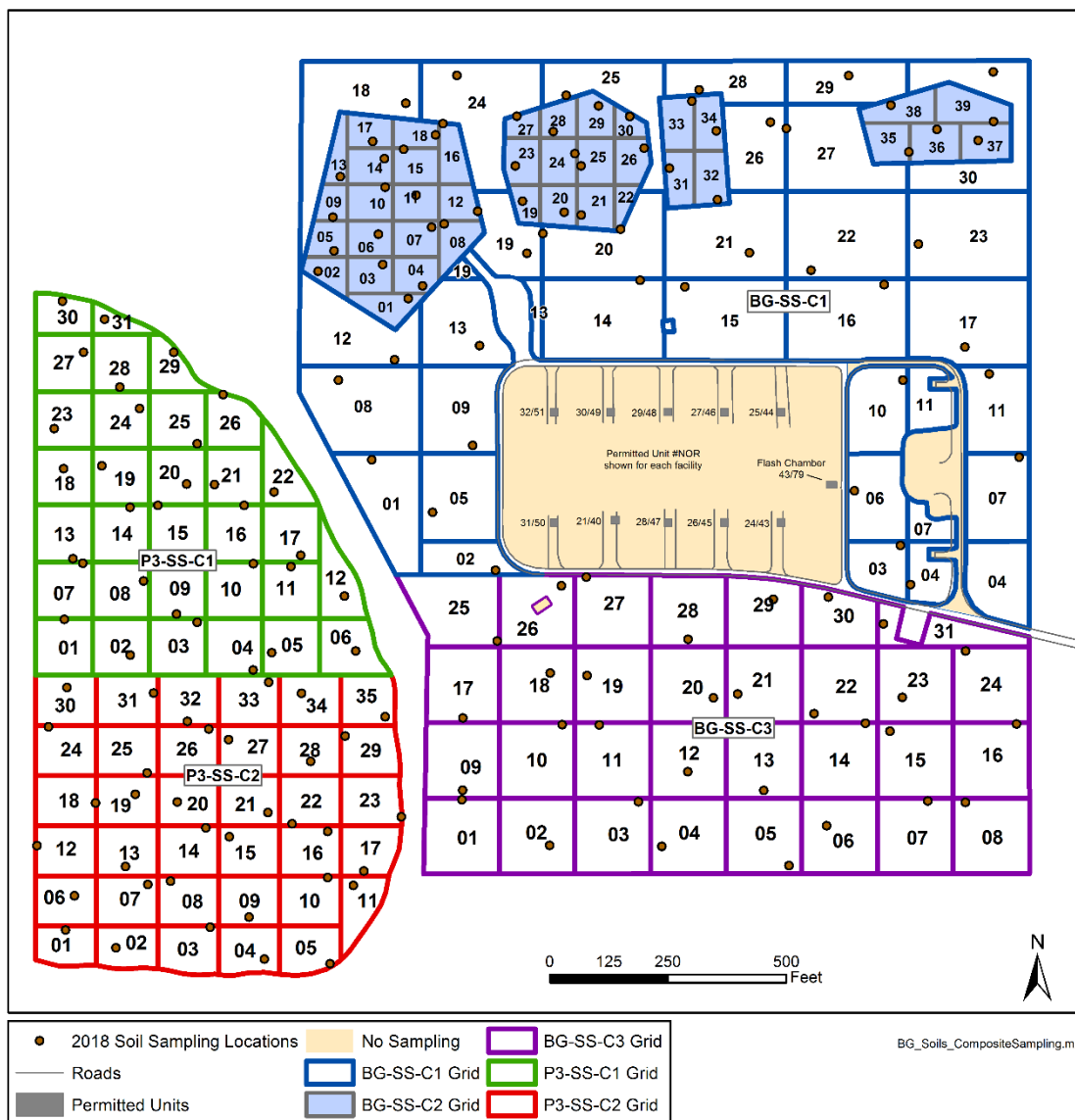
In 2018, surface soil samples were collected from two general landscape positions: playa bottoms and interplaya uplands. The characteristic soil types for these landscape positions are Randall clay in playas, and Pullman clay loam in the uplands. During 2018, soil was sampled at five on-site locations, representing three upland and two playa sampling areas associated with the Burning Ground. Samples were collected from a depth of 0 to 5 centimeters (cm) (0 to 2 inches [in]) from each associated grid area, and combined to form individual composite samples (Figure 10.1).

#### 10.2.1 Surface Soil Data Comparisons

Background comparison levels were determined by obtaining samples during three consecutive calendar quarters in 2006 for each monitoring parameter required by Permit HW-50284. If all analytical results of the background samples for a particular constituent at any location were less than the Method Detection Limit (MDL) identified in Permit HW-50284, the background value was set at the MDL or the Practical Quantitation Limit (PQL), whichever was greater. If less than 50 percent of the analytical results of the background samples for a particular constituent at any location were greater than the MDL, the background value was set at the highest detected value, the MDL, or the PQL, whichever was greater. If the analytical results of more than 50 percent of the background samples for a particular constituent at any location were greater than the MDL, the background value was calculated using a 95 percent upper tolerance limit with 99.9 percent coverage.

#### 10.2.2 Surface Soil Metals Analysis

Soil samples collected from the Burning Ground and Playa 3 were analyzed for 10 metals (See the “BG Soil” column in Appendix A). All of the metal concentrations observed in 2018 were below the established permit background concentrations and are reported in Tables 10.1 through 10.5 in this report.



**Figure 10.1 – Burning Ground Multi-Incremental Soil Sampling Locations for 2018**

**Table 10.1 – Calendar Year 2018 Monitoring Results at Location BG-SS-C1 (in mg/kg)**

Constituent (Code)	2018 Monitoring Result	Background Comparison Level	Monitoring Result Exceeds Background?
Silver (Ag)	1.2	8.4	No
Boron (B)	<3.3	50	No
Cadmium (Cd)	0.7	1	No
Cobalt (Co)	7.6	17.6	No
Chromium (Cr)	16	19.9	No
Copper (Cu)	20	67.3	No
2,4-dinitrotoluene (2,4-DNT)	<0.05	0.5	No
2,6-dinitrotoluene (2,6-DNT)	<0.05	0.5	No

Constituent (Code)	2018 Monitoring Result	Background Comparison Level	Monitoring Result Exceeds Background?
Mercury (Hg)	0.1	0.3	No
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetraazazine (HMX)	130	858.2	No
Nickel (Ni)	16	29.8	No
Lead (Pb)	18	54.8	No
Pentaerythritol tetranitrate (PETN)	<0.5	5	No
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	1.2	2.6	No
Triaminonitrobenzene (TATB)	2	23.3	No
1,3,5-trinitrobenzene (TNB135)	<0.05	10	No
Trinitrotoluene (TNT)	<0.05	10	No
Zinc (Zn)	69	160.6	No

**Table 10.2 – Calendar Year 2018 Monitoring Results at Location BG-SS-C2 (in mg/kg)**

Constituent (Code)	2018 Monitoring Result	Background Comparison Level	Monitoring Result Exceeds Background?
Silver (Ag)	<0.1	1	No
Boron (B)	<9	50	No
Cadmium (Cd)	0.3	1	No
Cobalt (Co)	7.2	8.8	No
Chromium (Cr)	15	16.2	No
Copper (Cu)	20	75.4	No
2,4-dinitrotoluene (2,4-DNT)	< 0.05	0.5	No
2,6-dinitrotoluene (2,6-DNT)	< 0.05	0.5	No
Mercury (Hg)	<0.018	0.2	No
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetraazazine (HMX)	< 0.05	1	No
Nickel (Ni)	15	24.5	No
Lead (Pb)	12	77.8	No
Pentaerythritol tetranitrate (PETN)	< 0.5	5	No
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	< 0.05	1	No
Triaminonitrobenzene (TATB)	< 0.05	3	No
1,3,5-trinitrobenzene (TNB135)	< 0.05	10	No
Trinitrotoluene (TNT)	< 0.05	10	No
Zinc (Zn)	96	317.3	No

**Table 10.3 – Calendar Year 2018 Monitoring Results at Location BG-SS-C3 (in mg/kg)**

Constituent (Code)	2018 Monitoring Result	Background Comparison Level	Monitoring Result Exceeds Background?
Silver (Ag)	0.4	1	No
Boron (B)	<3.2	50	No
Cadmium (Cd)	0.6	1	No
Cobalt (Co)	7.1	18.7	No
Chromium (Cr)	15	28.9	No
Copper (Cu)	19	53.8	No
2,4-dinitrotoluene (2,4-DNT)	< 0.05	0.5	No
2,6-dinitrotoluene (2,6-DNT)	< 0.05	0.5	No
Mercury (Hg)	<0.04	0.2	No
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetraazazine (HMX)	41	367.1	No
Nickel (Ni)	14	30.9	No
Lead (Pb)	21	54.9	No
Pentaerythritol tetranitrate (PETN)	< 0.5	5	No
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	1.1	1.8	No
Triaminonitrobenzene (TATB)	1.6	26.9	No
1,3,5-trinitrobenzene (TNB135)	< 0.05	10	No
Trinitrotoluene (TNT)	< 0.05	10	No
Zinc (Zn)	80	168	No

**Table 10.4 – Calendar Year 2018 Monitoring Results at Location P3-SS-C1 (in mg/kg)**

Constituent (Code)	2018 Monitoring Result	Background Comparison Level	Monitoring Result Exceeds Background?
Silver (Ag)	<0.1	1	No
Boron (B)	<9.5	50	No
Cadmium (Cd)	0.4	1	No
Cobalt (Co)	7.3	35.8	No
Chromium (Cr)	15	36.4	No
Copper (Cu)	16	44.2	No
2,4-dinitrotoluene (2,4-DNT)	<0.046	0.5	No
2,6-dinitrotoluene (2,6-DNT)	<0.046	0.5	No
Mercury (Hg)	<0.032	0.2	No
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetraazazine (HMX)	<0.046	1	No
Nickel (Ni)	15	43.4	No
Lead (Pb)	16	54.1	No
Pentaerythritol tetranitrate (PETN)	<0.46	5	No
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	<0.046	1	No
Triaminonitrobenzene (TATB)	<0.046	3	No
1,3,5-trinitrobenzene (TNB135)	<0.046	10	No

Constituent (Code)	2018 Monitoring Result	Background Comparison Level	Monitoring Result Exceeds Background?
Trinitrotoluene (TNT)	<0.046	10	No
Zinc (Zn)	63	129.8	No

**Table 10.5 – Calendar Year 2018 Monitoring Results at Location P3-SS-C2 (in mg/kg)**

Constituent (Code)	2018 Monitoring Result	Background Comparison Level	Monitoring Result Exceeds Background?
Silver (Ag)	<0.099	1	No
Boron (B)	<9.4	50	No
Cadmium (Cd)	<0.38	1	No
Cobalt (Co)	8.1	37.2	No
Chromium (Cr)	16	49.3	No
Copper (Cu)	16	43.9	No
2,4-dinitrotoluene (2,4-DNT)	<0.048	0.5	No
2,6-dinitrotoluene (2,6-DNT)	<0.048	0.5	No
Mercury (Hg)	<0.018	0.2	No
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetraazazine (HMX)	<0.048	1	No
Nickel (Ni)	16	53.2	No
Lead (Pb)	16	24.4	No
Pentaerythritol tetranitrate (PETN)	<0.48	5	No
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	<0.048	1	No
Triaminonitrobenzene (TATB)	<0.048	3	No
1,3,5-trinitrobenzene (TNB135)	<0.048	10	No
Trinitrotoluene (TNT)	<0.048	10	No
Zinc (Zn)	62	139.9	No

### 10.2.3 Surface Soil Explosives Analysis

Soil samples collected from the Burning Ground and Playa 3 were analyzed for eight explosive compounds (Appendix A). All sampling results for explosives in 2018 were below the established permit background concentrations as shown in Tables 10.1 through 10.5.

### 10.3 Subsurface Drip Irrigation System Soil Sampling and Analysis

In 2018, the annual TLAP subsurface drip irrigation system soil samples were collected from four locations, Tract 101, Tract 201, Tract 301, and Tract 401, with each tract representing 40.5 hectares (ha) (100 acres [ac]). Representative soil samples were collected from the root zones of the irrigation areas using random sampling and composite techniques. Each composite sample represented no more than 16.2 ha (40 ac) with no less than two soil cores representing each composite sample. Subsamples were composited by like sampling depth and soil type, and individually at depths of 0 to 30 cm (0 to 12 in) and 30 to 61 cm (12 to 24 in) for analysis and reporting (Figure 10.2). These composite samples were analyzed for agricultural parameters, reactivity, two high explosives, and one semi-volatile organic compound (SVOC). See the TLAP Soil column in Appendix A for specific analytes.

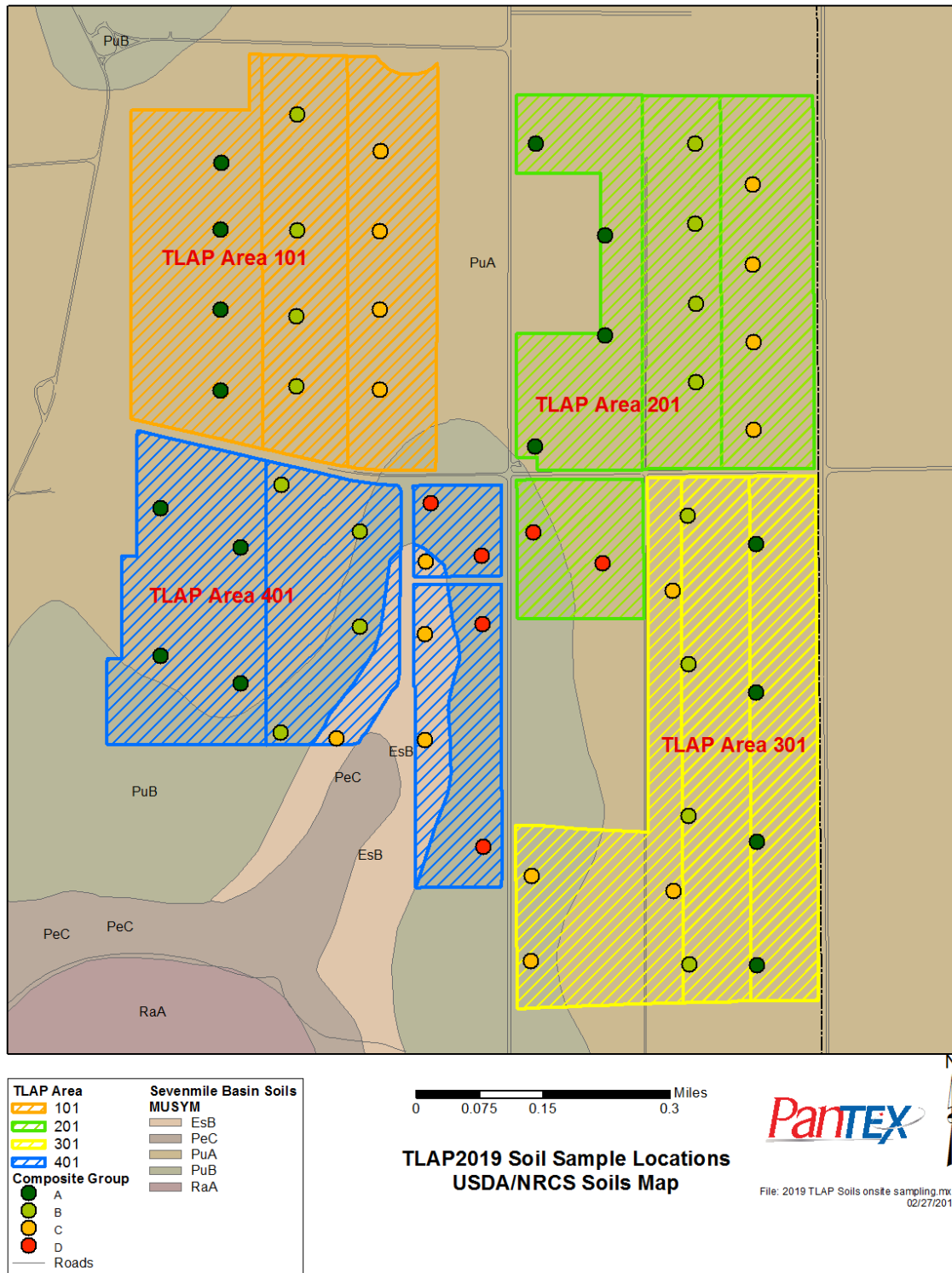


Figure 10.2 – TLAP Soil Sampling Locations for 2018

### 10.3.1 Subsurface Drip Irrigation System Soil Sampling Results

The 2018 subsurface soil sampling results for high explosives, reactivity, and the one SVOC were all non-detects. The results of the agricultural parameters (nutrient parameters analyzed on a plant available or extractable basis) are presented in Tables 10.6 through 10.9. The TLAP subsurface soil sampling results are reported annually to the Texas Commission on Environmental Quality (TCEQ) as report only information, with no comparison values. The agricultural parameters are also used for decision making regarding the addition of nutrient amendments to the agricultural soils.

**Table 10.6 – 2018 TLAP Soil Results from Tract 101**

Analyte (Agricultural Parameters)	Tract 101A Measured Value		Tract 101B Measured Value		Tract 101C Measured Value		Unit of Measurement
	Depth (in)		Depth (in)		Depth (in)		
	12	24	12	24	12	24	
pH (2:1 ratio soil pH)	7.6	8.2	7.8	8.1	7.7	8.1	pH Units
Total Nitrogen	764	652.2	774	692.5	961	570.7	mg/kg
Nitrate (as Nitrogen)	4.3	2.2	4.2	2.5	1	0.7	mg/kg
Total Kjeldahl Nitrogen	760	650	770	690	960	570	mg/kg
Ortho Phosphate (Plant-available)	11	5	8	4	12	4	mg/kg
Calcium (Plant-available)	3281	6560	3424	6073	3319	6017	mg/kg
Magnesium (Plant-available)	742	816	747	748	693	794	mg/kg
Sodium (Plant-available)	137	165	168	170	128	149	mg/kg
Sodium Absorption Ratio (SAR)	1.7	2	1.8	2	1.6	2	Percent
Potassium (Plant-available)	573	328	535	1676	575	258	mg/kg
Conductivity (Sat Paste ECe)	0.65	0.71	0.65	0.75	0.67	0.71	µmho/cm
Calcium (Water-soluble)	56	48	52	55	58	48	mg/L
Magnesium (Water-soluble)	15	19	14	18	17	17	mg/L
Sodium (Water-soluble)	54	64	58	68	54	64	mg/L
Sulfur (Plant-available)	16	11	17	15	16	15	mg/kg

**Table 10.7 – 2018 TLAP Soil Results from Tract 201**

Analyte (Agricultural Parameters)	Tract 201A Measured Value		Tract 201B Measured Value		Tract 201C Measured Value		Tract 201D Measured Value		Unit of Measurement
	Depth (in)		Depth (in)		Depth (in)		Depth (in)		
	12	24	12	24	12	24	12	24	
pH (2:1 ratio soil pH)	7.9	8.2	8	8.2	7.9	8.2	7.7	8.1	pH Units
Total Nitrogen	950.1	597.2	849.2	565.6	797.4	634.3	1008	646	mg/kg
Nitrate (as Nitrogen)	10.1	7.2	9.2	5.6	7.4	4.3	8	6	mg/kg
Total Kjeldahl Nitrogen	940	590	840	560	790	630	1000	640	mg/kg
Ortho Phosphate (Plant-available)	8	6	5	5	5	5	19	6	mg/kg

Analyte (Agricultural Parameters)	Tract 201A Measured Value		Tract 201B Measured Value		Tract 201C Measured Value		Tract 201D Measured Value		Unit of Measurement
	Depth (in)		Depth (in)		Depth (in)		Depth (in)		
	12	24	12	24	12	24	12	24	
Calcium (Plant-available)	3376	6087	5131	6092	3898	6093	4144	6043	mg/kg
Magnesium (Plant-available)	763	820	732	733	672	751	693	741	mg/kg
Sodium (Plant-available)	163	172	160	158	166	175	133	149	mg/kg
Sodium Absorption Ratio (SAR)	1.9	2.1	3	2.1	2	2.1	1.6	1.7	Percent
Potassium (Plant-available)	385	328	397	291	348	298	410	287	mg/kg
Conductivity (Sat Paste ECe)	0.61	0.57	0.66	0.64	0.64	0.64	0.64	0.54	µmho/cm
Calcium (Water-soluble)	45	38	118	51	50	46	58	44	mg/L
Magnesium (Water-soluble)	13	12	37	14	15	15	16	15	mg/L
Sodium (Water-soluble)	55	57	146	67	62	66	55	51	mg/L
Sulfur (Plant-available)	15	11	23	10	18	13	19	9	mg/kg

Table 10.8 – 2018 TLAP Soil Results from Tract 301

Analyte (Agricultural Parameters)	Tract 301A Measured Value		Tract 301B Measured Value		Tract 301C Measured Value		Unit of Measurement
	Depth (in)		Depth (in)		Depth (in)		
	12	24	12	24	12	24	
pH (2:1 ratio soil pH)	7.7	8.3	7.9	8.3	7.5	8.2	pH Units
Total Nitrogen	822.8	603.1	761.8	601.2	802.4	601	mg/kg
Nitrate (as Nitrogen)	2.8	3.1	1.8	1.2	2.4	1	mg/kg
Total Kjeldahl Nitrogen	820	600	760	600	800	600	mg/kg
Ortho Phosphate (Plant-available)	23	4	9	5	25	5	mg/kg
Calcium (Plant-available)	2909	5798	4455	7506	3034	6811	mg/kg
Magnesium (Plant-available)	711	813	848	902	889	937	mg/kg
Sodium (Plant-available)	140	181	167	192	121	173	mg/kg
Sodium Absorption Ratio (SAR)	1.7	2.2	1.6	1.9	1.5	1.7	Percent
Potassium (Plant-available)	353	224	480	342	502	344	mg/kg
Conductivity (Sat Paste ECe)	0.58	0.7	0.13	0.65	0.55	0.2	µmho/cm



Analyte (Agricultural Parameters)	Tract 301A Measured Value		Tract 301B Measured Value		Tract 301C Measured Value		Unit of Measurement
	Depth (in)		Depth (in)		Depth (in)		
	12	24	12	24	12	24	
Calcium (Water-soluble)	74	52	38	51	54	35	mg/L
Magnesium (Water-soluble)	20	15	10	15	17	10	mg/L
Sodium (Water-soluble)	63	69	43	59	48	44	mg/L
Sulfur (Plant-available)	15	9	22	11	15	8	mg/kg

Table 10.9 – 2018 TLAP Soil Results from Tract 401

Analyte (Agricultural Parameters)	Tract 401A Measured Value		Tract 401B Measured Value		Tract 401C Measured Value		Tract 401D Measured Value		Unit of Measurement
	Depth (in)		Depth (in)		Depth (in)		Depth (in)		
	12	24	12	24	12	24	12	24	
pH (2:1 ratio soil pH)	7.9	8.4	7.9	8.3	8.1	8.2	7.8		pH Units
Total Nitrogen	881.4	540.2	952.3	610.7	921.3	621.2	890.7		mg/kg
Nitrate (as Nitrogen)	1.4	0.2	2.3	0.7	1.3	1.2	0.7		mg/kg
Total Kjeldahl Nitrogen	880	540	950	610	920	620	890		mg/kg
Ortho Phosphate (Plant-available)	9	5	13	4	27	10	14		mg/kg
Calcium (Plant-available)	3124	6457	4006	7742	5039	7031	3620		mg/kg
Magnesium (Plant-available)	765	874	614	792	573	793	690		mg/kg
Sodium (Plant-available)	131	150	83	120	83	137	247		mg/kg
Sodium Absorption Ratio (SAR)	1.5	2.9	1.2	1.3	1.2	1.4	1.2		Percent
Potassium (Plant-available)	681	769	2357	447	578	471	485		mg/kg
Conductivity (Sat Paste ECe)	0.5	0.81	0.49	0.42	0.5	0.48	0.47		µmho/cm
Calcium (Water-soluble)	53	82	61	46	61	51	56		mg/L
Magnesium (Water-soluble)	13	18	14	9	11	12	12		mg/L
Sodium (Water-soluble)	46	112	39	37	38	43	38		mg/L
Sulfur (Plant-available)	15	9	19	6	23	11	17		mg/kg

#### **10.4 Conclusions**

On-site Burning Ground surface soil monitoring results for 2018 were within the concentration ranges of the established background levels. Results of soil monitoring conducted at the subsurface irrigation for 2018 were consistent with previous year's results.

## Chapter 11 – Fauna

*Radionuclide concentrations in faunal samples (black-tailed prairie dogs and cottontail rabbits) were compared to historical values and values observed in samples from control locations. Comparisons indicated no detrimental effects from Plant operations in 2018.*

### 11.1 The Scope of the Program

Faunal surveillance is complementary to air, flora, and water monitoring in assessing potential short- and long-term effects of operations at the Pantex Plant on the environment. Animals at the Pantex Plant were sampled to determine whether Plant activities had an impact on them. Black-tailed prairie dogs and cottontail rabbits were the species selected for sampling because they interact with both primary (air, water) and secondary (vegetation) environmental media also being analyzed.

### 11.2 Radiological Surveillance in Fauna

Radionuclide surveillance of fauna at Pantex was scheduled semi-annually at nine on-site locations and one control location. They were the Burning Ground, Firing Site 4 (FS-4), Zone 4, Zone 12 South, northwest of Building 12-36, west of Zone 4, Playa 2, Playa 3, Zone 8, and a control site, Buffalo Lake National Wildlife Refuge (BLNWR) near Umbarger, Texas (Randall County). BLNWR was chosen as the control site because populations there are far enough from the Pantex Plant (66 kilometers/41 miles) to be unaffected by Plant operations, and more so than on private lands, affords a dependable availability of prairie dogs, cottontails, and property access. In 2018, prairie dogs were only available west of Zone 4, in Zone 8, near Playa 2, at FS-4, and at BLNWR. Cottontails were secured from Zone 4 and BLNWR.

Sample animals are live-trapped, humanely euthanized, and shipped to the analytical lab. Whole-body composites are prepared for determination of tritium, uranium-233/234 (U-233/234), and uranium-238 (U-238) activities. These radionuclides are associated with Pantex activities, but are also naturally occurring in Pantex soils.

Analytical results of the 2018 faunal sampling are presented in Table 11.1 (prairie dogs) and 11.2 (cottontails), as are historical means (prairie dogs, 1997-2000; cottontails, 2007-2010). The range of years established as historical data is consistent among the soil, flora, and fauna media programs, allowing for comparison. The ranges represent the first four years of overlap of sampling under the three programs. Sampling of cottontails began in 2007.

Sixteen prairie dogs and six cottontails were sampled during 2018. Results for prairie dogs and cottontails were similar to or less than historic data. Most results for prairie dogs were below minimal detection activity (MDA; 85.4%), as were all of the cottontails.

### 11.3 Conclusions

Radionuclide concentrations in fauna samples (prairie dogs and cottontails) were comparable to values observed in samples from control locations and historical data. Thus, results indicate that the fauna monitoring program at the Plant continues to provide information that supports the hypothesis that current operations do not have a detrimental effect on the quality of the environment at or near the Pantex Plant.

**Table 11.1 – Tritium, U-233/234, and U-238 in Prairie Dogs in 2018, in pCi/g Dry Weight**

Location	No. of Samples (# ≤ MDA)	Maximum <sup>a</sup>	Minimum <sup>a</sup>	Mean ± Std. <sup>b</sup>	No. of Samples in 1997-2000	1997-2000 <sup>c</sup> Mean ± Std.
<b>Tritium</b>						
Zone 4 (W)	4 (4)	-0.042 ± 0.350	-0.154 ± 0.341	-0.101 ± 0.046	10	0.012 ± 0.279
Zone 8	4 (4)	0.087 ± 0.377	-0.278 ± 0.335	-0.027 ± 0.169	14	0.017 ± 0.065
Playa 2	4 (4)	-0.031 ± 0.404	-0.237 ± 0.393	-0.118 ± 0.090	14	0.055 ± 0.136
Burning Ground	--	--	--	--	11	0.152 ± 0.300
Playa 3	--	--	--	--	14	0.019 ± 0.070
FS-4	1 (1)	0.004 ± 0.333	--	--	8	0.313 ± 0.321
12-36	--	--	--	--	10	-0.065 ± 0.365
Buffalo Lake <sup>d</sup>	3 (3)	0.019 ± 0.372	-0.426 ± 0.360	-0.133 ± 0.254	14	0.015 ± 0.055
<b>U-233/234</b>						
Zone 4 (W)	4 (4)	0.024 ± 0.014	0.005 ± 0.011	0.018 ± 0.009	10	0.018 ± 0.011
Zone 8	4 (2)	0.051 ± 0.017	0.022 ± 0.015	0.036 ± 0.015	14	0.012 ± 0.019
Playa 2	4 (3)	0.043 ± 0.017	0.019 ± 0.010	0.031 ± 0.012	14	0.013 ± 0.022
Burning Ground	--	--	--	--	11	0.018 ± 0.040
Playa 3	--	--	--	--	14	0.020 ± 0.022
FS-4	1 (1)	0.012 ± 0.013	--	--	8	0.017 ± 0.018
12-36	--	--	--	--	10	0.021 ± 0.025
Buffalo Lake	3 (3)	0.015 ± 0.011	0.009 ± 0.009	0.012 ± 0.003	14	0.017 ± 0.025
<b>U-238</b>						
Zone 4 (W)	4 (4)	0.022 ± 0.015	0.012 ± 0.010	0.017 ± 0.004	10	0.012 ± 0.008
Zone 8	4 (2)	0.042 ± 0.015	0.013 ± 0.008	0.027 ± 0.014	11	0.010 ± 0.021
Playa 2	4 (2)	0.037 ± 0.016	0.017 ± 0.010	0.026 ± 0.009	11	0.009 ± 0.009
Burning Ground	--	--	--	--	9	0.013 ± 0.026
Playa 3	--	--	--	--	11	0.011 ± 0.015
FS-4	1 (1)	0.016 ± 0.012	--	--	8	0.012 ± 0.015
12-36	--	--	--	--	10	0.009 ± 0.006
Buffalo Lake	3 (3)	0.017 ± 0.009	0.000 ± 0.012	0.010 ± 0.009	11	0.015 ± 0.029

<sup>a</sup> Counting error at 95 percent confidence level. The second of each paired set of values in the “Maximum” and “Minimum” columns is the “error.”

<sup>b</sup> Standard deviation. (see definition in glossary.)

<sup>c</sup> Historical data period for Zone 4 (W), FS-4 and 12-36 is 2007-2010 due to these being newer sampling areas.

<sup>d</sup> Prairie dogs unavailable.

<sup>e</sup> Negative values indicate results below the (statistically determined) background level for the counting system used at the analytical laboratory.

<sup>f</sup> Control site.

**Table 11.2 – Tritium, U-233/234, and U-238 in Cottontail Rabbits in 2018, in pCi/g Dry Weight**

Location	No. of Samples (# ≤ MDA)	Maximum <sup>a</sup>	Minimum <sup>a</sup>	Mean ± Std. <sup>b</sup>	No. of Samples 2007-2010 <sup>c</sup>	2007-2010 Mean ± Std.
<b>Tritium</b>						
Zone 4	4 (4)	0.025 ± 0.361	-0.469 ± 0.332	-0.175 ± 0.224	12	0.087 ± 0.274
Zone 12 South	-- <sup>d</sup>	--	--	--	13	0.346 ± 0.397
Buffalo Lake <sup>e</sup>	2 (2)	0.049 ± 0.427	-0.263 ± 0.346	-0.107 ± 0.220	10	0.175 ± 0.260
<b>U-233/234</b>						
Zone 4	4 (4)	0.017 ± 0.012	0.006 ± 0.010	0.012 ± 0.005	12	0.014 ± 0.013
Zone 12 South	--	--	--	--	13	0.012 ± 0.008
Buffalo Lake	2 (2)	0.020 ± 0.011	0.014 ± 0.010	0.017 ± 0.004	10	0.042 ± 0.031
<b>U-238</b>						
Zone 4	4 (4)	0.020 ± 0.010	0.006 ± 0.008	0.011 ± 0.007	12	0.009 ± 0.011
Zone 12 South	--	--	--	--	13	0.005 ± 0.005
Buffalo Lake	2 (2)	0.018 ± 0.010	0.011 ± 0.009	0.015 ± 0.005	10	0.029 ± 0.022

<sup>a</sup> Counting error at 95 percent confidence level. The second of each paired set of values in the “Maximum” and “Minimum” columns is the “error.”

<sup>b</sup> Standard deviation. (see definition in glossary.)

<sup>c</sup> Historical data period for Zone 4 (W), FS-4 and 12-36 is 2007-2010 due to these being newer sampling areas.

<sup>d</sup> Prairie dogs unavailable.

<sup>e</sup> Negative values indicate results below the (statistically determined) background level for the counting system used at the analytical laboratory.

<sup>f</sup> Control site.

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## Chapter 12 – Flora

*Radionuclide concentrations in vegetation samples, which included both native vegetation and crops from on-site and off-site locations, were compared to historical values and values observed in samples from control locations. These comparisons indicated no adverse effects from Plant operations in 2018.*

### 12.1 The Scope of the Program

Flora surveillance is complementary to air, fauna, and surface water monitoring in assessing potential short- and long-term effects of operations at the Pantex Plant on the environment. Radionuclide analyses were performed on both native vegetation and crops. Native vegetation species on the southern High Plains consist primarily of prairie grasses and forbs. Crops are defined as any agricultural product harvested or gathered for animal or human food, including garden produce, forage, or fiber. Because vegetation species accumulate contaminants differently under varied growing conditions, data interpretation is complex, and results must be evaluated in concert with other environmental media.

### 12.2 Radiological Surveillance of Vegetation

Surveillance of vegetation and crops at on-site and off-site locations monitors potential impacts from current Plant operations at the Burning Ground, the Firing Sites, Zone 12, off-site at the immediate perimeter of the Plant site and out to approximately eight kilometers (five miles) from the center of the Plant (Figures 12.1 and 12.2). Rotational crops are also sampled (Figure 12.3). Background samples of crop and native vegetation species were collected from control locations at Bushland, Texas. The control locations were selected because of their distance and direction from the Pantex Plant, ease of access, lack of industrial activity, and the presence of typical Southern High Plains vegetation.

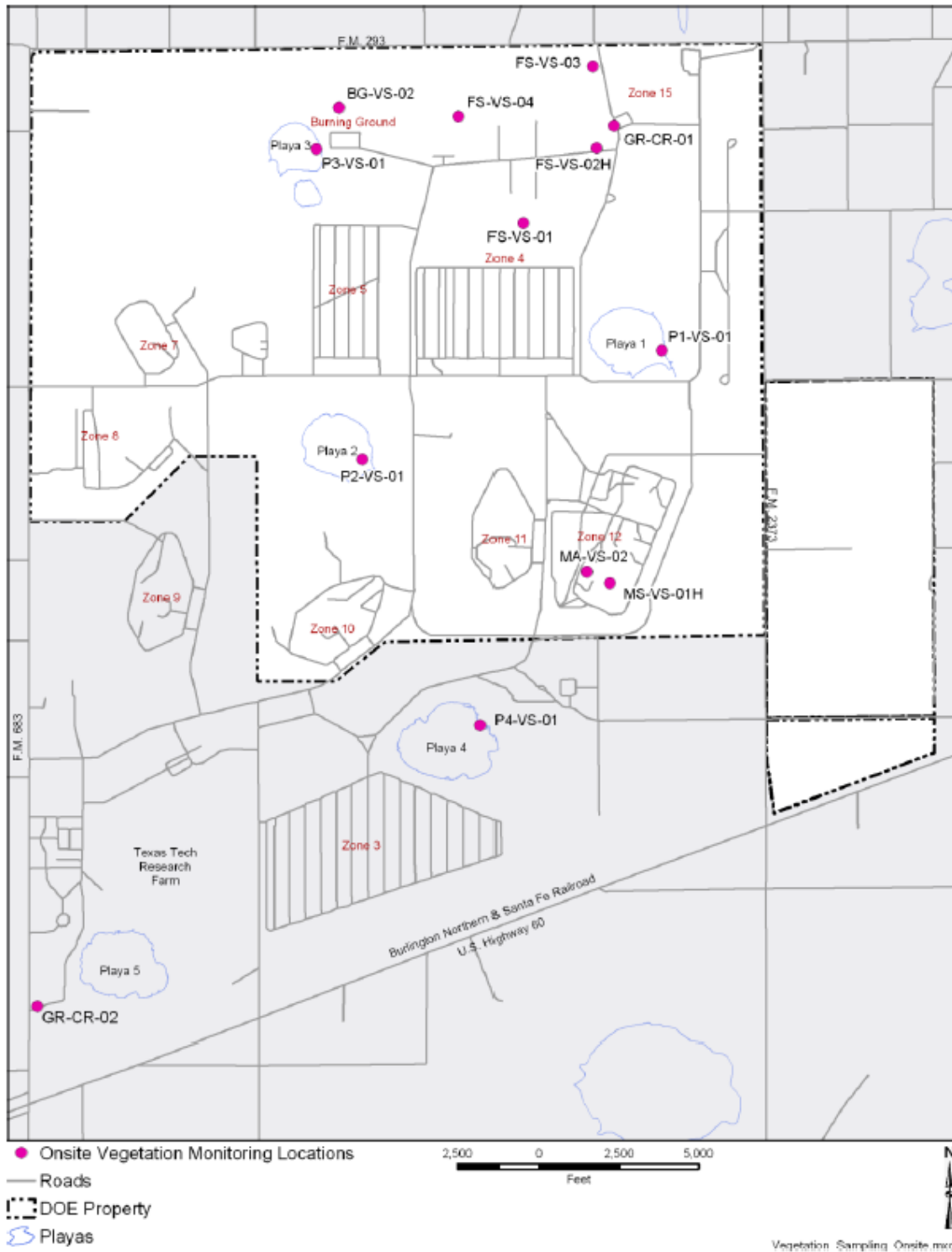
Sampling locations are approximately 10-meter (33 feet) diameter circles from which vegetation is collected, when it is available. Drought, cultivation, excessive grazing, prescribed burning, and/or mowing may limit vegetation availability during certain parts of the growing season. Vegetation samples were analyzed for tritium, uranium-233/234 (U-233/234), and uranium-238 (U-238). Analytical data were corrected for moisture content and reported in picocuries per gram (pCi/g) dry weight. The on-site and off-site data were compared to those from the control locations and six-year mean values, where possible, to identify and interpret differences. Although the Department of Energy (DOE) limits the dose to terrestrial plants to one rad/day (see Chapter 4), there are currently no limiting concentrations for tritium or uranium in vegetation.

#### 12.2.1 Native Vegetation

Native vegetation samples, primarily consisting of stem and leaves from grasses and forbs were collected from one control, 11 on-site, and nine off-site locations. Samples were collected during the growing season, no more frequently than once per month in 2018. The presence of adequate vegetation for sampling in 2018 was difficult due to lower than normal rainfall during the growing season.

Tritium results from 94 percent of on-site and off-site sample locations were at or below minimum detection activity (MDA) levels with the exception of two locations (P3-VS-01 and FS-VS-03). The mean results of tritium analyses at all other on-site and off-site locations were similar to the results at the control location OV-VS-20 (Figure 12.2) and the historical mean (calendar years 1997-2017).

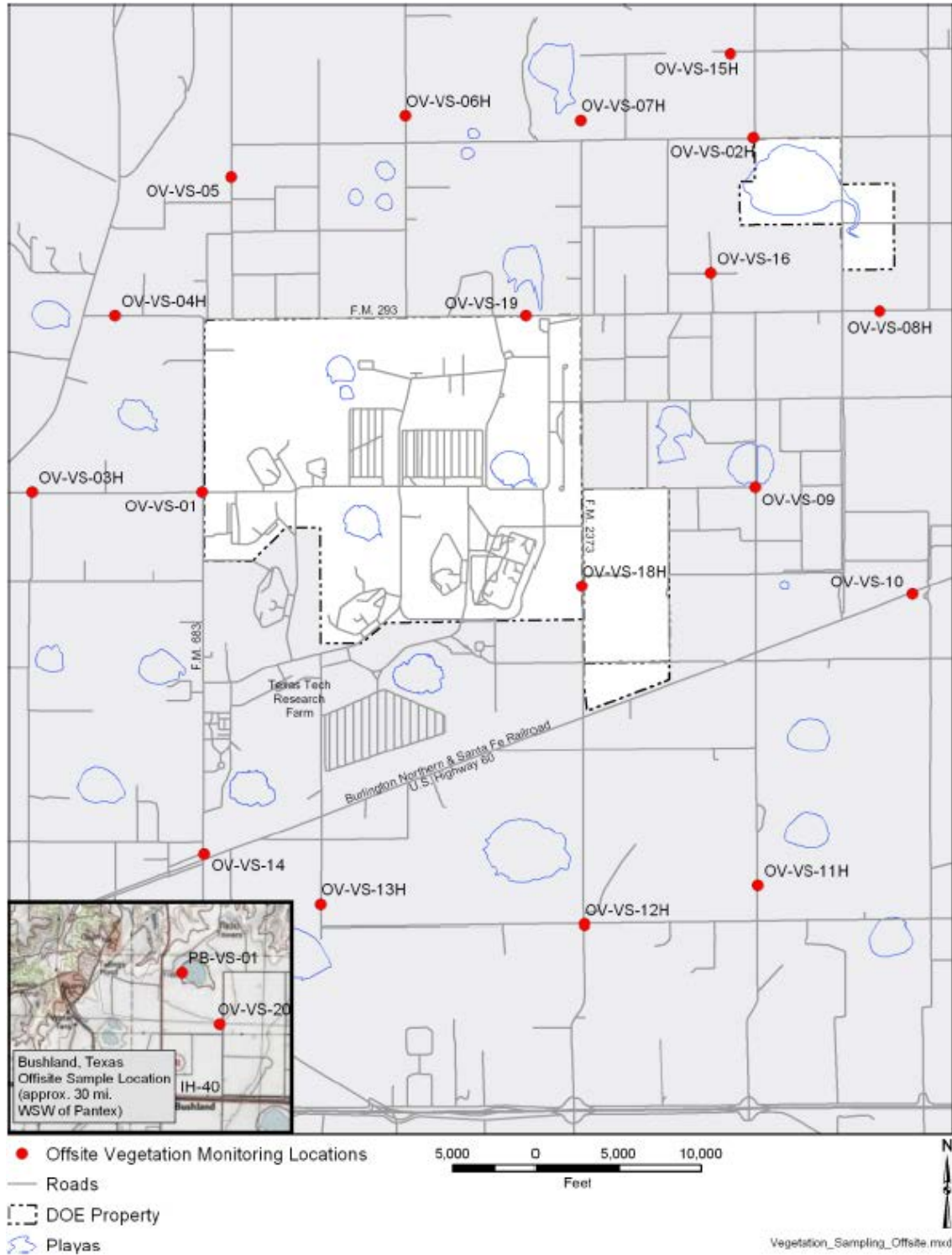
Results from sampling events during the year starting in late June yielded similar values for tritium when compared to the control location during the year and were also equivalent to the historical mean results from the control location. The P3-VS-01 sample location had a non-detection at a negative  $-0.15 \pm 0.56$  the month before the higher result.



**Figure 12.1 – On-site Vegetation Monitoring Locations**

NOTE: On Figures 12.1, 12.2, and 12.3, note the following designations: B- Bushland, BG- Burning Ground, CR- crops, FS- Firing Sites, GR- garden produce, MA- Material Access Area, O- off-site, P- playa, S- sample, SO- grain sorghum, TL-Texas Land Application Permit, V-vegetation, and WW- winter wheat. Any sample location with H behind it is historical and is not currently being sampled.





**Figure 12.2 – Off-site Vegetation Monitoring Locations**

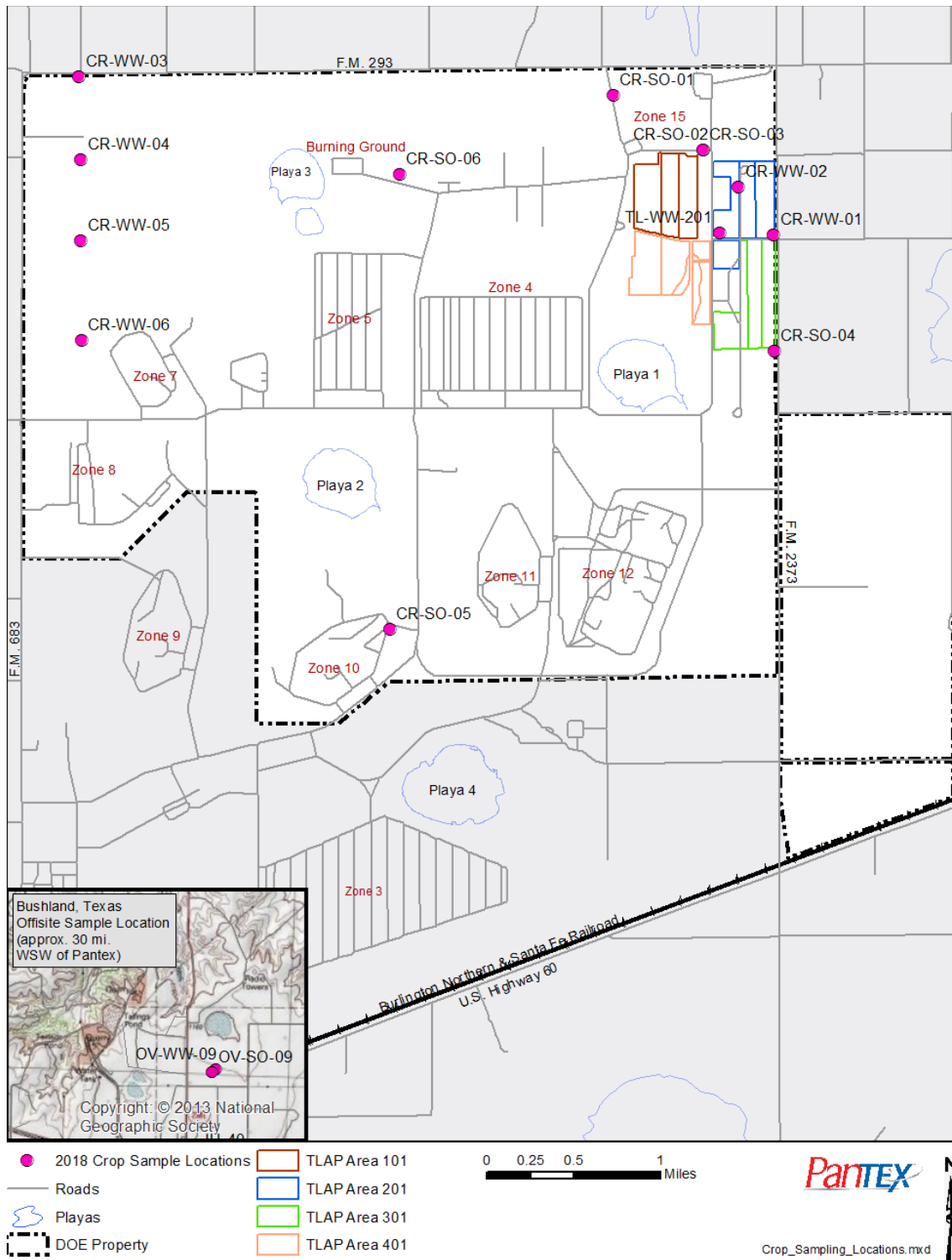


Figure 12.3 – Crop Monitoring Locations for 2018

The two native vegetation samples with the highest activity in 2018 were all time historical highs but were not significantly different than the control location when comparing the mean and one standard deviation (see Table 12.1).

**Table 12.1 – Native Vegetation Comparison of Tritium 2018, Control Location, and All Time Highs**

Sampling Location	Tritium pCi/g + Error (2018)	Tritium Mean + 1 St. Dev. (2018)	Sampling Location	Tritium pCi/g + Error (all-time highs and date)
P3-VS-01	11.90±2.21	4.23±6.67	OV-VS-15	4.28±0.42 (2008)
FS-VS-03	2.41±0.89	1.19±1.13	P3-VS-01	1.45±0.23 (2010)
OV-VS-20 (control)	0.18±0.46	0.09±0.07	OV-VS-20 (control)	0.39±0.14 (2010)

The percentage of vegetation samples at or below the MDA level for U-233/234 and U-238 in all vegetation were 97 and 94 percent, respectively. Usually the percentage of vegetation samples at or below the MDA level is near 50 percent. The measured values in general for locations for the year were not significantly elevated and were comparable to the control location and historical data (Table 12.2). Results for all on-site and off-site locations were consistent with those found in previous years. Concentration of U-233/234 and U-238 in native vegetation indicates that no uptake of U-233/234 and U-238 into vascular plants has occurred.

**Table 12.2 – Native Vegetation Comparison of U-238 2018 and the Control Location**

Sampling Location	U-238 pCi/g	U-238 Mean + 1 St. Dev.
MA-VS-02	0.08±0.05	0.040±0.035
P4-VS-01	0.05±0.04	0.025±0.020
OV-VS-20 (control)	0.03±0.03	0.009±0.014

### 12.2.2 Crops

Crop surveillance enables evaluation of potential impacts from Plant operations on humans and livestock. Samples consisting of stems and leaves of dryland and irrigated winter wheat and irrigated grain sorghum were collected on-site and at the Bushland, Texas control locations.

Crop sampling locations vary annually according to crop rotation. Garden produce was sampled at two specially-grown garden locations: one on the northeast side of the Pantex property and one on the southwest side of the Texas Tech University (TTU) property (Figure 12.1).

Six dryland and one location from the Texas Land Applied Permit (TLAP) area winter wheat samples, along with a duplicate from on-site, were collected in April 2018, and one control sample was collected from the control site (Bushland, Texas). The majority of on-site winter wheat sampling locations were located on the west and northeast side of the Plant and on the TLAP area, with dryland grain sorghum sampling locations, in the northeast corner of the Plant, and none from the TLAP area (Figure 12.3). Six dryland grain sorghum samples, a control sample, and duplicate from on-site were collected in September 2018. Fruits and leaves from garden plants were sampled in September 2018.

All crop and garden samples were analyzed for tritium, U-233/234 and U-238. All crop and garden produce analyses in 2018 were at or below the MDA level for tritium, U-233/234, and U-238 and were comparable to the off-site control location. Results for all crop and garden results were similar to historical data with

the exception of three crop samples (CR-WW-05, CR-WW-06, CR-SO-06, and the wheat control location OV-WW-09). Results for these crop locations are in (Table 12.3). Concentration of U-233/234 and U-238 in crop and garden vegetation indicates no uptake of U-233/234 and U-238 into vascular plants has occurred.

**Table 12.3 – Crop Comparison of U-233/234 and U-238 2018 and the Control Locations**

Sampling Location	U-233/234 pCi/g	Sampling Location	U-238 pCi/g
CR-WW-05	0.08±0.06	CR-WW-06	0.08±0.06
OV-WW-09 (control)	0.12±0.07	CR-SO-06	0.05±0.04

### 12.3 Conclusions

Radionuclide concentrations in flora samples were comparable to values observed in samples from control locations or historical data and indicate no detrimental effects from Plant operations in 2018.

## Chapter 13 – Quality Assurance

*Pantex, because of its unique mission and service to our country, must strive to become a High Reliability Organization. High reliability includes robust quality assurance (QA) that ensures all environmental monitoring data provides definitive evidence of regulatory compliance and protection of human health and the environment. The complexity of analytical chemistry and radiochemistry performed to support environmental monitoring programs necessitates that Pantex maintain an unparalleled QA and quality control (QC) program that meets our need for high reliability. Of the 27,274 individual analytical results obtained during 2018, 99.85 percent were useable for making environmental decisions.*

### 13.1 The Scope of the Program

The Pantex Plant has an established QA/QC program designed to ensure the reliability of analytical data used to support all site environmental programs. This program also satisfies the quality requirements implemented under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Record of Decision (ROD), Texas Commission on Environmental Quality (TCEQ)-issued environmental permits, Department of Energy (DOE) Order 414.1D Quality Assurance (DOEg), and International Organization for Standardization (ISO)-2004 Environmental Management Systems – Requirements with Guidance for Use, 2004 (ISO, 2004). During 2018, the QA/QC program enhanced the reliability of data acquired for environmental monitoring, which includes air, soil, groundwater, surface water, flora, and fauna programs.

The ultimate goal of the Pantex environmental monitoring QA/QC program is to consistently generate reliable, high quality environmental monitoring data. One measure of success for this QA/QC program is the amount of useable environmental data based on technical acceptance criteria for chemical and radiochemical measurements. By providing consistently useable data, Pantex fosters a high degree of confidence for regulatory compliance and protection of human health and the environment with stakeholders. This approach also allowed Pantex to provide maximum value for the resources utilized to acquire environmental monitoring data.

### 13.2 Environmental Data Acquisition, Planning, and Execution

Acquisition of environmental monitoring data is planned with its end use in mind. Each media scientist or subject matter expert defined data collection requirements based on program needs and used guidance such as Environmental Protection Agency (EPA) QA/G4 Guidance for Data Quality Objective Process (EPAa), in developing Data Quality Objectives (DQOs) for data collection. The media scientists prepared the DQOs based on the overall data collection needs, regulatory requirements, stakeholder concerns, technical factors, quality requirements, and historical data in their respective areas of expertise.

The approved DQO for a specific monitoring program was scheduled and executed by using technical specifications in the DQO. This includes sample location, sampling frequency, analytical method, and data acceptance criteria. During 2018, each DQO was associated with a procedure, defining requirements for sample collection and data management. Procedures were reviewed and updated, as necessary, to reflect new requirements in associated DQOs or enhancements to the sample collection and data management process.

### 13.3 Environmental Data Quality Assurance and Control

Pantex relies on a robust quality system described in the Pantex Plant Environmental Monitoring Program Management and Quality Plan, QPLAN-0010 (PANTEXd). The intent of this system is to integrate and manage quality elements for field sampling, laboratory analysis, data management, and to monitor and control factors that affect overall data quality. Components of this quality system are described below.

## **Field and Laboratory Assessments**

Internal assessments are conducted annually, at a minimum, on representative field and laboratory operations. The assessments on field operations are performed on both liquid and solid media sampling programs. These assessments are used to assure the reliability and defensibility of analytical data acquired to support environmental monitoring programs. They are also a tool for continuous improvement of sampling operations, administrative functions, control procedures, and quality systems. Activities reviewed in the field assessment may include calibration and documentation for field equipment, proper field sampling procedures, provisions for minimization of potential sample contamination, compliance with Chain-of-Custody (COC) procedures, sample documentation, and sample transfer to the laboratory. Activities reviewed for laboratory operations may include quality systems, sample receiving, handling, COC, storage procedures, documentation for laboratory procedures, such as run logs, data reduction, standard operating procedures (SOPs), condition and calibration of analytical instruments, and sample disposal.

Other assessments, including management and independent assessments are also conducted. Most assessments are performed using checklists with specific criteria for each procedure observed. Checklists from the United States Department of Energy Consolidated Audit Program (DOECAP) are used as guidance in developing the checklists for the laboratory assessments. An exit meeting is conducted at the end of an audit to discuss the findings. The findings are summarized in a report, and a Corrective Action Plan (CAP) is submitted by the laboratory for all the findings, including the root cause, corrective action, personnel responsible for the corrective action implementation, and projected date for completion of the corrective action. A nonconformance report (NCR) is generated when a departure from documented requirements such as procedures, sampling plans, and QC criteria occurs. A formal Corrective Action Report (CAR) may be necessary depending on the severity, repetitiveness, and impact to reported data. Corrective actions are required to be implemented in a timely manner by the appropriate personnel who are knowledgeable about the work.

## **Annual Review of all Operations**

An annual review of the sampling operations, administrative functions, and quality systems is conducted by Pantex to assure their continued effectiveness. The items reviewed include the suitability of policies and procedures, outcome of internal and external assessments, trending of NCRs and CARs, client complaints, changes in volume of work, staffing and resources.

## **Recordkeeping**

All environmental records and documents are issued, revised, controlled, stored, and archived in accordance with requirements of the Pantex Plant.

### **13.3.1 Quality Plan Requirements for Subcontract Laboratories**

Subcontract laboratories are accredited by The NELAC Institute (TNI) and in accordance with Title 30 of the Texas Administrative Code (TAC), Chapter 25 for all parameters within the scope of work provided by the Pantex Plant. Exceptions might be made when TNI accreditation is not available.

Each subcontract laboratory must be qualified by Pantex prior to receiving samples for analysis. The prequalification process includes a review of the technical proposal submitted by the prospective laboratory, successful analysis of Performance Evaluation (PE) samples, and a systems audit performed by DOECAP, National Nuclear Security Administration (NNSA), Analytical Management Program, or Pantex Supplier Quality Department.

In addition to the initial systems audit, all subcontract laboratories must submit to annual systems audits in order to maintain status as a qualified subcontract laboratory. These audits are technical and programmatic and performed by DOECAP. Their purpose is to ensure that all existing subcontract laboratories are qualified to provide high quality analytical laboratory services.

A Data Package Assessment is conducted annually at subcontract laboratories. In this type of assessment, random analytical deliverables are selected, and all the supporting documentation such as calibration records, method detection limits, and QA/QC reports are reviewed. The subcontract laboratory is also required to conduct internal audits at least annually to assure they are compliant with the laboratory's quality systems and with the Pantex Statement of Work (SOW) for Analytical Laboratories (PANTEXM).

Qualified subcontract laboratories must successfully analyze PE samples semi-annually in order to maintain qualified status, and they may be subject to submission of PE samples from the Pantex Plant at any time. PE sample analyses are designed to evaluate normal laboratory operations, and evaluation of the PE sample results must consider factors such as identification of false positives, false negatives, large analytical errors, and indications of calibration or dilution errors. If the subcontract laboratory performs any combination of inorganic, organic, and radiological testing, participation in two semi-annual inter-laboratory comparison PE programs is required. One program must be the Mixed Analyte Performance Evaluation Program (MAPEP), and the other program should be from a vendor accredited by the National Institute of Standards and Technology (NIST) under TNI Proficiency Test Standards. Participation in additional inter-laboratory comparison PE programs is necessary if the laboratory provides other unique services such as asbestos or lead in paint.

NCRs are submitted by the laboratory if unacceptable PE results are reported. PE sample requirements may be waived for any analysis in which a suitable PE sample is not available. Sample shipments to a subcontract laboratory may be suspended if it is determined that the laboratory is not capable of meeting the analytical, quality assurance, and deliverable requirements of the SOW.

### **13.4 Laboratory Quality Assurance**

During 2018, the Pantex Laboratory Quality Assurance Program (LQAP) continued to provide qualified laboratory auditors to participate in DOECAP. The primary function of DOECAP is to evaluate laboratory quality assurance systems and verify that they are effective. Pantex supports this resource-sharing approach to laboratory quality assurance.

During 2018, all Pantex requirements for the subcontract laboratories were met. All of the subcontract laboratories had the proper certifications for analyzing environmental samples from Pantex. They performed the necessary internal audits, and participated in the appropriate PE programs. Annual DOECAP audits were also conducted. A technical and contractual verification of the laboratory deliverables, performed by staff scientists as analytical results were received from the laboratories, ensured that contractual deliverable specifications, technical content, and QC deliverables complied with SOW requirements consistent with industry standards.

#### **13.4.1 Data Review and Qualification**

Historically, the vast majority of analytical results are useable unless there is a catastrophic QA/QC failure (such as no surrogate or radiotracer recovery) during the analytical process that causes the results to be rejected (declared not useable). Based on industry standard conventions, sample results are qualified as useable by means of various data qualifier flags to alert the end user to any limitations in using the result. This approach was taken to make use of as many sample results as possible without sacrificing quality. Sample results that were completely unusable were rejected and not made available for use. Several criteria

were used during the verification process so that analytical results could be appropriately qualified. Some of the criteria that caused data to be rejected during the verification process were:

- Missed Holding Times. The analysis was not initiated, or the sample was not extracted/prepared, within the time frame required by the EPA method and the SOW.
- Control Limits. A quality control parameter such as a surrogate, spike recovery, response factor, or tracer recovery associated with a sample failed to meet the limits of acceptability.
- Not Confirmed. Analytical methods for high explosives and perchlorate may employ enhanced confirmation techniques, such as mass spectral or diode array detectors. This information is used to qualify data obtained from traditional techniques, such as use of a second chromatographic column, which may be prone to matrix interference. Second column confirmation is especially susceptible to false positives when the constituent of interest is at or near the method detection limit.
- Sample or Blank Contamination. The sensitivity of modern analytical techniques makes it virtually impossible to have a blank sample that is truly analyte-free. This is especially true for inorganic parameters such as metals. When the laboratory either accidentally contaminated the actual sample or the lab blank contained parameters of interest above a control limit, the associated sample results may be rejected.
- Other. This category includes, but is not limited to, the following:
  - Broken COC. There was a failure to maintain proper custody of samples, as documented on COC forms and laboratory sample log-in records.
  - Instrument Failure. Either the instrument failed to attain minimum method performance specifications or the instrument or a piece of equipment was not functioning.
  - Preservation Requirements. The requirements, as identified by the EPA or a specific method, were not met and/or properly documented.
  - Incorrect Test Method. The analysis was not performed according to a method contractually required by Pantex.
  - Incorrect or Inadequate Detection or Reporting Limit. The laboratory is required to attain specific levels of sensitivity when reporting target analytes, unless matrix effects prevent adequate detection and quantitation of the compound of interest.

The Pantex media scientist was alerted to any limitations in the use of the data, based on the DQO requirements. Of the 27,274 individual results obtained in 2018 from all laboratory analyses, 99.85 percent were deemed to be of suitable quality for the intended end use of the data. Figure 13.1 graphically summarizes the causes for the 0.15 percent of data rejected.

#### **13.4.2 Laboratory Technical Performance**

All subcontract laboratories were required to participate in inter-laboratory comparison studies administered by DOE and EPA. In 2018, Pantex off-site subcontract laboratories participated in MAPEP PE sample analysis, sponsored by the DOE/Idaho Operations Office.

The MAPEP samples include radiological, inorganic, and organic compounds in matrices including water, soil, air filters, and vegetation. Under MAPEP, the DOE Idaho Operations Office publishes evaluation reports, rating the analyses from each participating laboratory. MAPEP results, particularly the results for MAPEP Series 38 and 39, for all participating subcontract laboratories used by Pantex in 2018 (GEL and TestAmerica) are presented in Figure 13.2. Both subcontract laboratories had acceptable MAPEP results in 2018.



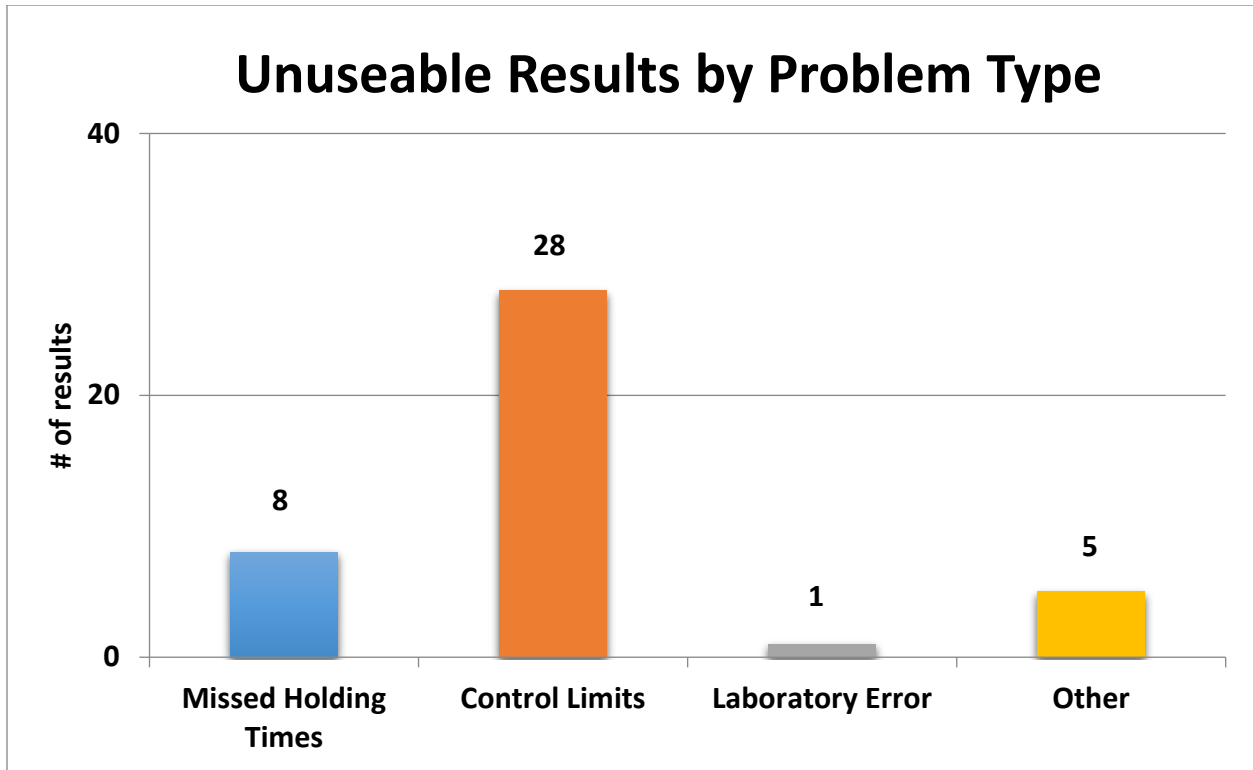


Figure 13.1 – 2018 Data Rejection Summary

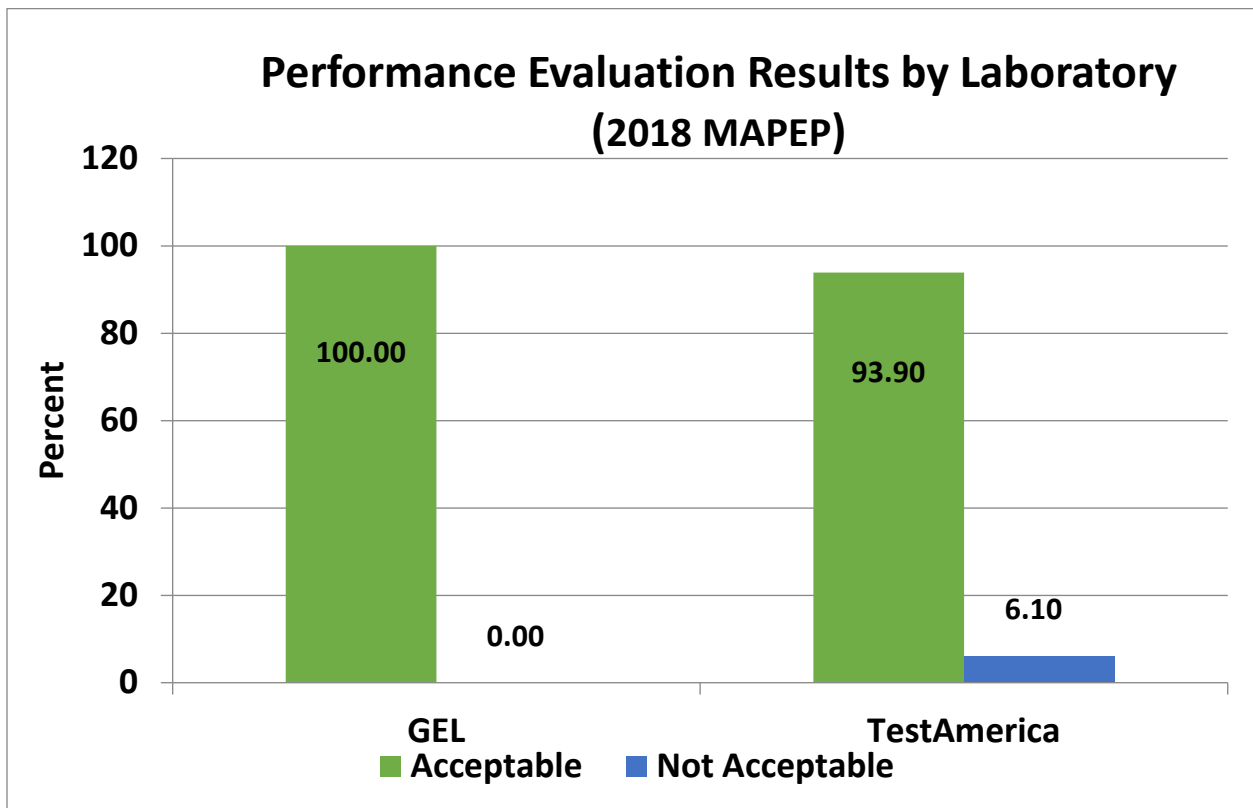


Figure 13.2 – 2018 MAPEP Results

The primary purpose of the PE programs is to measure a laboratory's implementation of methods to obtain accurate results and serve as a comparison between laboratories. The SOW and DOECAP have requirements that all labs shall participate in several PE programs, including the potable and non-potable water programs (EPA Supply and Water Pollution), and MAPEP.

### 13.5 Field Operations Quality Assurance

Quality assurance samples, such as duplicates, replicates, blanks, and equipment rinsates were collected at intervals specified in the DQOs. This was initiated to allow the media scientists to evaluate the data for potential bias or variability originating from either the sampling or the analytical process.

#### 13.5.1 Duplicate and Replicate Analyses

During 2018, Pantex continued to collect and analyze field duplicate and replicate samples. A true field duplicate sample set consists of a thoroughly homogenized sample collected from one desired location. The sample is split into two discrete samples and may even be labeled as representing two separate sampling locations. When the laboratory is not informed that the two samples are sub-samples from a single sampling location, these samples are referred to as "blind duplicate samples." When samples are collected from the same site at the same time, the samples are considered field replicates. For comparison purposes, field duplicates and field replicates are evaluated by the same criteria. Random replicate samples were collected for all media except air and fauna. These exceptions are based upon the uniqueness of the sample type and the inability to replicate the sample.

The vegetation program's isotopic uranium data were analyzed to compare actual sample values to field replicate values. This program was chosen for statistical analysis because of the relatively high number of replicates required during the sample collection process. The replicate error ratio (RER) was used to perform the replicate analysis. The ratio takes into account the sample and replicate uncertainty to determine data variability. The RER is given by:

$$\text{RER} = |S - R| / (\sigma_{95S} + \sigma_{95R});$$

Where:

RER = replicate error ratio

S = sample value (original)

R = replicate sample value

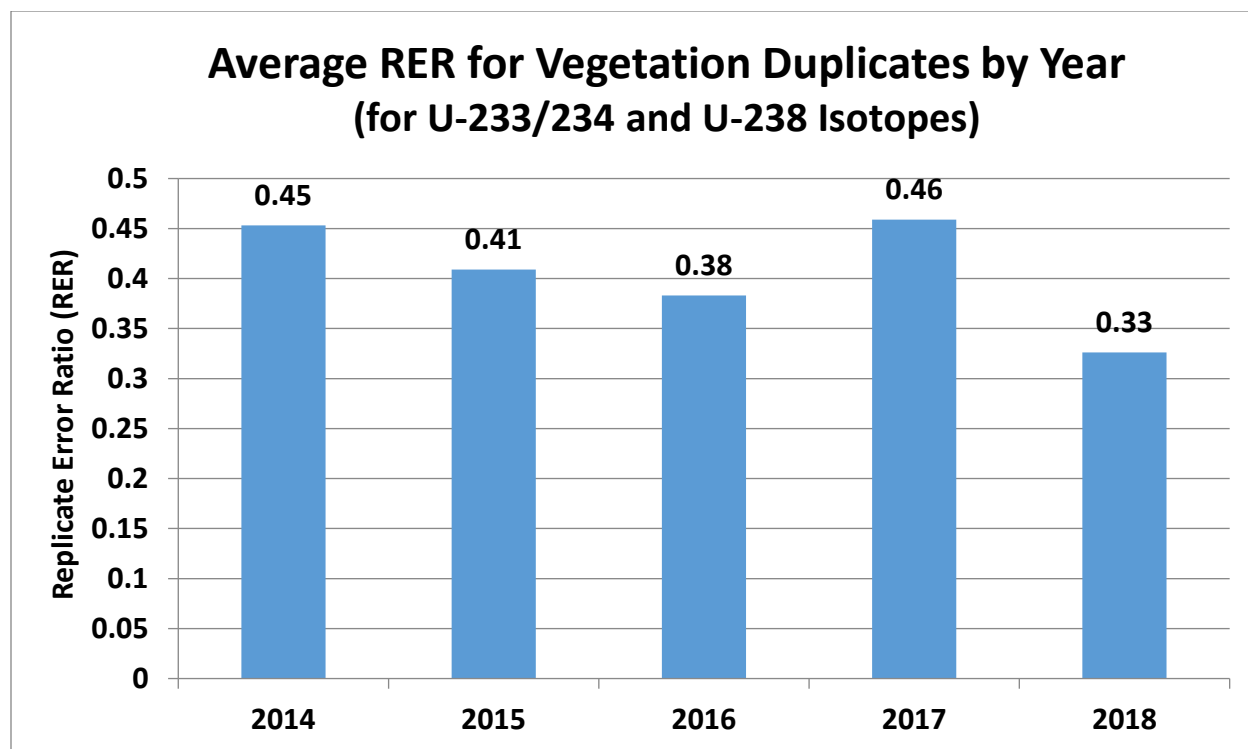
$\sigma_{95S}$  = sample uncertainty (95 percent)

$\sigma_{95R}$  = replicate uncertainty (95 percent)

An RER of less than or equal to one indicates that the replicates are comparable within the 95 percent confidence interval. For 2018, the average RER value for vegetation data was 0.326 with an associated standard deviation of 0.175. The 2018 vegetation sample RER analysis indicated that field replicate sample precision accurately reflects the actual sample value. Figure 13.3 summarizes the RER data.

#### 13.5.2 Blanks and Rinsates

During 2018, trip blanks, field blanks, and/or rinsate samples were collected for all applicable media programs. Blank samples were used to evaluate contamination that may have occurred during sampling, sample shipment, or laboratory operations. Trip blank and field blank values were used to flag detects found in sample values. The detects found were used to flag associated sample detects as "U" (undetected).



**Figure 13.3 – Five Year Average Replicate Error Ratio for Vegetation Duplicates**

A rinsate (equipment) blank is a sample of analyte-free water poured over or through decontaminated sampling equipment. The rinse solution is collected to show that there is no contamination from the sampling tool, or cross-contamination between samples.

Field blanks are analyte-free water samples that are taken to the field and opened for the duration of the sampling event and then closed and sent to the lab. Field blanks assess if airborne contamination exists at the sampling site.

Trip blanks are provided for each shipping container (cooler) containing VOC vials to evaluate potential contamination of the sample bottles during shipment from the manufacturer, storage of the bottles, shipment to the laboratory, or analysis at the laboratory. VOCs such as methylene chloride and 1,2-dichloroethane were detected in trip blanks in 2018. These compounds are indicative of common laboratory solvents. The frequency of detection was 0.8 percent.

### 13.6 On-site Analytical Laboratories

A limited number of samples were analyzed on-site during 2018, using approved EPA or standard industry methods. On-site analyses included the following:

- Pantex Materials and Analytical Services Laboratory performed analysis of samples for alkalinity, asbestos, nitrate, nitrite, and hexavalent chromium.

The on-site laboratories followed an internal quality control program similar to the program outlined in the SOW. The on-site laboratories were audited by the Plant's internal quality audit program. Sampling technicians performed field measurements of certain samples for residual chlorine, dissolved oxygen, turbidity, conductivity, hydrogen sulfide, temperature, Oxidation Reduction Potential and pH.

### 13.7 Continuous Improvement

During 2018, the Pantex Plant acquired analytical data to support several aspects of the environmental monitoring program as required by permits, regulations, and DOE Orders. The QA/QC program described in this chapter was implemented to ensure the programmatic and technical elements required to meet these criteria were executed. In addition, this program functioned to provide cost efficient analytical data of known and defensible quality.

Overall programmatic data quality has continued to improve because of improved analytical methods, QA/QC practices, and refinement of DQOs, which can be quantified by trending the amount of useable data acquired over the past 20+ years (Figure 13.4). Using 1996 as the base year, a 95 percent lower performance target was established to trend data usability. As with any data collection process, improvements are continually being made in defining technical specifications and improving sample collection methodology, laboratory instrumentation, and QC practices. It is important to remember that any viable quality system undergoes continuous improvement by the very nature of the quality elements employed. This is the QA/QC program perspective used to review data critically for the annual site environmental report.

A well-established quality framework exists at Pantex that supports the environmental monitoring program. The acquisition and review of analytical data is based on procedurally controlled sampling, analysis, data management (validation), and standardized technical specifications governing analytical measurements. The integration of each of these elements ensures environmental data collection and monitoring requirements are achieved meeting all site and stakeholder requirements for quality and reliability.

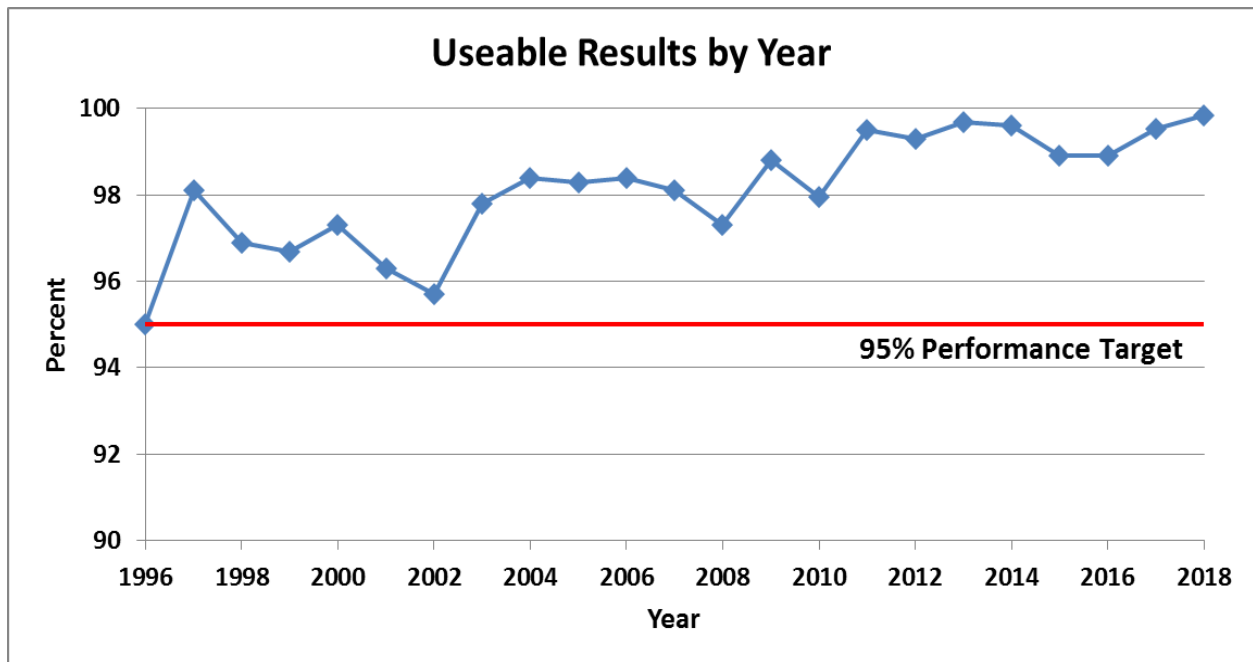


Figure 13.4 – History of Useable Results Data

**Appendix A – Analytes Monitored in 2018**

Analyte	CAS Number	Air	GW <sup>a</sup>	DW <sup>b</sup>	SW <sup>c</sup>	IW <sup>d</sup>	BG <sup>e</sup> Soil	TLAP Soil <sup>f</sup>	Veg. <sup>g</sup>	Fauna
<b>Radionuclides</b>										
Gross alpha, total	12587-46-1	-	-	-	-	-	-	-	-	-
Gross beta, total	12587-47-2	-	-	-	-	-	-	-	-	-
Plutonium-238	12059-95-9	-	-	-	-	-	-	-	-	-
Plutonium-239/240	10-12-8	+	-	-	-	-	-	-	-	-
Tritium	10028-17-8	+	-	-	+	-	-	-	+	+
Uranium-233/234	11-08-5	+	-	-	-	-	-	-	+	+
Uranium-235/236	15117-96-1	-	-	-	+	-	-	-	-	-
Uranium-238	7440-61-1	+	-	-	+	-	-	-	+	+
<b>Metals</b>										
Aluminum	7429-90-5	-	+	+	-	-	-	-	-	-
Antimony	7440-36-0	-	+	+	-	-	-	-	-	-
Arsenic	7440-38-2	-	+	+	+	-	-	-	-	-
Barium	7440-39-3	-	+	+	+	-	-	-	-	-
Beryllium	7440-41-7	-	+	+	-	-	-	-	-	-
Boron	7440-42-8	-	+	-	+	+	+	+ <sup>i</sup>	-	-
Cadmium	7440-43-9	-	+	+	+	-	+	-	-	-

Appendix A – Analytes Monitored in 2018

Analyte	CAS Number	Air	GW <sup>a</sup>	DW <sup>b</sup>	SW <sup>c</sup>	IW <sup>d</sup>	BG <sup>e</sup> Soil	TLAP Soil <sup>f</sup>	Veg. <sup>g</sup>	Fauna
Calcium	7440-70-2	-	+	-	-	-	-	+ <sup>i</sup>	-	-
Chromium	7440-47-3	-	+	+	+	-	+	-	-	-
Chromium (hexavalent)	18540-29-9	-	+	-	-	-	-	-	-	-
Cobalt	7440-48-4	-	-	-	+	-	+	-	-	-
Copper	7440-50-8	-	-	+	+	+	+	+ <sup>i</sup>	-	-
Iron	7439-89-6	-	+	+	+	-	-	+ <sup>i</sup>	-	-
Ferric Iron	N/A	-	+	-	-	-	-	-	-	-
Ferrous Iron	1345-25-1	-	+	-	-	-	-	-	-	-
Lead	7439-92-1	-	+	+	+	-	+	-	-	-
Magnesium	7439-95-4	-	+	-	-	-	-	+ <sup>i</sup>	-	-
Manganese	7439-96-5	-	+	+	+	+	-	+ <sup>i</sup>	-	-
Manganese, divalent	16397-91-4	-	+	-	-	-	-	-	-	-
Mercury	7439-97-6	-	-	+	+	-	+	-	-	-
Molybdenum	7439-98-7	-	+	-	-	-	-	-	-	-
Nickel	7440-02-0	-	+	+	+	-	+	-	-	-
Potassium	7440-09-7	-	+	+	-	-	-	+ <sup>i</sup>	-	-
Selenium	7782-49-2	-	+	+	+	-	-	-	-	-
Silver	7440-22-4	-	+	+	+	-	+	-	-	-
Sodium	7440-23-5	-	+	+	-	-	-	+ <sup>i</sup>	-	-

Appendix A – Analytes Monitored in 2018

Analyte	CAS Number	Air	GW <sup>a</sup>	DW <sup>b</sup>	SW <sup>c</sup>	IW <sup>d</sup>	BG <sup>e</sup> Soil	TLAP Soil <sup>f</sup>	Veg. <sup>g</sup>	Fauna
Strontium	7440-24-6	-	-	-	-	-	-	-	-	-
Thallium	7440-28-0	-	+	+	-	-	-	-	-	-
Tin	7440-31-5	-	+	-	-	-	-	-	-	-
Titanium	7440-32-6	-	-	-	-	-	-	-	-	-
Uranium, Total	11-09-6	-	+	-	-	-	-	-	-	-
Vanadium	7440-62-2	-	+	-	-	-	-	-	-	-
Zinc	7440-66-6	-	+	+	+	+	+	+ <sup>i</sup>	-	-
<b>Explosives</b>										
1,3-dinitrobenzene	99-65-0	-	+	-	+	-	-	-	-	-
1,3,5-trinitrobenzene	99-35-4	-	+	-	+	-	+	-	-	-
2-amino-4,6-dinitrotoluene	35572-78-2	-	+	-	+	-	-	-	-	-
2-nitrotoluene	88-72-2	-	-	-	+	-	-	-	-	-
2,4-dinitrotoluene	121-14-2	-	+	-	+	-	+	+	-	-
2,6-dinitrotoluene	606-20-2	-	+	-	+	-	+	-	-	-
3-nitrotoluene	99-08-1	-	-	-	+	-	-	-	-	-
4-amino-2,6-dinitrotoluene	1946-51-0	-	+	-	+	-	-	-	-	-
4-nitrotoluene	99-99-0	-	-	-	+	-	-	-	-	-
HMX	2691-41-0	-	+	-	+	+	+	-	-	-
Nitrobenzene	98-95-3	-	-	-	+	-	-	+	-	-

Appendix A – Analytes Monitored in 2018

Analyte	CAS Number	Air	GW <sup>a</sup>	DW <sup>b</sup>	SW <sup>c</sup>	IW <sup>d</sup>	BG <sup>e</sup> Soil	TLAP Soil <sup>f</sup>	Veg. <sup>g</sup>	Fauna
PETN	78-11-5	-	-	-	+	+	+	-	-	-
RDX	121-82-4	-	+	-	+	+	+	-	-	-
TATB	3058-38-6	-	-	-	-	+	+	-	-	-
Tetryl	479-45-8	-	-	-	+	-	-	-	-	-
TNT	118-96-7	-	+	-	+	+	+	-	-	-
MXN	5755-27-1	-	+	-	-	-	-	-	-	-
DNX	80251-29-2	-	+	-	-	-	-	-	-	-
TNX	13980-04-6	-	+	-	-	-	-	-	-	-
<b>Polychlorinated Biphenyls (PCBs)</b>										
Aroclor 1016	12674-11-2	-	-	+	-	-	-	-	-	-
Aroclor 1221	1104-28-2	-	-	+	-	-	-	-	-	-
Aroclor 1232	11141-16-5	-	-	+	-	-	-	-	-	-
Aroclor 1242	53469-21-9	-	-	+	-	-	-	-	-	-
Aroclor 1248	12672-29-6	-	-	+	-	-	-	-	-	-
Aroclor 1254	11091-69-1	-	-	+	-	-	-	-	-	-
Aroclor 1260	11096-82-5	-	-	+	-	-	-	-	-	-
<b>Pesticides</b>										
Alachlor	15972-60-8	-	-	+	-	-	-	-	-	-
Aldrin	309-00-2	-	-	+	-	-	-	-	-	-



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Atrazine	1912-24-9	-	-	+	-	-	-	-	-	-
Bromacil	314-40-9	-	-	+	-	-	-	-	-	-
Chlordane	57-74-9	-	-	+	-	-	-	-	-	-
Dieldrin	60-57-1	-	-	+	-	-	-	-	-	-
Endrin	72-20-8	-	-	+	-	-	-	-	-	-
Heptachlor	76-44-8	-	-	+	-	-	-	-	-	-
Heptachlor epoxide	1024-57-3	-	-	+	-	-	-	-	-	-
Lindane (gamma-BHC)	58-89-9	-	-	+	-	-	-	-	-	-
Methoxychlor	72-43-5	-	-	+	-	-	-	-	-	-
Methyl n,n-dimethyl-n- {(methlycarbamoyl)oxy}-1	23135-22-0	-	-	+	-	-	-	-	-	-
s-Methyl-n-((Methylcarb amoyl)-oxy)-thioacetimidate	16752-77-5	-	-	+	-	-	-	-	-	-
Metribuzin	21087-64-9	-	-	+	-	-	-	-	-	-
Prometon	1610-18-0	-	-	+	-	-	-	-	-	-
Propachlor	1918-16-7	-	-	+	-	-	-	-	-	-
Sevin (carbaryl)	63-25-2	-	-	-	-	-	-	-	-	-
Simazine	122-34-9	-	-	+	-	-	-	-	-	-
<b>Herbicides</b>										
2,4-D	94-75-7	-	-	-	-	-	-	-	-	-
<b>Miscellaneous</b>										

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Alkalinity	T-005	-	+	-	-	-	-	-	-	-
Ammonia (as N)	7664-41-7	-	+	-	-	+	-	-	-	-
Biochemical oxygen demand	10-26-3	-	-	-	-	+	-	-	-	-
Bromide	24959-67-9	-	+	-	-	-	-	-	-	-
Chemical oxygen demand	C-004	-	-	-	-	+	-	-	-	-
Chlorate	14866-68-3	-	-	-	-	-	-	-	-	-
Chloride	16887-00-6	-	+	-	-	-	-	-	-	-
Chlorine residual	7782-50-5	-	-	+	-	-	-	-	-	-
Color	M-002	-	-	-	-	-	-	-	-	-
Corrosivity	10-37-7	-	-	-	-	-	-	-	-	-
Cyanide, free	10-71-9	-	-	-	-	-	-	-	-	-
Cyanide, total	57-12-5	-	-	-	-	-	-	-	-	-
Dissolved Organic Carbon	11-59-6	-	+	-	-	-	-	-	-	-
Dissolved Oxygen	NA	-	+	-	-	-	-	-	-	-
Electrical Conductivity-Paste	NA	-	-	-	-	-	-	+ <sup>i</sup>	-	-
Fluoride	7782-41-4	-	+	-	-	-	-	-	-	-
Foaming agents (surfactants)	NA	-	-	-	-	-	-	-	-	-
Ignitability	NA	-	-	-	-	-	-	+	-	-
Nitrate (as N)	14797-55-8	-	+	+	-	-	-	+	-	-

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Nitrate/nitrite (as N)	1-005	-	-	-	-	+	-	-	-	-
Nitrite (as N)	14797-65-0	-	+	-	-	-	-	-	-	-
Oil and grease	10-30-0	-	-	-	-	+	-	-	-	-
Ortho Phosphate	14265-44-2	-	-	-	-	-	-	+ <sup>i</sup>	-	-
Oxidation – Reduction Potential		-	+	-	-	-	-	-	-	-
Perchlorate	14797-73-0	-	+	-	-	-	-	-	-	-
pH	10-29-7	-	+	+	+	+	-	-	-	-
pH (1:1 ratio soil pH)	NA	-	-	-	-	-	-	+ <sup>i</sup>	-	-
pH (2:1 ratio soil pH)	NA	-	-	-	-	-	-	+ <sup>i</sup>	-	-
Phosphorus, Total (As P)	7723-14-0	-	+	-	-	-	-	-	-	-
Reactivity	NA	-	-	-	-	-	-	+	-	-
Sodium Adsorption Ratio	NA	-	-	-	-	-	-	+ <sup>i</sup>	-	-
Specific conductance	10-34-4	-	-	-	-	-	-	-	-	-
Sulfate	14808-79-8	-	+	-	-	-	-	-	-	-
Sulfide	18496-25-8	-	+	-	-	-	-	-	-	-
Sulfur	NA	-	-	-	-	-	-	+ <sup>i</sup>	-	-
Temperature	NA	-	+	+	+	+	-	-	-	-
Total dissolved solids	10-33-3	-	+	-	-	-	-	-	-	-
Total hardness (as CaCO <sub>3</sub> )	11-02-9	-	-	+	-	-	-	-	-	-

Appendix A – Analytes Monitored in 2018

Analyte	CAS Number	Air	GW <sup>a</sup>	DW <sup>b</sup>	SW <sup>c</sup>	IW <sup>d</sup>	BG <sup>e</sup> Soil	TLAP Soil <sup>f</sup>	Veg. <sup>g</sup>	Fauna
Total Kjeldahl Nitrogen	NA	-	+	-	-	-	-	+ <sup>i</sup>	-	-
Total Nitrogen	NA	-	-	-	-	-	-	+ <sup>i</sup>	-	-
Total organic carbon	C-012	-	+	-	-	-	-	-	-	-
Total petroleum hydrocarbons	10-90-2	-	-	-	+	-	-	-	-	-
Turbidity	G-019	-	+	-	-	-	-	-	-	-
<b>Volatile Organics</b>										
1,1,1,2-tetrachloroethane	630-20-6	-	-	+	+	-	-	-	-	-
1,1,2,2-tetrachloroethane	79-34-5	-	-	+	+	-	-	-	-	-
1,1,1-trichloroethane	71-55-6	-	-	+	+	-	-	-	-	-
1,1,2-trichloroethane	79-00-5	-	-	+	+	-	-	-	-	-
1,2,3-trichlorobenzene	87-61-6	-	-	+	-	-	-	-	-	-
1,2,3-trichloropropane	96-18-4	-	-	+	+	-	-	-	-	-
1,2,4-trimethylbenzene	95-63-6	-	-	+	-	-	-	-	-	-
1,3,5-trimethylbenzene	108-67-8	-	-	+	-	-	-	-	-	-
1,1-dichloroethane	75-34-3	-	-	+	+	-	-	-	-	-
1,1-dichloroethene	75-35-4	-	-	+	+	-	-	-	-	-
1,1-dichloropropene	563-58-6	-	-	-	-	-	-	-	-	-
1,2-dibromo-3-chloropropane	96-12-8	-	-	-	+	-	-	-	-	-
1,2-dibromoethane	106-93-4	-	-	+	+	-	-	-	-	-

Appendix A – Analytes Monitored in 2018

Analyte	CAS Number	Air	GW <sup>a</sup>	DW <sup>b</sup>	SW <sup>c</sup>	IW <sup>d</sup>	BG <sup>e</sup> Soil	TLAP Soil <sup>f</sup>	Veg. <sup>g</sup>	Fauna
1,2-dichlorobenzene	95-50-1	-	-	+	+	-	-	-	-	-
1,2-dichloroethane	107-06-2	-	+	+	+	-	-	-	-	-
1,2-dichloroethene	156-60-5	-	-	-	+	-	-	-	-	-
<i>cis</i> -1,2-dichloroethene	156-59-2	-	+	+	+	-	-	-	-	-
<i>trans</i> -1,2-dichloroethene	156-60-5	-	+	+	+	-	-	-	-	-
1,2-dichloropropane	78-87-5	-	-	+	+	-	-	-	-	-
1,3-dichlorobenzene	541-73-1	-	-	+	+	-	-	-	-	-
1,3-dichloropropane	142-28-9	-	-	+	-	-	-	-	-	-
<i>cis</i> -1,3-dichloropropene	10061-01-5	-	-	+	+	-	-	-	-	-
<i>trans</i> -1,3-dichloropropene	10061-02-6	-	-	+	+	-	-	-	-	-
<i>trans</i> -1,4-dichloro-2-butene	110-57-6	-	-	-	+	-	-	-	-	-
1,4-dichlorobenzene	106-46-7	-	-	+	+	-	-	-	-	-
2,2-dichloropropane	594-20-7	-	-	+	-	-	-	-	-	-
2-butanone (methyl ethyl ketone)	78-93-3	-	-	+	+	-	-	-	-	-
2-chloro-1,3-butadiene	126-99-8	-	-	-	+	-	-	-	-	-
2-chlorotoluene	95-49-8	-	-	+	-	-	-	-	-	-
2-hexanone	591-78-6	-	-	+	+	-	-	-	-	-
4-chlorotoluene	106-43-4	-	-	+	-	-	-	-	-	-
4-isopropyltoluene	99-87-6	-	-	+	-	-	-	-	-	-

Appendix A – Analytes Monitored in 2018

Analyte	CAS Number	Air	GW <sup>a</sup>	DW <sup>b</sup>	SW <sup>c</sup>	IW <sup>d</sup>	BG <sup>e</sup> Soil	TLAP Soil <sup>f</sup>	Veg. <sup>g</sup>	Fauna
Acetone	67-64-1	-	-	+	+	-	-	-	-	-
Acetonitrile	75-05-8	-	-	-	+	-	-	-	-	-
Acetylene	74-86-2	-	+	-	-	-	-	-	-	-
Acrolein	107-02-8	-	-	-	+	-	-	-	-	-
Acrylonitrile	107-13-1	-	-	+	+	-	-	-	-	-
Allyl Chloride	107-05-1	-	-	-	+	-	-	-	-	-
Benzene	71-43-2	-	-	+	+	-	-	-	-	-
Bromobenzene	108-86-1	-	-	+	-	-	-	-	-	-
Bromochloromethane	74-97-5	-	-	+	-	-	-	-	-	-
Bromodichloromethane	75-27-4	-	-	+	+	-	-	-	-	-
Bromoform	75-25-2	-	-	+	+	-	-	-	-	-
Bromomethane	74-83-9	-	-	+	+	-	-	-	-	-
sec-Butylbenzene	135-98-8	-	-	+	-	-	-	-	-	-
tert-Butylbenzene	98-06-6	-	-	+	-	-	-	-	-	-
Carbon disulfide	75-15-0	-	-	+	+	-	-	-	-	-
Carbon tetrachloride	56-23-5	-	-	+	+	-	-	-	-	-
Chlorobenzene	108-90-7	-	-	+	+	-	-	-	-	-
Chloroethane	75-00-3	-	-	+	+	-	-	-	-	-
Chloroform	67-66-3	-	+	+	+	-	-	-	-	-

Appendix A – Analytes Monitored in 2018

Analyte	CAS Number	Air	GW <sup>a</sup>	DW <sup>b</sup>	SW <sup>c</sup>	IW <sup>d</sup>	BG <sup>e</sup> Soil	TLAP Soil <sup>f</sup>	Veg. <sup>g</sup>	Fauna
Chloromethane	74-87-3	-	-	+	+	-	-	-	-	-
Dibromochloromethane	124-48-1	-	-	+	+	-	-	-	-	-
Dibromomethane	74-95-3	-	-	+	+	-	-	-	-	-
Dichlorodifluoromethane	75-71-8	-	-	+	+	-	-	-	-	-
Ethylbenzene	100-41-4	-	-	+	+	-	-	-	-	-
Ethyl methacrylate	97-63-2	-	-	+	+	-	-	-	-	-
Freon 113	76-13-1	-	-	-	+	-	-	-	-	-
Iodomethane	74-88-4	-	-	-	+	-	-	-	-	-
Isobutyl alcohol	78-83-1	-	-	-	+	-	-	-	-	-
Isopropylbenzene	98-82-8	-	-	+	-	-	-	-	-	-
Methylacrylonitrile	126-98-7	-	-	-	+	-	-	-	-	-
Methylene chloride	75-09-2	-	-	+	+	-	-	-	-	-
Methyl isobutyl ketone	108-10-1	-	-	-	+	-	-	-	-	-
Methyl methacrylate	80-62-6	-	-	+	+	-	-	-	-	-
n-Butylbenzene	104-51-8	-	-	+	-	-	-	-	-	-
n-Propylbenzene	103-65-1	-	-	+	-	-	-	-	-	-
Pentachloroethane	76-01-7	-	-	-	+	-	-	-	-	-
Propionitrile	107-12-0	-	-	-	+	-	-	-	-	-
Styrene	100-42-5	-	-	+	+	-	-	-	-	-

Appendix A – Analytes Monitored in 2018

Analyte	CAS Number	Air	GW <sup>a</sup>	DW <sup>b</sup>	SW <sup>c</sup>	IW <sup>d</sup>	BG <sup>e</sup> Soil	TLAP Soil <sup>f</sup>	Veg. <sup>g</sup>	Fauna
tert-Butyl methyl ether	1634-04-4	-	-	+	-	-	-	-	-	-
Tetrachloroethylene	127-18-4	-	+	+	+	-	-	-	-	-
Tetrahydrofuran	109-99-9	-	-	+	-	-	-	-	-	-
Toluene	108-88-3	-	-	+	+	-	-	-	-	-
Trichloroethene (Trichloroethylene)	79-01-6	-	+	+	+	-	-	-	-	-
Trichlorofluoromethane	75-69-4	-	+	+	+	-	-	-	-	-
Vinyl acetate	108-05-4	-	-	+	+	-	-	-	-	-
Vinyl chloride	75-01-4	-	+	+	+	-	-	-	-	-
Xylene, m	108-38-3	-	-	+	+	-	-	-	-	-
Xylene, o	95-47-6	-	-	+	+	-	-	-	-	-
Xylene, p	106-42-3	-	-	+	+	-	-	-	-	-
Xylenes, Total	1330-20-7	-	-	+	+	-	-	-	-	-
<b>Semi Volatile Organic Compounds</b>										
1,2,4,5-tetrachlorobenzene	95-94-3	-	-	-	+	-	-	-	-	-
1,2,4-trichlorobenzene	120-82-1	-	-	+	+	-	-	-	-	-
1,2-diphenylhydrazine	122-66-7	-	-	-	+	-	-	-	-	-
1,4-dioxane	123-91-1	-	+	-	-	-	-	-	-	-
1,4-naphthoquinone	130-15-4	-	-	-	-	-	-	-	-	-
2,3,4,6-tetrachlorophenol	58-90-2	-	-	-	+	-	-	-	-	-



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Analyte	CAS Number	Air	GW <sup>a</sup>	DW <sup>b</sup>	SW <sup>c</sup>	IW <sup>d</sup>	BG <sup>e</sup> Soil	TLAP Soil <sup>f</sup>	Veg. <sup>g</sup>	Fauna
2,4,5-trichlorophenol	95-95-4	-	-	-	+	-	-	-	-	-
2,4,6-trichlorophenol	88-06-2	-	-	-	+	-	-	-	-	-
2,4-dichlorophenol	120-83-2	-	-	-	+	-	-	-	-	-
2,4-dimethylphenol	105-67-9	-	-	-	+	-	-	-	-	-
2,4-dinitrophenol	51-28-5	-	-	-	+	-	-	-	-	-
2-chloronaphthalene	91-58-7	-	-	-	+	-	-	-	-	-
2-chlorophenol	95-57-8	-	-	-	+	-	-	-	-	-
2-methylnaphthalene	91-57-6	-	-	-	+	-	-	-	-	-
2-methylphenol (o-Cresol)	795-48-7	-	-	-	+	-	-	-	-	-
4,6-dinitro-2-methylphenol	534-52-1	-	-	-	+	-	-	-	-	-
4-chloroaniline	106-47-8	-	-	-	+	-	-	-	-	-
4-chlorophenyl phenyl ether	7005-72-3	-	-	-	+	-	-	-	-	-
4-methylphenol (p-Cresol)	106-44-5	-	-	-	+	-	-	-	-	-
Acenaphthene	83-32-9	-	-	-	+	-	-	-	-	-
Acenaphthylene	208-96-8	-	-	-	+	-	-	-	-	-
Acetophenone	98-86-2	-	-	-	+	-	-	-	-	-
Anthracene	120-12-7	-	-	-	+	-	-	-	-	-
Benzidine	92-87-5	-	-	-	+	-	-	-	-	-
Benzo[a]anthracene	56-55-3	-	-	-	+	-	-	-	-	-

Appendix A – Analytes Monitored in 2018

Analyte	CAS Number	Air	GW <sup>a</sup>	DW <sup>b</sup>	SW <sup>c</sup>	IW <sup>d</sup>	BG <sup>e</sup> Soil	TLAP Soil <sup>f</sup>	Veg. <sup>g</sup>	Fauna
Benzo[ <i>a</i> ]pyrene	50-32-8	-	-	+	+	-	-	-	-	-
Benzo[ <i>b</i> ]fluoranthene	205-99-2	-	-	-	+	-	-	-	-	-
Benzo[ <i>g,h,i</i> ]perylene	191-24-2	-	-	-	+	-	-	-	-	-
Benzo[ <i>k</i> ]fluoranthene	207-08-9	-	-	-	+	-	-	-	-	-
Benzoic acid	65-85-0	-	-	-	+	-	-	-	-	-
Benzyl alcohol	100-51-6	-	-	-	+	-	-	-	-	-
bis(2-chloroethyl) ether	111-44-4	-	-	-	+	-	-	-	-	-
bis(2-chloroisopropyl) ether	39638-32-9	-	-	-	+	-	-	-	-	-
bis(2-ethylhexyl) phthalate	117-81-7	-	-	+	+	-	-	-	-	-
Butyl benzyl phthalate	85-68-7	-	-	-	+	-	-	-	-	-
Carbazole	86-74-8	-	-	-	+	-	-	-	-	-
Cresol, m	108-39-4	-	-	-	+	-	-	-	-	-
Chrysene	218-01-9	-	-	-	+	-	-	-	-	-
Dibenz[ <i>a,h</i> ]anthracene	53-70-3	-	-	-	+	-	-	-	-	-
Dibenzofuran	132-64-9	-	-	-	+	-	-	-	-	-
Dibromoacetic acid	631-64-1	-	-	+	-	-	-	-	-	-
Dichloroacetic acid	79-43-6	-	-	+	-	-	-	-	-	-
Diethyl phthalate	84-66-2	-	-	-	+	-	-	-	-	-
Dimethyl phthalate	131-11-3	-	-	-	-	-	-	-	-	-

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Analyte	CAS Number	Air	GW <sup>a</sup>	DW <sup>b</sup>	SW <sup>c</sup>	IW <sup>d</sup>	BG <sup>e</sup> Soil	TLAP Soil <sup>f</sup>	Veg. <sup>g</sup>	Fauna
Di-n-butyl phthalate	84-74-2	-	-	-	+	-	-	-	-	-
Di-n-octyl phthalate	117-84-0	-	-	-	+	-	-	-	-	-
Diphenylamine	122-39-4	-	-	-	+	-	-	-	-	-
Fluoranthene	206-44-0	-	-	-	+	-	-	-	-	-
Fluorene	86-73-7	-	-	-	+	-	-	-	-	-
Hexachlorobenzene	118-74-1	-	-	+	-	-	-	-	-	-
Hexachlorobutadiene	87-68-3	-	-	+	+	-	-	-	-	-
Hexachlorocyclopentadiene	77-47-4	-	-	+	-	-	-	-	-	-
Hexachloroethane	67-72-1	-	-	-	+	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	193-39-5	-	-	-	+	-	-	-	-	-
Isophorone	78-59-1	-	-	-	+	-	-	-	-	-
Monobromoacetic acid	79-08-3	-	-	+	-	-	-	-	-	-
Monochloroacetic acid	79-11-8	-	-	+	-	-	-	-	-	-
Naphthalene	91-20-3	-	-	+	+	-	-	-	-	-
N-nitrosodiethylamine	55-18-5	-	-	-	+	-	-	-	-	-
N-nitrosodimethylamine	62-75-9	-	-	-	+	-	-	-	-	-
N-nitrosodiphenylamine	86-30-6	-	-	-	+	-	-	-	-	-
N-nitrosodi-n-propylamine	621-64-7	-	-	-	+	-	-	-	-	-
N-nitrosopyrrolidine	930-55-2	-	-	-	+	-	-	-	-	-

Appendix A – Analytes Monitored in 2018

Analyte	CAS Number	Air	GW <sup>a</sup>	DW <sup>b</sup>	SW <sup>c</sup>	IW <sup>d</sup>	BG <sup>e</sup> Soil	TLAP Soil <sup>f</sup>	Veg. <sup>g</sup>	Fauna
Parathion, ethyl	56-38-2	-	-	-	-	-	-	-	-	-
Parathion, methyl	298-00-0	-	-	-	-	-	-	-	-	-
Pentachlorophenol	87-86-5	-	-	-	+	-	-	+	-	-
Phenanthrene	85-01-8	-	-	-	+	-	-	-	-	-
Phenol	108-95-2	-	-	-	+	-	-	-	-	-
Pronamide	23950-58-5	-	-	-	+	-	-	-	-	-
Pyrene	129-00-0	-	-	-	+	-	-	-	-	-
Pyridine	110-86-1	-	-	-	-	-	-	-	-	-
Trichloroacetic acid	76-03-9	-	-	+	-	-	-	-	-	-
<b>Biological</b>										
Complete blood count	NA	-	-	-	-	-	-	-	-	+
Histopathology	NA	-	-	-	-	-	-	-	-	+
Necropsy	NA	-	-	-	-	-	-	-	-	+
Total coliform bacteria	10-46-8	-	-	+	-	-	-	-	-	-
<i>Escherichia coli</i>	NA	-	-	+	-	-	-	-	-	-
Eastern encephalitis	NA	-	-	-	-	-	-	-	-	+
Western encephalitis	NA	-	-	-	-	-	-	-	-	+
Hanta virus	NA	-	-	-	-	-	-	-	-	+
Plague bacteria	NA	-	-	-	-	-	-	-	-	+

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Analyte	CAS Number	Air	GW <sup>a</sup>	DW <sup>b</sup>	SW <sup>c</sup>	IW <sup>d</sup>	BG <sup>e</sup> Soil	TLAP Soil <sup>f</sup>	Veg. <sup>g</sup>	Fauna
Pseudorabies	NA	-	-	-	-	-	-	-	-	+
Tularemia	NA	-	-	-	-	-	-	-	-	+
<b>Volatile Fatty Acids<sup>h</sup></b>										
Acetic Acid	64-19-7	-	+	-	-	-	-	-	-	-
Butyric Acid	107-92-6	-	+	-	-	-	-	-	-	-
Hexanoic Acid	142-62-1	-	+	-	-	-	-	-	-	-
i-Hexanoic Acid	646-07-1	-	+	-	-	-	-	-	-	-
i-Pentanoic Acid	503-74-2	-	+	-	-	-	-	-	-	-
Lactic Acid and HIBA	50-21-5	-	+	-	-	-	-	-	-	-
Pentanoic Acid	109-52-4	-	+	-	-	-	-	-	-	-
Propionic Acid	79-09-4	-	+	-	-	-	-	-	-	-
Pyruvic Acid	127-17-3	-	+	-	-	-	-	-	-	-
<b>Dissolved Gases<sup>h</sup></b>										
Ethane	74-84-0	-	+	-	-	-	-	-	-	-
Ethene	74-85-1	-	+	-	-	-	-	-	-	-
Methane	74-82-8	-	+	-	-	-	-	-	-	-

Appendix A – Analytes Monitored in 2018

Analyte	CAS Number	Air	GW <sup>a</sup>	DW <sup>b</sup>	SW <sup>c</sup>	IW <sup>d</sup>	BG <sup>e</sup> Soil	TLAP Soil <sup>f</sup>	Veg. <sup>g</sup>	Fauna
a	Groundwater									
b	Drinking water									
c	Storm water and playas									
d	Irrigation water									
e	Burning Ground soils & sediment									
f	Texas Land Application Permit (TLAP) soils									
g	Vegetation									
h	Only applicable to ISB and ISPM wells to monitor performance of the ISB Systems									
i	TLAP nutrient parameters analyzed on a plant available or extractable basis									
+	= Sampled for									
-	= Not sampled									
NA	= Not available									

**Appendix B – Birds Identified at Pantex**

Common Name	Scientific Name
Mallard	<i>Anas platyrhynchos</i>
Northern shoveler	<i>Anas clypeata</i>
Killdeer	<i>Charadrius vociferus</i>
Upland sandpiper	<i>Bartramia longicauda</i>
American kestrel	<i>Falco sparverius</i>
Swainson's hawk	<i>Buteo swainsoni</i>
Ferruginous hawk	<i>Buteo regalis</i>
Northern harrier	<i>Circus cyaneus</i>
Golden eagle	<i>Aquila chrysaetos</i>
American bald eagle	<i>Haliaeetus leucocephalus</i>
Mourning dove	<i>Zenaida macroura</i>
Eurasian collared dove	<i>Streptopelia decaocto</i>
Rock pigeon (feral)	<i>Columba livia</i>
Greater roadrunner	<i>Geococcyx californianus</i>
Burrowing owl	<i>Athene cunicularia hypugea</i>
Western kingbird	<i>Tyrannus verticalis</i>
Cliff swallow	<i>Hirundo pyrrhonota</i>
European starling	<i>Sturnus vulgaris</i>
White-crowned sparrow	<i>Zonotrichia leucophrys</i>
Western meadowlark	<i>Sturnella neglecta</i>
House sparrow	<i>Passer domesticus</i>
House finch	<i>Carpodacus mexicanus</i>

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### Appendix C – References

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**Appendix D – Helpful Information****Units of Radiation Measurement**

<b>Current System</b>	<b><i>Système International</i></b>	<b>Conversion</b>
curie (Ci)	becquerel (Bq)	1 Ci = 3.7 x 10 <sup>10</sup> Bq
rad	gray (Gy)	1 rad = 0.01 Gy
rem	sievert (Sv)	1 rem = 0.01 Sv

**Scientific Notation Used for Units**

<b>Multiple</b>	<b>Decimal Equivalent</b>	<b>Notation</b>	<b>Prefix</b>	<b>Symbol</b>
1 x 10 <sup>3</sup>	1,000	E+03	kilo-	k
1 x 10 <sup>-2</sup>	0.01	E-02	centi-	c
1 x 10 <sup>-3</sup>	0.001	E-03	milli-	m
1 x 10 <sup>-6</sup>	0.000001	E-06	micro-	μ
1 x 10 <sup>-9</sup>	0.000000001	E-09	nano-	n
1 x 10 <sup>-12</sup>	0.000000000001	E-12	pico-	p
1 x 10 <sup>-18</sup>	0.000000000000000001	E-18	atto-	a

**Metric Conversions**

When you know	Multiply by	To Get	When you know	Multiply by	To Get
cm	0.39	in.	in.	2.54	cm
m	3.28	ft	ft	0.305	m
km	0.62	mi	mi	1.61	km
kg	2.21	lb	lb	0.45	kg
L	0.26	gal	gal	3.79	L
L	1.04	quart	quart	0.95	L
hectare	2.47	acre	acre	0.40	hectare
km <sup>2</sup>	0.39	mi <sup>2</sup>	mi <sup>2</sup>	2.59	km <sup>2</sup>
m <sup>3</sup>	35.32	ft <sup>3</sup>	ft <sup>3</sup>	0.03	m <sup>3</sup>
To convert the temperature in degrees Celsius (degrees C) to degrees Fahrenheit (degrees F), use degrees F = 1.8(degrees C) + 32 degrees.					

**Prefixes Used in the Metric System**

Prefix	Abbreviation	Meaning	Example
Giga	G	10 <sup>9</sup>	1 gigameter (Gm) = 1 x 10 <sup>9</sup> m
Mega	M	10 <sup>6</sup>	1 megameter (Mm) = 1 x 10 <sup>6</sup> m
Kilo	k	10 <sup>3</sup>	1 kilometer (km) = 1 x 10 <sup>3</sup> m
Deci	d	10 <sup>-1</sup>	1 decimeter (dm) = 0.1m
Centi	c	10 <sup>-2</sup>	1 centimeter (cm) = 0.01m
Milli	m	10 <sup>-3</sup>	1 millimeter (mm) = 0.001m
Micro	μ <sup>a</sup>	10 <sup>-6</sup>	1 micrometer (μm) = 1 x 10 <sup>-6</sup> m
Nano	n	10 <sup>-9</sup>	1 nanometer (nm) = 1 x 10 <sup>-9</sup> m
Pico	p	10 <sup>-12</sup>	1 picometer (pm) = 1 x 10 <sup>-12</sup> m
Femto	f	10 <sup>-15</sup>	1 femtometer (fm) = 1 x 10 <sup>-15</sup> m

<sup>a</sup> This is the Greek letter mu (pronounced “mew”).

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Pantex Plant, Amarillo, Texas