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NEVADA NATIONAL SECURITY SITE (NNSS)

Environmental Report 2016

September 2017

NNSA
National Nuclear Security Administration

National Security Technologies LLC
Vision • Service • Partnership

A Message from the Manager

The U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO) strives to achieve our missions in a safe, secure, sustainable, and environmentally responsible manner. Our staff, our contractor and laboratory partners, as well as other users of the Nevada National Security Site (NNSS) succeed through demonstrated teamwork, innovation, and continuous improvement.

The NNSA/NFO presents this environmental report to summarize actions taken in 2016 to protect the environment and the public while achieving our mission goals. It is prepared for the public and our stakeholders in hopes that it is readily understandable and usable. It is a key component in our efforts to keep the public informed of environmental conditions at the NNSS and its support facilities in Las Vegas, Nevada. The NNSA/NFO ensures the validity and accuracy of the data contained in this report.

We invite you to help us improve the usefulness and readability of this Environmental Report by providing your comments and concerns to Peter A. Sanders, (peter.sanders@nnsa.doe.gov).

Steven J. Lawrence

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Nevada Field Office
Manager

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Environmental Report 2016

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By:

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Executive Summary

This report was prepared to meet the information needs of the public and the requirements and guidelines of the U.S. Department of Energy (DOE) for annual site environmental reports. It was prepared by National Security Technologies, LLC (NSTec), for the U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO). This and previous years' reports, called Annual Site Environmental Reports (ASERs), Nevada Test Site Environmental Reports (NTSERs), and Nevada National Security Site Environmental Reports (NNSSERs), are posted on the NNSA/NFO website at http://www.nnss.gov/pages/resources/library/NNSSER.html.

Purpose and Scope of the NNSSER

This NNSSER was prepared to satisfy DOE Order DOE O 231.1B, "Environment, Safety and Health Reporting." Its purpose is to (1) report compliance status with environmental standards and requirements, (2) present results of environmental monitoring of radiological and nonradiological effluents, (3) report estimated radiological doses to the public from releases of radioactive material, (4) summarize environmental incidents of noncompliance and actions taken in response to them, (5) describe the NNSA/NFO Environmental Management System and characterize its performance, and (6) highlight significant environmental programs and efforts.

This NNSSER summarizes data and compliance status for calendar year 2016 at the Nevada National Security Site (NNSS) and its two support facilities, the North Las Vegas Facility (NLVF) and the Remote Sensing Laboratory–Nellis (RSL-Nellis). It also addresses environmental restoration (ER) projects conducted at the Tonopah Test Range (TTR) and the Nevada Test and Training Range (NTTR). Through a Memorandum of Agreement, NNSA/NFO is responsible for the oversight of these ER projects, and the Sandia Field Office of NNSA (NNSA/SFO) has oversight of all other TTR and NTTR activities. NNSA/SFO produces the TTR annual environmental report, which is available at http://www.sandia.gov/news/publications/environmental/index.html.

Major Site Programs and Facilities

NNSA/NFO directs the management and operation of the NNSS and six sites across the nation. The six sites include two in Nevada (NLVF and RSL-Nellis) and four in other states (RSL-Andrews in Maryland, Livermore Operations in California, Los Alamos Operations in New Mexico, and Special Technologies Laboratory in California). Los Alamos, Lawrence Livermore, and Sandia National Laboratories are the principal organizations that sponsor and implement the nuclear weapons programs at the NNSS. NSTec is the current Management and Operating contractor accountable for the successful execution of work and ensuring that work is performed in compliance with environmental regulations. The six sites all provide support to enhance the NNSS as a location for weapons experimentation and nuclear test readiness.

The three major NNSS missions include National Security/Defense, Environmental Management, and Nondefense. The major programs that support these missions are Stockpile Stewardship and Management, Nonproliferation and Counterterrorism, Nuclear Emergency Response, Strategic Partnership Projects, Environmental Restoration, Waste Management, Conservation and Renewable Energy, Other Research and Development, and Infrastructure. The major facilities that support the programs include the U1a Facility, Big Explosives Experimental Facility (BEEF), Device Assembly Facility, Dense Plasma Focus Facility, Joint Actinide Shock Physics Experimental Research Facility, Radiological/Nuclear Countermeasures Test and Evaluation Complex, Nonproliferation Test and Evaluation Complex (NPTEC), Radiological/Nuclear Weapons of Mass Destruction Incident Exercise Site (known as the T-1 Site), Area 5 Radioactive Waste Management Complex (RWMC), and the Area 3 Radioactive Waste Management Site (RWMS).

Other Key Environmental Initiatives

In addition to the environmental restoration efforts to clean up legacy contamination from historical nuclear testing activities, NNSA/NFO pursues several other environmental key initiatives. They are components of the Nondefense mission of NNSA/NFO to prevent pollution, minimize waste generation, conserve water, advance energy efficiency, reduce fossil fuel use, pursue renewable energy sources, and support the federal goals within all of these areas promulgated through executive orders and DOE orders. These initiatives are pursued through the Energy Management Program and the Pollution Prevention and Waste Minimization (P2/WM) Program discussed below.

Environmental Performance Measures Programs

During the conduct of the major programs mentioned above, NNSA/NFO complies with applicable environmental and public health protection regulations and strives to manage the NNSS as a unique and valuable national resource. To identify NNSS environmental initiatives, NNSA/NFO implements an Integrated Safety Management System (ISMS) and an Environmental Management System (EMS). The ISMS is designed to ensure the systematic integration of environment, safety, and health concerns into management and work practices so that NNSS missions are accomplished safely and in a manner that protects the environment. NNSA/NFO oversees ISMS implementation through the Integrated Safety Management Council.

The NSTec EMS is designed to incorporate concern for environmental performance throughout NNSA/NFO programs and activities, with the ultimate goal being continual reduction of program impacts on the environment. NSTec's EMS attained International Organization for Standardization (ISO) 14001 certification in 2008. The ISO 14001 certifying organization, Lloyd's Register Quality Assurance (LRQA) recertified the EMS for another 3 years in June 2014. LRQA conducts annual surveillances on focused portions of the EMS, and findings and recommendations are tracked in the NSTec companywide issues tracking system, caWeb. In addition, internal independent audits, management assessments, and compliance evaluations are conducted annually to promote continual improvement. In March 2016, the LRQA conducted its annual surveillance, and no major nonconformities were identified. An internal audit of waste management was conducted in November 2016 and identified one opportunity for improvement which was resolved. NSTec also conducted a total of one internal management assessment and 43 compliance evaluations during 2016.

Each fiscal year (FY) (October 1 through September 30), an Environmental Working Group (EWG) helps determine what EMS objectives and targets will be worked on and tracked to address specific environmental aspects of NNSA/NFO operations. Some of the EMS objectives and targets support DOE in attaining their complex-wide site sustainability goals, which are published annually in a DOE Strategic Sustainability Performance Plan (SSPP), and implemented and tracked through the Energy Management Program (EMP) and the P2/WM Program. In 2016, the EWG identified the following targets: increase NSTec's oversight of air quality and waste aspects of NNSA/NFO operations, reduce the number of stored chemical containers, and identify bio-based and environmentally preferable products that can be purchased through the Just-in-Time (JIT) purchasing system catalog to replace products which are not. These targets were met (Chapter 3, Table 3-1). Two other EMS targets were to reduce energy intensity and to achieve High Performance Sustainable Buildings certification for additional qualifying buildings. These targets were not met in 2016, but they are ongoing goals, for which their progress is tracked annually under the EMP.

The EMP advances energy efficiency, water conservation, fossil fuel reduction, greenhouse gas reduction, and the use of solar and other renewable energy sources at the NNSS, NLVF, and RSL-Nellis. EMP personnel prepare an annual NNSA/NFO Site Sustainability Plan (SSP), which describes all of the DOE SSPP goals, NNSA/NFO's current performance status towards reaching each goal, and the planned actions to meet each goal. As of the end of 2016, NNSA/NFO has met 19 of the 33 DOE long-term sustainability goals (Chapter 3, Table 3-2).

The P2/WM Program promotes activities that reduce or eliminate waste generation, reduce the release of pollutants to the environment, and reduce the use of ozone-depleting substances. In 2016, 28% of non-hazardous solid waste and 23% of construction waste was diverted from disposal in NNSS landfills through re-use and recycling. The DOE SSPP target goals for FY 2016 were 50% for both. These goals may not be reached on the NNSS without additional funding.

The 2016 Facility EMS Annual Report Data for the NNSS was entered into the DOE Headquarters' EMS database. The report includes a scorecard section that is a series of questions regarding a site's EMS effectiveness in meeting the objectives of federal EMS directives. The NNSS scored "green" (the highest score) in 2016. Progress towards meeting EMS goals and DOE sustainability goals is summarized in Chapter 3.

Environmental Awards

The NNSS was recognized in 2016 for having one of the cleanest, most fuel-efficient government vehicle fleets in the nation. Competing with more than 38,000 public fleets, NSTec's Fleet, Fuel & Equipment Service operation was ranked 18th in the nation by the 100 Best Fleets, Green Fleet Awards Organization within the category of Government Green Fleets. To be recognized for having a top fleet, a company must demonstrate vision, outstanding operations, and strategic planning toward the future environmental role of their fleet that other public fleets can emulate; reduction in greenhouse gas emissions; and fleet composition demonstrating a commitment to the use of hybrid vehicles, plug-in electric vehicles, and alternative fueled vehicles (AFVs). Candidates must demonstrate fleet utilization goals that validate a strong commitment to a "green" approach toward keeping the environment clean. NSTec's fleet in FY 2016 comprised 984 vehicles ranging from sedans to large trucks. Ninety-six percent of the new light-duty vehicles leased in 2016 (110 of the 114) are either AFVs, zero emission, or plug-in hybrid electric vehicles.

> Throughout this document, the definition of word(s) that are in ***bold italics*** may be found by clicking on Glossary, Appendix B adjacent to the word(s). To return from the Glossary, right click and select Previous View.

Compliance

One measure of the effectiveness of the EMS is the degree of compliance with applicable environmental laws, regulations, and policies that protect the environment and the public from the effects of NNSA/NFO operations. In 2016, NNSA/NFO complied with all federal statutes, as shown below.

Federal Statute	What it Covers	2016 Status
Radiation Protection		
DOE O 458.1, "Radiation Protection of the Public and the Environment" (and its predecessor of the same name, DOE O 5400.5)	Measuring radioactivity in the environment and estimating radiological dose to the public due to NNSA/NFO activities	Radiological monitoring was conducted by NNSA/NFO at 17 onsite air stations, 5 offsite and 18 onsite groundwater sources, and 103 stations measuring direct ***gamma radiation*** (see Glossary, Appendix B). Six plant and 6 small mammal samples from 1 study site and its control site, 15 muscle samples of large game animals, and 2 blood and 6 scat samples from 2 radio-collared mountain lions were collected to monitor biota. The dose to the ***maximally exposed individual (MEI)*** (see Glossary, Appendix B) from all exposure pathways due to NNSA/NFO activities was estimated to be 1.53 millirem per year (mrem/yr), well below the DOE limit of 100 mrem/yr. The majority of this dose (1.50 mrem/yr) is estimated to come from the ingestion of game animals.
Atomic Energy Act (through compliance with DOE O 435.1, "Radioactive Waste Management")	Management of ***low-level waste (LLW)*** and ***mixed low-level waste (MLLW)*** (see Glossary, Appendix B) generated or disposed on site	895,695 cubic feet of radioactive wastes including LLW, MLLW, and non-radioactive classified items were received and disposed on site. All amounts of disposed radiological wastes for permitted disposal units were within permit limits. All vadose zone and groundwater monitoring continued to verify that disposed LLW and MLLW are not migrating to groundwater or threatening biota or the environment.
Air Quality and Protection		
Clean Air Act: National Emission Standards for Hazardous Air Pollutants (NESHAP) National Ambient Air Quality Standards (NAAQS) New Source Performance Standards (NSPS) Stratospheric Ozone Protection	Air quality and emissions into the air from facility operations	There are no major sources of ***criteria pollutants*** (see Glossary, Appendix B) or ***hazardous air pollutants*** (see Glossary, Appendix B) at the NNSS, NLVF, or RSL-Nellis. Monitored radioactive air emissions were below NESHAP's limits. All non-radiological air emission limits as well as all monitoring, record keeping, training, and reporting requirements of state and county air permits were met with one exception: a generator at RSL-Nellis exceeded its opacity limits. The 17 onsite continuous air sampling stations detected man-made ***radionuclides*** (see Glossary, Appendix B) at levels comparable to previous years and well below the regulatory dose limit for air emissions to the public of 10 mrem/yr. The estimated dose from all 2016 NNSS air emissions to the MEI is 0.034 mrem/yr.

Federal Statute	What it Covers	2016 Status
Water Quality and Protection		
Clean Water Act (CWA)	Water quality and effluent discharges from facility operations	All required maintenance, monitoring, and reporting were conducted for permitted wastewater systems and monitoring wells. All domestic and industrial wastewater systems and groundwater monitoring well samples were within permit limits for regulated water contaminants and water chemistry parameters. Pumped groundwater samples at the NLVF were all within National Pollutant Discharge Elimination System (NPDES) permit limits. NNSS operations do not require any NPDES permits.
Safe Drinking Water Act (SDWA)	Quality of drinking water	All three permitted ***public water systems (PWSs)*** (see Glossary, Appendix B) on the NNSS met the applicable national and state water quality standards.
Waste and Hazardous Materials Management and Environmental Restoration		
Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)/Superfund Amendments and Reauthorization Act (SARA)	Cleanup of waste sites containing hazardous substances	No ***hazardous waste (HW)*** (see Glossary, Appendix B) cleanup operations on the NNSS are regulated under CERCLA or SARA; they are regulated under the Resource Conservation and Recovery Act (RCRA) instead. The requirements of CERCLA applicable to the NNSS pertain to an emergency response program for hazardous substance releases (see Emergency Planning and Community Right-to-Know Act [EPCRA] below) and to how state laws concerning the removal and remediation of hazardous substances apply to federal facilities (specifically, implementation of the Federal Facility Agreement and Consent Order [FFACO]).
Federal Facility Agreement and Consent Order (FFACO)	Cleanup of waste sites containing hazardous substances	All 2016 milestones established under the FFACO with the State of Nevada were met for conducting corrective actions and closures of historical contaminated sites called corrective action sites (CASs). A total of 14 CASs were closed in accordance with state-approved corrective action plans.
Resource Conservation and Recovery Act (RCRA)	Generation, management, and/or disposal of HW and MLLW and cleanup of inactive, historical waste sites	A total of 907 tons of MLLW were received and disposed in Cell 18; 0.79 tons of HW and 0.137 tons of polychlorinated biphenyl (PCB) waste were received for onsite storage at the Hazardous Waste Storage Unit (HWSU); and 0.71 tons of HW and 0.10 tons of PCB waste were shipped for offsite disposal from the HWSU, all in accordance with state permits. No HW were shipped directly off site from Hazardous Waste Accumulation Areas, and no waste explosive ordnance were detonated on site. Semiannual water samples from three groundwater monitoring wells at the Area 5 RWMC confirmed that buried MLLW remains contained. All vadose zone monitoring and post-closure inspections of historical RCRA closure sites confirmed the sites' integrity to contain HW.
National Environmental Policy Act (NEPA)	Projects are evaluated for environmental impacts	NNSA/NFO evaluated 41 projects; 12 of them were exempted from further NEPA analysis due to their inclusion under previous analysis in the *Site-Wide Environmental Impact Statement for the Nevada National Security Site and Offsite Locations in Nevada* published in 2014, and 29 were exempted as categorical exclusions under NEPA.
Toxic Substances Control Act (TSCA)	Management and disposal of PCBs	One drum of PCB ballasts was shipped off site to a permitted disposal and treatment facility.

Federal Statute	What it Covers	2016 Status
Waste and Hazardous Materials Management and Environmental Restoration (continued)		
Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)	Storage and use of pesticides and herbicides	Only non-restricted-use pesticides/herbicides were applied by State of Nevada–certified personnel. Storage and use of pesticides were in compliance with federal and state regulations.
Emergency Planning and Community Right-to-Know Act (EPCRA)	The public's right to know about chemicals released into the community	No accidental or unplanned release of an extremely hazardous substance occurred at the NNSS, NLVF, or RSL-Nellis. The chemical inventory for NNSS, NLVF, and RSL-Nellis was updated and submitted to the State of Nevada. As part of routine activities and cleanup operations, reportable quantities of lead, mercury, and PCBs were released at the NNSS in 2016 and reported to the U.S. Environmental Protection Agency. Releases included onsite releases and disposal, offsite disposal, and offsite recycling, and totaled 120,720 pounds (lb) of lead, 5,154 lb of mercury, and 15.7 lb of PCBs.
Other Environmental Statutes		
Endangered Species Act (ESA)	Threatened or endangered species of plants and animals	Field surveys for 6 proposed projects in desert tortoise habitat and 10 projects in other habitats on the NNSS were conducted; 0.35 acres of tortoise habitat were disturbed. No tortoises were harmed at or displaced from project sites. One tortoise was accidentally killed by a vehicle on a paved road, and 17 were moved off of roads out of harm's way. All actions were in compliance with the U.S. Fish and Wildlife Service's requirements for work conducted in desert tortoise habitat.
National Historic Preservation Act (NHPA)	Identifying and preserving historic properties	NNSA/NFO maintained compliance with the NHPA. Surveys and evaluations for 13 projects were conducted; 900 acres were surveyed; and 66 cultural resources were identified, 20 of which were determined eligible to the National Register of Historic Places.
Migratory Bird Treaty Act (MBTA)	Protecting migratory birds, nests, and eggs from harm	Biologists rescued and released three grounded birds; the NSTec Power Group retrofitted two NNSS powerline poles with bird guards and protective covers to reduce raptor electrocutions; the draft NNSA/NFO Avian Protection Plan was submitted to the FWS for review; and winter raptor surveys were conducted. Eleven accidental bird deaths due to human activities were documented.

Occurrences and Unplanned Releases

No unplanned airborne releases and no unplanned releases of radioactive liquids occurred from the NNSS, NLVF, or RSL-Nellis in 2016. There were three DOE-reportable environmental occurrences in 2016 related to finding radioactive contamination outside of areas posted, controlled, and monitored for radiological contamination. They included finding pieces of contaminated debris outside posted radiological areas of legacy-contaminated Corrective Action Units (CAUs), two on the NNSS and one on the TTR. Areas surrounding the contaminated legacy debris at the CAUs were immediately posted as contamination areas. No personnel or equipment contamination occurred (see Table 2-8 of Chapter 2). Nineteen minor spills of hazardous materials occurred in 2016, 17 of which consisted of small-volume releases either to containment areas or to other surfaces and did not exceed a reportable quantity. Two of the spills met regulatory agency reporting criteria and included the release of 25 gallons of oil from a transformer damaged while being loaded into a truck on the NNSS, and the discovery of over 300 cubic yards of oil-contaminated soil at an NNSS transformer yard. All releases were cleaned up.

Corrective actions were taken in 2016 when a container of non-hazardous low-level waste, which was received from Nuclear Fuel Services (NFS) in August 2015 for burial at the NNSS, was subsequently identified by NFS in June 2016 as containing hazardous LLW. NNSA/NFO removed the container from the waste disposal cell permitted under the RCRA for only non-hazardous LLW, and then safely shipped the container back to the NFS. A DOE Occurrence Report was submitted to DOE as a Management Concern regarding the waste certification and shipping method used by NFS.

Radiation Dose to the Public

Background Gamma Radiation – Mean ***background*** (see Glossary, Appendix B) gamma radiation exposure rates on the NNSS are estimated using 10 ***thermoluminescent dosimeter (TLD)*** (see Glossary, Appendix B) stations located away from radiologically contaminated sites. The average mean exposure rate among these 10 stations in 2016 was 120 milliroentgen per year (mR/yr) and ranged from 79 to 168 mR/yr (Section 6.3.1). The Desert Research Institute (DRI) used TLDs at 23 offsite locations in 2016, and their mean measurements ranged from 85 mR/yr at Pahrump, Nevada, to 145 mR/yr at both Milford, Utah and Beatty, Nevada (Section 7.1.4).

Public Dose from Direct Radiation – Areas accessible to the public had direct external gamma radiation exposure rates in 2016 comparable to natural background rates. The TLD locations on the west and north sides of the parking area at Gate 100 (the NNSS entrance gate) had estimated annual mean exposures of 103 and 64 mR/yr, respectively, similar to the range of background exposures observed on the NNSS (Section 6.3.2). Military or other personnel on the NTTR could be exposed to direct radiation from legacy sites on Frenchman Lake playa. A TLD location in the playa and near the NNSS boundary with NTTR had an estimated annual exposure of 247 mR (Section 6.3.2). This represents an above-background exposure of 79 to 168 mrem/yr (depending on which background radiation value is subtracted), which might exceed the 100 mrem/yr dose limit if a member of the public were to reside at this location. However, there are no living quarters or full-time personnel in that area. Because the nearest resident does not live in close proximity of the site, there is no dose contribution from external gamma radiation from NNSS operations to the public.

Public Dose from Drinking Water – Man-made radionuclides from past nuclear testing have not been detected in offsite drinking water supply wells or springs in the past or during 2016 (Sections 5.1.3.5, 7.2, and 7.3). Therefore, there is no dose contribution from drinking water to the public due to NNSS operations.

Public Dose from Inhalation – The radiation dose limit to the public via the air transport pathway is established by NESHAP under the Clean Air Act to be 10 mrem/yr. The U.S. Environmental Protection Agency (EPA), Region 9, has approved the use of six air sampling stations on the NNSS to verify compliance with this dose limit. The following radionuclides were detected in samples from at least one of the ***critical receptor samplers*** (see Glossary, Appendix B): americium-241 (^{241}Am), plutonium-238 (^{238}Pu), plutonium-239+240 ($^{239+240}$Pu), cesium-137 (^{137}Cs), and ***tritium*** (see Glossary, Appendix B) (^{3}H) (Section 4.1.4). Concentrations of these radionuclides at each of the stations indicated that the NESHAP dose limit to the public was not exceeded. The Schooner station in the far northwest corner of the NNSS showed the highest concentrations of radioactive air emissions (Section 4.1.5). The Gate 510 sampler, however, is the closest station to a public receptor (3.5 kilometers [km] [2.2 miles (mi)]). The estimated ***effective dose equivalent*** (see Glossary, Appendix B) from air emissions for a hypothetical individual living year-round at the Gate 510 sampler would be 0.034 mrem/yr.

Public Dose from Ingestion of Radionuclides in Game Animals – Game animals are analyzed for their radionuclide content to estimate the dose to the public who might consume these animals if they were to move off the NNSS and be harvested by hunters. In 2016, tissue samples were collected from one cottontail rabbit and two jackrabbits from each of two locations: the T2 legacy contaminated study site and its control site. Also, muscle tissue from four pronghorn antelope accidentally killed on NNSS roads and from 11 NNSS mule deer killed by radio-collared mountain lions were sampled. An individual who consumes one mule deer having radionuclide concentrations similar to a 2016 sampled mule deer that had the highest concentrations among all game species sampled in 2016 may receive an estimated 1.50 mrem/yr dose (Section 9.1.1.2).

Public Dose from All Pathways – The radiation dose limit to the general public via all possible transport pathways (over and above background dose) established by DOE is 100 mrem/yr. The public dose from all NNSS pathways in 2016 was estimated to be 1.53 mrem/yr. This is 1.53% of the 100 mrem/yr dose limit and about 0.80% of the total dose the MEI receives from natural background radiation (360 mrem/yr) (Section 9.1.3).

Monitoring of Radiological Releases into Air

Offsite – An offsite radiological air monitoring program is run by the Community Environmental Monitoring Program (CEMP) and is coordinated by DRI of the Nevada System of Higher Education under contract with NNSA/NFO (Chapter 7). It is a non-regulatory public informational and outreach program, and its purpose is to provide monitoring for radionuclides that might be released from the NNSS. A network of 24 CEMP stations monitor gross ***alpha*** and ***beta radioactivity*** (see Glossary, Appendix B) in airborne particulates using low-volume particulate air samplers, penetrating gamma radiation using TLDs, gamma radiation exposure rates using pressurized ion chamber (PIC) detectors, and meteorological parameters using automated weather instrumentation. The stations are located in selected towns and communities of southern Nevada, southeastern California, and southwestern Utah. DRI also manages four stations having only automated weather instrumentation that are located on private ranches.

As in previous years, no airborne radioactivity related to historical or current NNSS operations was detected in any of the samples from the CEMP particulate air samplers during 2016. TLD and PIC detectors measure gamma radiation from all sources: natural background radiation from cosmic and terrestrial sources and man-made sources. The offsite TLD and PIC results remained consistent with previous years' background levels and are well within background levels observed in other parts of the United States.

Onsite – Radionuclide emissions on the NNSS are from the following sources: (1) evaporation of tritiated water from containment ponds; (2) diffusion of tritiated water vapor from soil at the Area 3 RWMS, the Area 5 RWMC, and historical surface or near-surface nuclear device test locations (particularly Sedan and Schooner Craters); (3) resuspension of contaminated soil at historical surface or near-surface nuclear device test locations; and (4) release of radionuclides from current operations. A network of 17 air sampling stations and a network of 103 TLDs on the NNSS were used to monitor onsite radioactive emissions.

Total radiological atmospheric releases from the NNSS in curies (Ci) for 2016 (Section 4.1.8) are shown in the table below. An estimated 0.0021 Ci of tritium were released at the NLVF.

^{3}H	^{85}Kr	Noble Gases (T½* <40 days)	Total Radio-iodine	Total Radio-strontium	Other Fission and Activation Products (T½ >3 hr)	Short-Lived Fission and Activation Products (T½ <3 hr)	Plutonium	Other Actinides
210	0.00016	305.6	0.068	0.055	0.06	1.90	0.041 (^{238}Pu) 0.29 ($^{239+240}Pu$)	0.069 (^{241}Am) 0.019 (DU)**

* T ½ = half-life **DU = depleted uranium

The mean tritium concentration in air samples from across all tritium sampling stations was 5.67×10^{-6} picocuries per milliliter (pCi/mL) and ranged from below detection to 236.28×10^{-6} pCi/mL at the Schooner station (Section 4.1.4.6). The mean annual exposure rate for direct gamma radiation at the 41 TLDs located near active projects, working personnel, and public access areas was 116 mR, slightly less than the mean of 120 mR for the 10 NNSS stations that measure natural background levels (Section 6.3).

Monitoring of Radionuclides in Water

Offsite – An offsite monitoring program for tritium in groundwater sampled from community or private wells is run by the CEMP and coordinated by DRI (Section 7.2). In 2016, the CEMP sampled groundwater for tritium in one community well from each of four communities: Tecopa (in California) and Amargosa Valley, Beatty, and Sarcobatus Flats (all in Nevada). These groundwater wells are located within the regional groundwater flow system that are downgradient or perceived to be downgradient of the NNSS. Tritium concentrations in the four wells in 2016 were all below analytical detection limits (Section 7.2.3).

NNSA/NFO has a network of offsite groundwater sampling locations that is part of a larger onsite and offsite network established for the purpose of the safe closure-in-place of five known areas of groundwater contamination on the NNSS called underground test area (UGTA) corrective action units (CAUs) (Section 11.1). The sampling network includes eight NTTR Characterization wells (wells used to support the objectives of groundwater characterization and of modeling the flow of man-made radionuclides downgradient from historical underground nuclear tests), two NTTR Early Detection wells (wells that are the first wells downgradient of an underground nuclear test or a Source/Plume well, but which currently contain no radiological contaminants above background levels), one NTTR Distal well (a well farther downgradient from Early Detection wells), and nine Community water sources that are on Bureau of Land Management (BLM) or private lands. In 2016, NNSA/NFO sampled three of the eight Characterization wells, one of the two Early Detection wells, and one of the two Distal wells on NTTR. Tritium was detected at low levels (194 pCi/L) in only one of these sampled NTTR wells, PM-3 (Section 5.1.1.3.1). Sample results collected to date, along with future sampling of the NTTR wells and modeling will be used to further develop flow and transport contamination models of the area.

Twenty other offsite downgradient wells, all within Nye County, were sampled in 2016 under Nye County's new Tritium Sampling and Monitoring Program supported by NNSA/NFO (Section 7.3). The DOE Environmental Management (EM) office issued a 5-year grant to Nye County for this program, expanding its support of offsite community-based groundwater monitoring. The grant supports annual sampling of 10 wells in the first year (2015) and up to 20 wells every year thereafter. Nye County did not detect tritium in any of the 20 wells.

Offsite water monitoring conducted in 2016 and over the past decade continues to verify that there are no man-made radionuclides from NNSS underground contamination areas in any public or private water supply wells or springs being monitored.

Onsite – NNSA/NFO's groundwater sampling network on the NNSS includes 23 Characterization wells (three of which were added in 2016), 20 Source/Plume wells (wells that contain contaminated groundwater verified to originate from NNSS underground nuclear testing and that are within the detonation region or are downgradient of the detonation at the plume edge), eight Early Detection wells, and six Distal wells. NNSA/NFO also samples annually six permitted NNSS PWS wells and five onsite locations called Compliance wells/surface waters, which are monitored to demonstrate compliance with specific federal/state regulations or NNSS permits.

In 2016, NNSA/NFO sampled seven Characterization, three Source/Plume, one Early Detection, and two Distal wells on the NNSS for tritium. Of these, one of the Characterization and three of the Source/Plume had elevated tritium levels, as they have in previous years (Sections 5.1.3.1 and 5.1.3.2). Along with data from the offsite wells in the groundwater sampling network, data from all onsite wells are being used to aid in the development of a long-term closure monitoring network for each of the five known areas of groundwater contamination on the NNSS. The monitoring well networks will provide an early warning and allow for protective measures to be taken if contaminants are detected. The network will also comply with all corrective actions established under the FFACO with the State of Nevada (Section 11.1). In 2016, one of the known areas of groundwater contamination, the Frenchman Flat CAU, reached the State-approved closure phase of a CAU under the FFACO.

In 2016, the six NNSS PWS wells were sampled for tritium, gross alpha and gross beta radioactivity, and for uranium (Section 5.1.3.6). PWS water samples were analyzed for uranium to establish a baseline. None of the PWS wells had detectable concentrations of tritium. Detectable gross alpha and gross beta radioactivity found in many of the PWS well samples likely represents the presence of naturally occurring radionuclides, and none exceeded their EPA allowable limits for drinking water. Uranium was found at very low concentrations and is believed to be naturally occurring. Uranium levels were 1.2 to 23% of the EPA allowable limits for drinking water.

In 2016, the five onsite Compliance wells/surface waters were sampled for tritium and for gross alpha and gross beta radioactivity. They include three RCRA permitted wells for the Area 5 Mixed Waste Disposal Unit and one monitoring well and a series of holding ponds for the NDEP permitted E Tunnel Wastewater Disposal System in Area 12. All water samples were within their permit limits for these analytes (Section 5.1.3.7). Groundwater and drilling fluids discharged from wells monitored in 2016 were also sampled and found to be below the fluid management criteria limits for selected radiological and non-radiological parameters (Section 5.1.3.7.3).

Release of Property Containing Residual Radioactive Material

No property can be released from the NNSS unless the amount of residual radioactivity on the property is less than the authorized limits, which are consistent with DOE O 458.1. Items proposed for unrestricted release are either surveyed (physically sampled), or a process knowledge evaluation is conducted to verify that the material has not been exposed to radioactive material or beams of radiation capable of generating radioactive material. In 2016, 232 pieces of laboratory equipment, 16 vehicles, 2 pieces of heavy equipment, 11 trailers, 34.9 miles of ground surface laid cable, and 359,500 pounds of scrap metal were released off site to the public (Section 9.1.5). In addition, 89,420 pounds of lead in waste (e.g., lead acid batteries) were released to vendors for recycling or reuse (Section 2.4.4.1). No released items had residual radioactivity in excess of the authorized limits.

Onsite Nonradiological Releases into Air

The release of air pollutants is regulated on the NNSS under a Class II air quality operating permit. Class II permits are issued for minor sources where annual emissions must not exceed 100 tons of any one criteria pollutant, 10 tons of any one of the 189 hazardous air pollutants (HAPs), or 25 tons of any combination of HAPs. Criteria pollutants include sulfur dioxide, nitrogen oxides (NO_x), carbon monoxide, particulate matter, and volatile organic compounds. The NNSS facilities regulated by the permit include (1) approximately 14 facilities and 131 pieces of equipment throughout the NNSS, (2) NPTEC, (3) Site-Wide Chemical Release Areas, (4) BEEF, (5) Explosives Ordnance Disposal Unit, and (6) Explosives Activities Sites in Areas 5, 14, 25, 26, and 27.

An estimated 12.14 tons of criteria air pollutants were released on the NNSS in 2016 (Section 4.2.3). The majority was NO_x from diesel generators. Total HAPs emissions from permitted operations was 0.02 tons. Lead air emissions from non-permitted activities, such as weapons use, are reported to the EPA, and this quantity in 2016 was 1.77 pounds (Section 2.4.4.1). No emission limits for any criteria air pollutants or HAPs were exceeded.

One chemical release test series was conducted in 2016 at the NPTEC in Area 5. The series consisted of 16 small releases conducted over a 2-day period. The second test took place over 8 days and involved 34 releases (Section 4.2.6). The chemicals released were non-regulated; thus, no permit limits were exceeded. In 2016, explosives were detonated at the BEEF, Port Gaston, and in Area 15; no permit limits were exceeded.

Onsite Nonradiological Releases into Water

There are no liquid discharges to navigable waters, offsite surface water drainage systems, or publicly owned treatment works resulting from operations on the NNSS. Therefore, no Clean Water Act NPDES permits are required for operations on the NNSS. Industrial discharges on the NNSS are limited to three operating sewage lagoon systems: the Area 6 Yucca Lake, the Area 23 Mercury, and the Area 6 Device Assembly Facility (DAF) systems. Sewage systems are monitored quarterly for influent quality and flow rate. Influent water samples are analyzed for 5-day biological oxygen demand, total suspended solids, and pH. In 2016, all water quality results were within the permit limits (Section 5.2.3.1). The Area 6 DAF sewage system exceeded its flow limit, but NDEP issued a waiver for the exceedance. Groundwater that drains from E Tunnel in Area 12, sampled for nonradiological contaminants (mainly metals), had levels of contaminants below permit limits (Section 5.2.4).

Nonradiological Releases into Air and Water at NLVF and RSL-Nellis

Sources of air pollutants at the NLVF and RSL-Nellis are regulated by permits from the Clark County Department of Air Quality. The regulated sources of air emissions include an abrasive blaster, an aluminum sander, a spray paint booth, diesel and gasoline generators, fire pumps, cooling towers, and boilers. The calculated total emissions of criteria pollutants at NLVF and RSL-Nellis in 2016 were 2.68 and 4.02 tons per year, respectively (Appendix A, Sections A.1.1 and A.2.1). HAPs emissions are minor and are not regulated at either the NLVF or RSL-Nellis.

Water discharges at the NLVF are regulated by a permit with the City of North Las Vegas (CNLV) for sewer discharges and by an NPDES discharge permit issued by the Nevada Division of Environmental Protection for dewatering operations to control rising groundwater levels that surround the facility (Appendix A, Section A.1.2).

The NPDES permit authorizes the discharge of pumped groundwater to the groundwater of the state via percolation and to the Las Vegas Wash via the CNLV storm drain system. In 2016, the discharge from pumped groundwater did not exceed NPDES permit limits, and samples of the pumped groundwater analyzed in 2016 had water quality measurements that were all below permit limits. Sewer discharge waters at the NLFV are no longer required to be sampled and analyzed for various contaminants. NLVF operates under a Storm Water No Exposure Waiver which specifies that storm water discharges from the NLVF will not be exposed to industrial activities or materials. In 2016, no storm water exposures to such activities or materials occurred.

No wastewater quality monitoring is required by the Clark County Water Reclamation District (CCWRD) at RSL-Nellis (Appendix A, Section A.2.2). Instead, a Zero Discharge Form is submitted annually to the CCWRD.

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Acknowledgements

The Ecological and Environmental Monitoring (E&EM) group of National Security Technologies, LLC (NSTec), is responsible for producing this document for the U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO). Each year, the production of the annual Nevada National Security Site Environmental Report (NNSSER) requires the knowledge, skill, experience, and cooperation of many people and organizations.

Contributing Subject Matter Experts

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Contributing Organizations

NSTec

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Navarro Research and Engineering, Inc. (Navarro)

Navarro provided data and discussion in Chapters 5 and 11 regarding their design, sampling, and analysis results of the NNSS Integrated Groundwater Sampling Plan that addresses the legacy contamination of historical nuclear underground test areas (UGTAs). In Chapter 11, Navarro provided summary information of their characterization and remediation work towards State-approved closure of UGTA, Industrial, and Soils corrective action sites, and post-closure monitoring of Soil corrective action sites. In Chapter 14, Navarro provided data quality assurance information related to collected and analyzed UGTA groundwater samples. In Chapter 10, Navarro provided a description of their activities to verify that a designated percentage of mixed waste and classified hazardous materials and waste are appropriately packaged for receipt at the NNSS.

Desert Research Institute (DRI)

The Division of Hydrologic Sciences of DRI authored Chapters 7 and 15, reporting on their offsite radiological monitoring of air and groundwater within communities surrounding the NNSS and on their data quality assurance program. The Division of Hydrologic Sciences reported in Chapter 11 on their newly initiated post-closure monitoring of the Frenchman Flat UGTA corrective action unit. Also in Chapter 11, the DRI divisions of Hydrologic Sciences and Atmospheric Sciences reported on their soil and meteorological monitoring at two NNSS Soils corrective action units. The Division of Earth and Ecosystem Sciences of DRI authored Chapter 12, summarizing their annual activities managing cultural resources on the NNSS. Harold Drollinger of the Division of Earth and Ecosystem Sciences provided the synoptic description of the prehistory and history of the NNSS, which is included in *Attachment A: Site Description* on the compact disc of this report.

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ARL/SORD provided summary descriptions of the NNSS climate that are included in *Attachment A: Site Description* on the compact disc of this report.

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E&EM Support Staff

The following individuals within NSTec E&EM are responsible for the numerous tasks that are integral to the collection, quality assurance, and quality control of much of the environmental data provided in this NNSSER.

Terrence P. Sonnenburg supervised and coordinated field sampling operations and assisted with field sampling.

Elizabeth Burns was responsible for radiological monitoring data verification, validation, and review; quality assurance oversight; administration of the data management system; and she assisted with field sampling.

Martin D. Cavanaugh and Matthew O. Weaver conducted field sampling and supported work requested from other agencies/departments.

Catherine D. Castaneda was responsible for sample management supporting the sub-contracting of environmental analytical services.

Lynn N. Jaussi managed laboratory operations for sample screening and processing.

Theodore J. Redding, the E&EM manager, provided oversight for radiological monitoring data verification, validation, and review; quality assurance; and sample management.

NSTec Report Production and Distribution Support Personnel

The following individuals were responsible for improving the quality, appearance, and timely production and distribution of this NNSSER.

Ashley Burns and **Chad Ricks** worked with all the authors to produce the high-quality GIS-generated maps and figures.

Shirley Burns provided a thorough review of this document to ensure spelling, format, grammar, references, tables, figures, acronyms, table of contents, etc., were all in order, and assisted with creating the final electronic files of the report for Internet posting and burning onto compact disc.

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Chapter 1: Introduction and Helpful Information

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1.1 Site Location

The U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO) (called the Nevada Site Office [NNSA/NSO] prior to March 2013) directs the management and operation of the Nevada National Security Site (NNSS). The NNSS is located in Nye County in south-central Nevada (Figure 1-1). The southeast corner of the NNSS is about 88 kilometers (km) (55 miles [mi]) northwest of the center of Las Vegas in Clark County. By highway, it is about 105 km (65 mi) from the center of Las Vegas to Mercury. Mercury, at the southern end of the NNSS, is the main base camp for worker housing and administrative operations for the NNSS.

The NNSS encompasses about 3,522 square kilometers (km^2) (1,360 square miles [mi^2]) based on the most recent land survey. It varies from 46 to 56 km (28 to 35 mi) in width from west to east and from 64 to 88 km (40 to 55 mi) from north to south. The NNSS is surrounded on all sides by federal lands (Figure 1-1). It is bordered on the west and north by the Nevada Test and Training Range (NTTR), on the east by an area used by both the NTTR and the Desert National Wildlife Range, and on the south and southwest by Bureau of Land Management lands. The combination of the NTTR and the NNSS represents one of the largest unpopulated land areas in the United States, comprising some 14,200 km^2 (5,470 mi^2).

1.2 Environmental Setting

The NNSS is located in the southern part of the Great Basin, the northern-most sub-province of the Basin and Range Physiographic Province. The NNSS terrain is typical of much of the Basin and Range Physiographic Province, characterized by generally north–south trending mountain ranges and intervening valleys. These mountain ranges and valleys, however, are modified on the NNSS by very large volcanic calderas (Figure 1-2). The principal valleys are Frenchman Flat, Yucca Flat, and Jackass Flats (Figure 1-2). Both Yucca and Frenchman Flat are topographically closed and contain dry lake beds, or playas, at their lowest elevations. Jackass Flats is topographically open, and surface water from this basin flows off the NNSS via the Fortymile Wash. The dominant highlands are Pahute Mesa and Rainier Mesa (high volcanic plateaus), Timber Mountain (a resurgent dome of the Timber Mountain caldera complex), and Shoshone Mountain. In general, the slopes of the highland areas are steep and dissected, and the slopes in the lowland areas are gentle and less eroded. The lowest elevation on the NNSS is 823 meters (m) (2,700 feet [ft]) in Jackass Flats in the southeast, and the highest elevation is 2,341 m (7,680 ft) on Rainier Mesa in the north-central region.

The topography of the NNSS has been altered by historical U.S. Department of Energy (DOE) actions, particularly underground nuclear testing. The principal effect of testing has been the creation of numerous collapse sinks (craters) in Yucca Flat basin and fewer craters on Pahute and Rainier Mesas. Shallow detonations that created surface disruptions were also performed during the ***Plowshare Program*** (see Glossary, Appendix B) to determine the potential uses of nuclear devices for large-scale excavation.

The reader is directed to *Attachment A: Site Description*, a file on the compact disc of this report, where the geology, hydrology, climatology, ecology, and cultural resources of the NNSS are described.

Throughout this document, the definition of word(s) that are in ***bold italics*** may be found by clicking on Glossary, Appendix B adjacent to the word(s). To return from the Glossary, right click and select Previous View.

1.3 Site History

The history of the NNSS, as well as its current missions, directs the focus and design of the environmental monitoring and surveillance activities on and near the site. Between 1940 and 1950, the area known as the NNSS was under the jurisdiction of Nellis Air Force Base and was part of the Nellis Bombing and Gunnery Range. The site was established in 1950 to be the primary location for testing the nation's nuclear explosive devices. It was

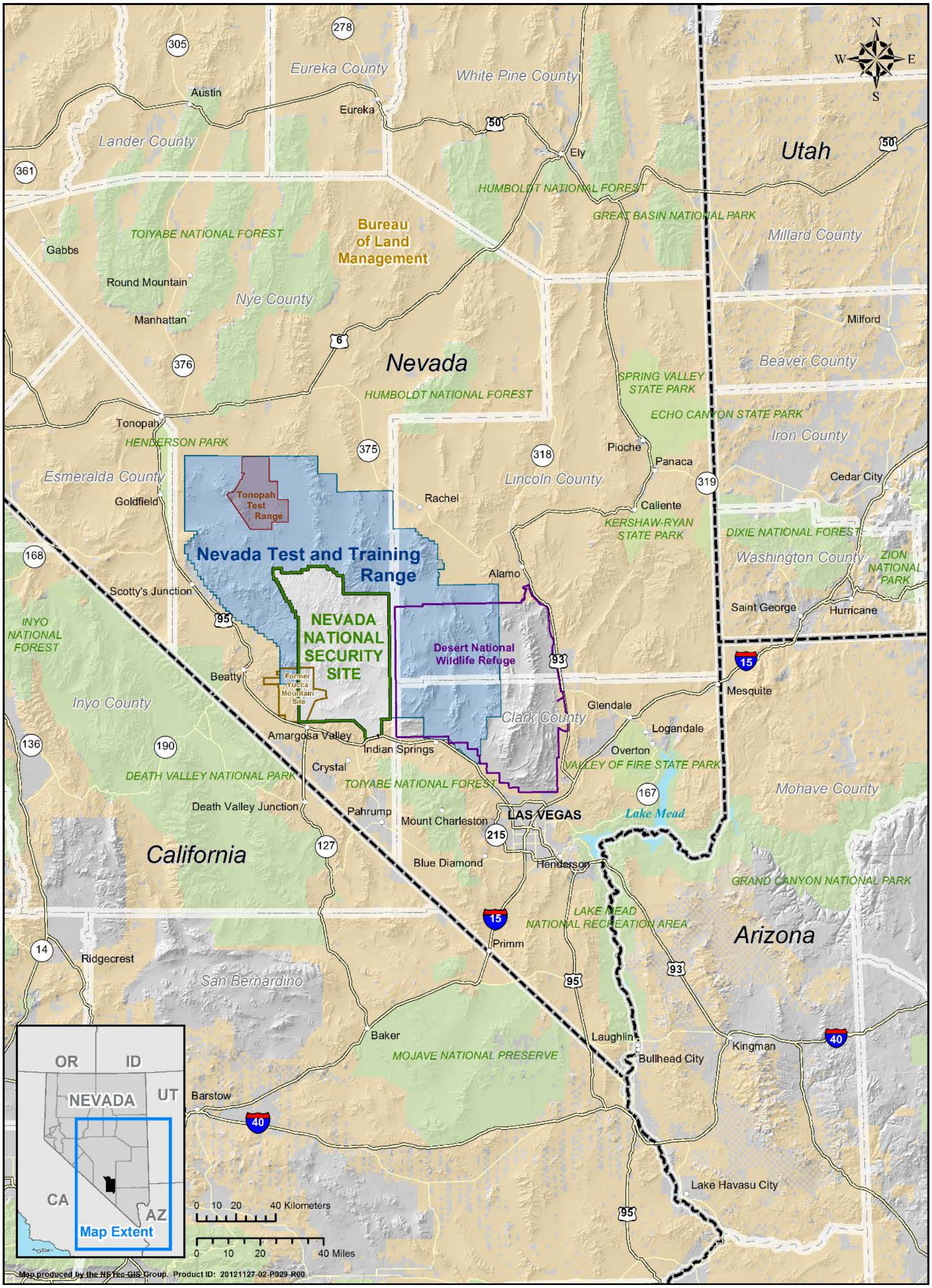


Figure 1-1. NNSS vicinity map

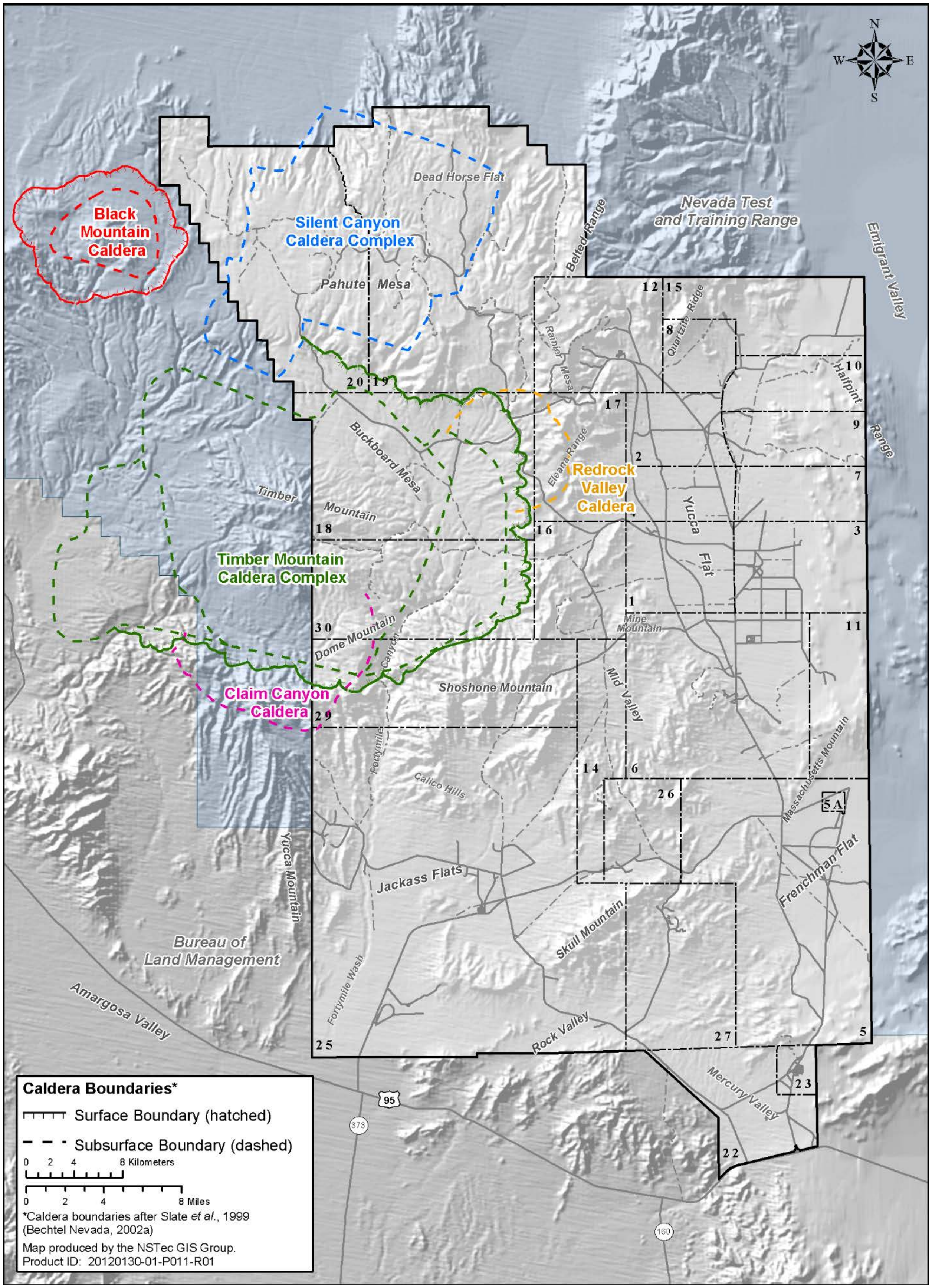


Figure 1-2. Major topographic features and calderas of the NNSS

named the Nevada Test Site (NTS) in 1951 and supported nuclear testing from 1951 to 1992. The types of tests conducted during this period are briefly described below. On August 23, 2010, the NTS was named the NNSS to reflect the diversity of nuclear, energy, and homeland security activities now conducted at the site. Nuclear experiments conducted at the NNSS are currently limited to ***subcritical experiments*** (see Glossary, Appendix B).

Atmospheric Tests – Tests conducted through the 1950s were predominantly atmospheric tests. They involved a nuclear explosive device detonated while either on the ground surface, on a steel tower, suspended from tethered balloons, dropped from an aircraft, or placed on a rocket. Several tests were categorized as "safety experiments" and "storage-transportation tests," involving the destruction of a nuclear device with non-nuclear explosives. Some of these tests resulted in the dispersion of plutonium in the test vicinity. One of these test areas lies just north of the NNSS boundary at the south end of the NTTR, and four others are at the north end of the NTTR.

Underground Tests – The first underground test, a cratering test, was conducted in 1951. The first totally contained underground test was in 1957. Testing was discontinued during a bilateral moratorium that began October 31, 1958, but was resumed in September 1961 after the Union of Soviet Socialist Republics resumed nuclear testing. After late 1962, nearly all tests were conducted in sealed vertical shafts drilled into Yucca Flat and Pahute Mesa or in horizontal tunnels mined into Rainier Mesa and Shoshone Mountain. From 1951 to 1992, a total of 828 underground nuclear tests were conducted at the NNSS. Approximately one-third of them were detonated near or in the ***saturated zone*** (see Glossary, Appendix B).

Cratering Tests – Five earth-cratering (shallow-burial) tests were conducted from 1962 through 1968 as part of the ***Plowshare Program*** (see Glossary, Appendix B) that explored peaceful uses of nuclear explosives. The first and highest yield Plowshare crater test, Sedan, was detonated at the northern end of Yucca Flat on the NNSS. The second-highest yield crater test was Schooner, located in the northwest corner of the NNSS. From these tests, mixed fission products, tritium, and plutonium were entrained in the soil ejected from the craters and deposited on the ground surrounding the craters.

Other Tests – Other nuclear-related experiments at the NNSS have included the BREN [Bare Reactor Experiment–Nevada] series in the early 1960s conducted in Area 4. These tests were performed with a 14-million electron volt neutron generator mounted on a 465 m (1,527 ft) steel tower to produce neutron and gamma radiation for the purpose of estimating the radiation doses received by survivors of Hiroshima and Nagasaki. The tower was moved in 1966 to Area 25 and used for conducting Operation HENRE [High-Energy Neutron Reactions Experiment], jointly funded by the U.S. Department of Defense (DoD) and the Atomic Energy Commission (AEC) to provide information for the AEC's Division of Biology and Medicine. From 1959 through 1973, a series of open-air nuclear reactor, nuclear engine, and nuclear furnace tests was conducted in Area 25, and a series of tests with a nuclear ramjet engine was conducted in Area 26. Erosion of metal cladding on the reactor fuel released some fuel particles that caused negligible deposition of radionuclides on the ground. Most of the radiation released from these tests was gaseous in the form of radio-iodines, radio-xenons, and radio-kryptons.

Fact sheets on many of the historical tests mentioned above can be found at http://www.nnss.gov/pages/resources/library/FactSheets.html. All nuclear device tests are listed in *United States Nuclear Tests, July 1945 through September 1992* (NNSA/NFO 2015).

1.4 Site Mission

NNSA/NFO directs the facility management and program operations at the NNSS, North Las Vegas Facility (NLVF), and Remote Sensing Laboratory–Nellis (RSL-Nellis) in Nevada and directs selected operations at four sites outside of Nevada that include RSL-Andrews in Maryland, Livermore Operations in California, Los Alamos Operations in New Mexico, and the Special Technologies Laboratory in California. Los Alamos National Laboratory, Lawrence Livermore National Laboratory, and Sandia National Laboratories are the principal organizations that sponsor and implement the nuclear weapons programs at the NNSS. National Security Technologies, LLC, is the current Management and Operations contractor accountable for the successful execution of work and ensuring that work is performed in compliance with environmental regulations. The three major NNSS missions include National Security/Defense, Environmental Management, and Nondefense. The programs that support these missions are listed in the text box below.

NNSS Missions and Programs

National Security/Defense Missions

Stockpile Stewardship and Management Program – Conducts high-hazard operations in support of defense-related nuclear and national security experiments and maintains the capability to resume underground nuclear weapons testing, if directed.

Nuclear Emergency Response, Nonproliferation, and Counterterrorism Programs – Provides support facilities, training facilities, and capabilities for government agencies involved in emergency response, nonproliferation technology development, national security technology development, and counterterrorism activities.

Strategic Partnership Projects – Provides support facilities and capabilities for other DOE programs and federal agencies/organizations involved in defense-related activities (formerly known as the Work for Others Program).

Environmental Management Missions

Environmental Restoration Program – Characterizes and remediates the environmental legacy of nuclear weapons and other testing at NNSS and NTTR locations, and develops and deploys technologies that enhance environmental restoration.

Waste Management Program – Manages and safely disposes of low-level waste, mixed low-level waste, and classified waste/matter received from DOE- and DoD-approved facilities throughout the U.S. and wastes generated in Nevada by NNSA/NFO. Safely manages and characterizes hazardous and transuranic wastes for offsite disposal.

Nondefense Missions

General Site Support and Infrastructure Program – Maintains the buildings, roads, utilities, and facilities required to support all NNSS programs and to provide a safe environment for NNSS workers.

Conservation and Renewable Energy Programs – Operates the pollution prevention program and supports renewable energy and conservation initiatives at the NNSS.

Other Research and Development – Provides support facilities and NNSS access to universities and organizations conducting environmental and other research unique to the regional setting.

1.5 Primary Facilities and Activities

The NNSS facilities or centers that support the National Security/Defense missions include the U1a Complex, Big Explosives Experimental Facility, Device Assembly Facility (DAF), Dense Plasma Focus (DPF) Facility (located within the Los Alamos Technical Facility [LATF]), Joint Actinide Shock Physics Experimental Research (JASPER) Facility, Nonproliferation Test and Evaluation Complex (NPTEC), the National Criticality Experiments Research Center (located within the DAF), the Radiological/Nuclear Countermeasures Test and Evaluation Complex (RNCTEC), and the Radiological/Nuclear Weapons of Mass Destruction Incident Exercise Site (known as the T-1 Site). NNSS facilities that support Environmental Management missions include the currently active Area 5 Radioactive Waste Management Complex (RWMC) and the Area 3 Radioactive Waste Management Site (RWMS), which is in cold standby (Figure 1-3).

The primary NNSS activity in 2016 was helping to ensure that the U.S. stockpile of nuclear weapons remains safe and reliable. Other 2016 NNSS activities included weapons of mass destruction first responder training; the controlled release of hazardous material at NPTEC; remediation of legacy contamination sites; processing of waste destined for the Waste Isolation Pilot Plant in Carlsbad, New Mexico, or the Idaho National Laboratory in Idaho Falls, Idaho; and disposal of low-level and mixed low-level radioactive waste. Land use by each of the NNSS missions occurs within designated zones (Figure 1-4).

1.6 Scope of Environmental Report

This report summarizes data and the compliance status of the NNSA/NFO environmental protection and monitoring programs for calendar year 2016 at the NNSS and at its two support facilities, the NLVF and RSL-Nellis. This report also addresses environmental restoration (ER) projects conducted at the Tonopah Test Range (TTR) (see Figure 1-1).

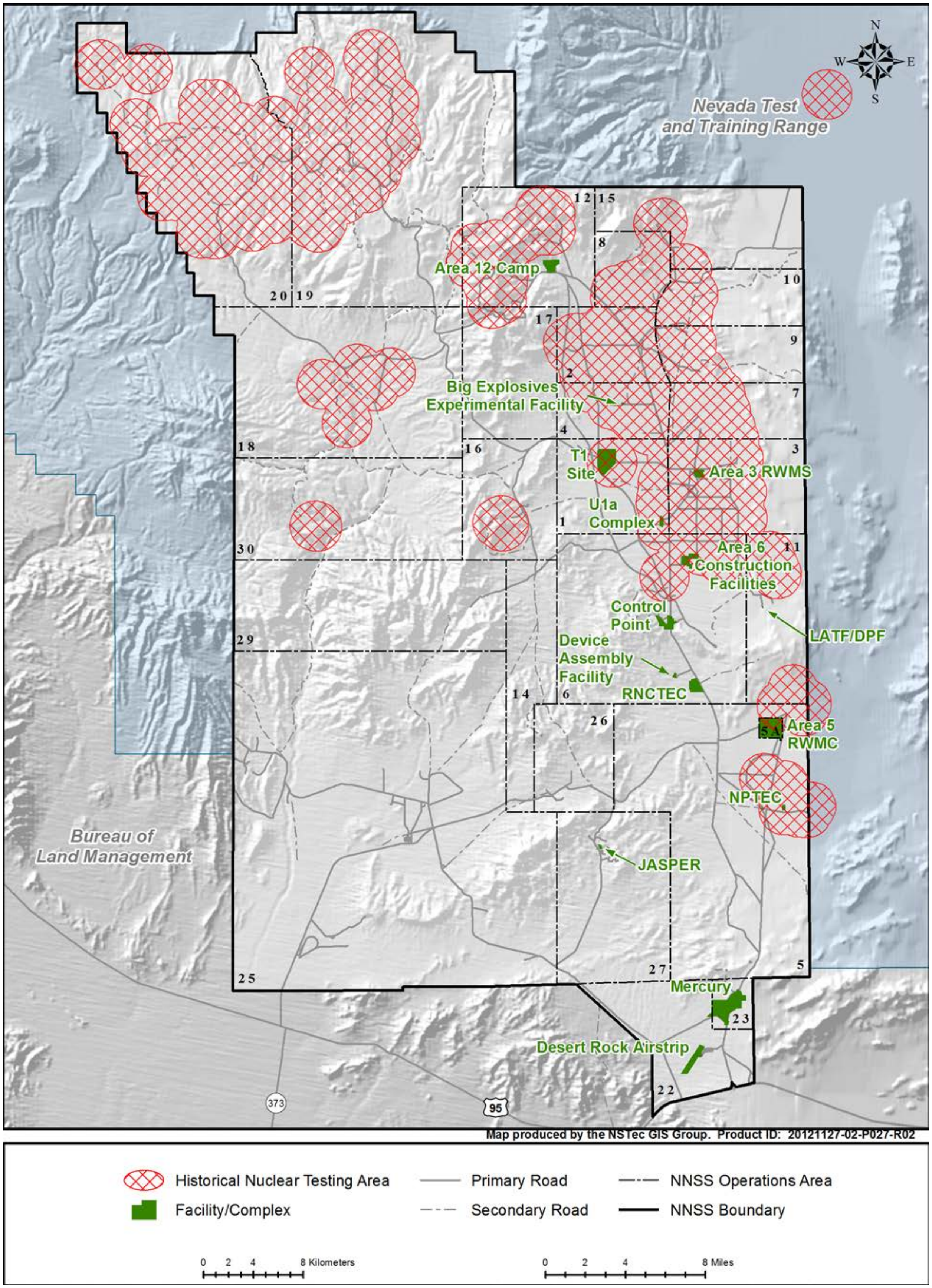


Figure 1-3. NNSS operational areas, principal facilities, and past nuclear testing areas

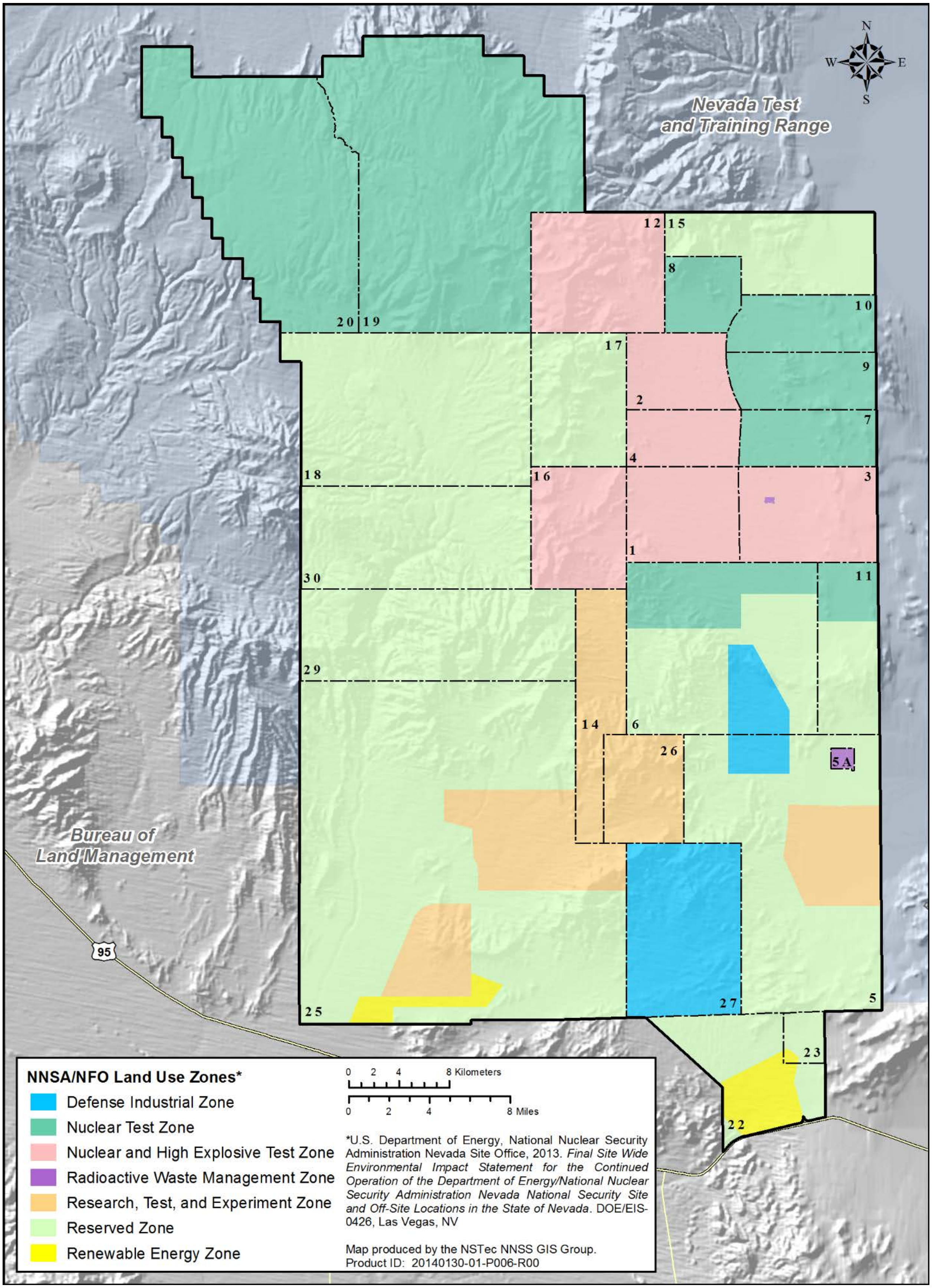


Figure 1-4. NNSS land-use map

Through a Memorandum of Agreement, NNSA/NFO is responsible for the oversight of TTR ER projects, and the U.S. Department of Energy, National Nuclear Security Administration Sandia Field Office (NNSA/SFO) has oversight of all other TTR activities. NNSA/SFO produces the TTR annual site environmental reports, which are posted at http://www.sandia.gov/news/publications/environmental/index.html.

1.7 Populations Near the NNSS

The population of the area surrounding the NNSS (see Figure 1-1) is predominantly rural. The most recent population estimates for Nevada communities are for 2016 and are provided by the Nevada State Demographer's Office (2017). The most recent population estimate for Nye County is 45,737, and the largest Nye County community is Pahrump (38,238), located approximately 80 km (50 mi) south of the NNSS Control Point facility (near the center of the NNSS). Other Nye County communities include Tonopah (2,291), Amargosa (1,390), Beatty (950), Round Mountain (799), Gabbs (226), and Manhattan (130). Lincoln County to the east of the NNSS includes a few small communities including Caliente (1,031), Pioche (773), Panaca (798), and Alamo (660). Clark County, southeast of the NNSS, is the major population center of Nevada and has an estimated population of 2,166,181. The total annual population estimate for all Nevada counties, cities, and towns is 2,953,375.

The Mojave Desert of California, which includes Death Valley National Park, lies along the southwestern border of Nevada. This area is still predominantly rural; however, tourism at Death Valley National Park swells the population to more than 5,000 on any particular day during holiday periods when the weather is mild.

The extreme southwestern region of Utah is more developed than the adjacent portion of Nevada. The latest population estimates for Utah communities are for 2015 taken from the U.S. Census Bureau (2017) of the U.S. Department of Commerce. Southern Utah's largest community is St. George, located 220 km (137 mi) east of the NNSS, with an estimated population of 80,202. The next largest town, Cedar City, is located 280 km (174 mi) east-northeast of the NNSS and has an estimated population of 30,184.

The northwestern region of Arizona is mostly rangeland except for that portion in the Lake Mead recreation area. In addition, several small communities lie along the Colorado River. The largest towns in the area are Bullhead City, 165 km (103 mi) south-southeast of the NNSS, with an estimated population of 39,948, and Kingman, 280 km (174 mi) southeast of the NNSS, with an estimated population of 29,063 (Arizona Department of Administration 2017).

1.8 Understanding Data in this Report

1.8.1 Scientific Notation

Scientific notation is used in this report to express very large or very small numbers. A very small number is expressed with a negative exponent, for example 2.0×10^{-5}. To convert this number from scientific notation to a more traditional number, the decimal point must be moved to the left by the number of places equal to the exponent (5 in this case). The number thus becomes 0.00002.

Very large numbers are expressed in scientific notation with a positive exponent. The decimal point should be moved to the right by the number of places equal to the exponent. The number 1,000,000,000 could be presented in scientific notation as 1.0×10^{9}.

1.8.2 Unit Prefixes

Units for very small and very large numbers are commonly expressed with a prefix. The prefix signifies the amount of the given unit. For example, the prefix k, or kilo-, means 1,000 of a given unit. Thus 1 kg (kilogram) is 1,000 g (grams). Other prefixes used in this report are listed in Table 1-1.

Table 1-1. Unit prefixes

Prefix	Abbreviation	Meaning
mega-	M	1,000,000 (1×10^{6})
kilo-	k	1,000 (1×10^{3})
centi-	c	0.01 (1×10^{-2})
milli-	m	0.001 (1×10^{-3})
micro-	μ	0.000001 (1×10^{-6})
nano-	n	0.000000001 (1×10^{-9})
pico-	p	0.000000000001 (1×10^{-12})

1.8.3 Units of Radioactivity

Much of this report deals with levels of radioactivity in various environmental media. The basic unit of radioactivity used in this report is the curie (Ci) (Table 1-2). The curie describes the amount of radioactivity present, and amounts are usually expressed in terms of fractions of curies in a given mass or volume (e.g., picocuries per liter). The curie is historically defined as the rate of nuclear disintegrations that occur in 1 gram of the radionuclide radium-226, which is 37 billion nuclear disintegrations per second. For any other radionuclide, 1 Ci is the quantity of the radionuclide that decays at this same rate. Nuclear disintegrations produce spontaneous emissions of alpha or beta particles, gamma radiation, or combinations of these.

Table 1-2. Units of radioactivity

Symbol	Name
Ci	curie
cpm	counts per minute
mCi	millicurie (1×10^{-3} Ci)
μCi	microcurie (1×10^{-6} Ci)
nCi	nanocurie (1×10^{-9} Ci)
pCi	picocurie (1×10^{-12} Ci)

1.8.4 Radiological Dose Units

The amount of ionizing radiation energy absorbed by a living organism is expressed in terms of radiological dose. Radiological dose in this report is usually written in terms of effective dose equivalent and reported numerically in units of millirem (mrem) (Table 1-3). Millirem is a term that relates ionizing radiation to biological effect or risk to humans. A dose of 1 mrem has a biological effect similar to the dose received from an approximate 1-day exposure to natural background radiation. An acute (short-term) dose of 100,000 to 400,000 mrem can cause radiation sickness in humans. An acute dose of 400,000 to 500,000 mrem, if left untreated, results in death approximately 50% of the time. Exposure to lower amounts of radiation (1,000 mrem or less) produces no immediate observable effects, but long-term (delayed) effects are possible. The average person in the United States receives an annual dose of approximately 300 mrem from exposure to naturally produced radiation. Medical and dental X-rays, air travel, and tobacco smoking add to this total.

Table 1-3. Units of radiological dose

Symbol	Name
mrad	millirad (1×10^{-3} rad)
mrem	millirem (1×10^{-3} rem)
R	roentgen
mR	milliroentgen (1×10^{-3} R)
μR	microroentgen (1×10^{-6} R)

The unit "rad," for radiation absorbed dose, is also used in this report. The rad is a measure of the energy absorbed by any material, whereas a "rem," for roentgen equivalent man, relates to both the amount of radiation energy absorbed by humans and its consequence. A roentgen (R) is a measure of radiation exposure. Generally speaking, 1 R of exposure will result in an effective dose equivalent of 1 rem. Additional information on radiation and dose terminology can be found in the Glossary (Appendix B).

1.8.5 International System of Units for Radioactivity and Dose

In some instances in this report, radioactivity and radiological dose values are expressed in other units in addition to Ci and rem. These units are the becquerel (Bq) and the sievert (Sv), respectively. The Bq and Sv belong to the International System of Units (SI), and their inclusion in this report is mandated by DOE. SI units are the internationally accepted units and may eventually be the standard for reporting both radioactivity and radiation dose in the United States. One Bq is equivalent to one nuclear disintegration per second.

The unit of radiation absorbed dose (rad) has a corresponding SI unit called the gray (Gy). The roentgen measure of radiation exposure has no SI equivalent. Table 1-4 provides the multiplication factors for converting to and from SI units.

Table 1-4. Conversion table for SI units

To Convert From	To	Multiply By
becquerel (Bq)	picocurie (pCi)	27
curie (Ci)	becquerel (Bq)	3.7×10^{10}
gray (Gy)	rad	100
millirem (mrem)	millisievert (mSv)	0.01
millisievert (mSv)	millirem (mrem)	100
picocurie (pCi)	becquerel (Bq)	0.03704
rad	gray (Gy)	0.01
sievert (Sv)	rem	100

1.8.6 Radionuclide Nomenclature

Radionuclides are frequently expressed with the one- or two-letter chemical symbol for the element. Radionuclides may have many different isotopes, which are shown by a superscript to the left of the symbol. This number is the atomic weight of the isotope (the number of protons and neutrons in the nucleus of the atom). Radionuclide symbols, many of which are used in this report, are shown in Table 1-5 along with the half-life of each radionuclide. The half-life is the time required for one-half of the radioactive atoms in a given amount of material to decay. For example, after one half-life, half of the original atoms will have decayed; after two half-lives, three-fourths of the original atoms will have decayed; and after three half-lives, seven-eighths of the original atoms will have decayed, and so on. The notation $^{236+238}$Ra and similar notations in this report (e.g., $^{239+240}$Pu) are used when the analytical method does not distinguish between the isotopes, but reports the total amount of both.

1.8.7 Units of Measurement

Both metric and non-metric units of measurement are used in this report. Metric system and U.S. customary units and their respective equivalents are shown in Table 1-6 on the following page.

1.8.8 Measurement Variability

There is always uncertainty associated with the measurement of environmental contaminants. For radioactivity, a major source of uncertainty is the inherent randomness of radioactive decay events.

Uncertainty in analytical measurements is also the consequence of variability related to collecting and analyzing the samples. This variability is associated with reading or recording the result, handling or processing the sample, calibrating the counting instrument, and numerical rounding.

The uncertainty of a measurement is denoted by following the result with an uncertainty value, which is preceded by the plus-or-minus symbol, ±. This uncertainty value gives information on what the measurement might be if the same sample were analyzed again under identical conditions. The uncertainty value implies that approximately 95% of the time, the average of many measurements would give a value somewhere between the reported value minus the uncertainty value and the reported value plus the uncertainty value. If the reported concentration of a given constituent is smaller than its associated uncertainty (e.g., 40 ± 200), then the sample may not contain that constituent.

Table 1-5. Radionuclides and their half-lives (in alphabetical order by symbol)

Symbol	Radionuclide	Half-Life [(a)]
^{241}Am	americium-241	432.2 yr
^{7}Be	beryllium-7	53.22 d
^{14}C	carbon-14	5.70×10^{3} yr
^{36}Cl	chlorine-36	3.01×10^{5} yr
^{134}Cs	cesium-134	2.1 yr
^{137}Cs	cesium-137	30.2 yr
^{51}Cr	chromium-51	27.7 d
^{60}Co	cobalt-60	5.3 yr
^{152}Eu	europium-152	13.5 yr
^{154}Eu	europium-154	8.6 yr
^{155}Eu	europium-155	4.8 yr
^{3}H	tritium	12.3 yr
^{129}I	iodine-129	1.6×10^{7} yr
^{131}I	iodine-131	8 d
^{40}K	potassium-40	1.3×10^{8}yr
^{85}Kr	krypton-85	10.8 yr
^{212}Pb	lead-212	10.6 hr
^{238}Pu	plutonium-238	87.7 yr
^{239}Pu	plutonium-239	2.4×10^{4} yr
^{240}Pu	plutonium-240	6.5×10^{3} yr
^{241}Pu	plutonium-241	14.4 yr
^{226}Ra	radium-226	1.6×10^{3} yr
^{228}Ra	radium-228	5.75 yr
^{220}Rn	radon-220	56 s
^{222}Rn	radon-222	3.8 d
^{103}Ru	ruthenium-103	39.3 d
^{106}Ru	ruthenium-106	373.6 d
^{125}Sb	antimony-125	2.8 yr
^{113}Sn	tin-113	115 d
^{90}Sr	strontium-90	28.8 yr
^{99}Tc	technetium-99	2.1×10^{5} yr
^{232}Th	thorium-232	1.4×10^{10} yr
U [(b)]	uranium total	- - - [(c)]
^{234}U	uranium-234	2.4×10^{5} yr
^{235}U	uranium-235	7×10^{8} yr
^{238}U	uranium-238	4.5×10^{9} yr
^{65}Zn	zinc-65	244.1 d
^{95}Zr	zirconium-95	63.98 d

(a) Source: International Commission on Radiological Protection (2008)

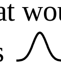
(b) Total uranium may also be indicated by U-natural (U-nat) or U-mass

(c) Natural uranium is a mixture dominated by ^{238}U; thus, the half-life is approximately 4.5×10^{9} years

Table 1-6. Metric and U.S. customary unit equivalents

Metric Unit	U.S. Customary Equivalent Unit	U.S. Customary Unit	Metric Equivalent Unit
Length			
1 centimeter (cm)	0.39 inches (in.)	1 inch (in.)	2.54 centimeters (cm)
1 millimeter (mm)	0.039 inches (in.)		25.4 millimeters (mm)
1 meter (m)	3.28 feet (ft)	1 foot (ft)	0.3048 meters (m)
	1.09 yards (yd)	1 yard (yd)	0.9144 meters (m)
1 kilometer (km)	0.62 miles (mi)	1 mile (mi)	1.6093 kilometers (km)
Volume			
1 liter (L)	0.26 gallons (gal)	1 gallon (gal)	3.7853 liters (L)
1 cubic meter (m^3)	35.32 cubic feet (ft^3)	1 cubic foot (ft^3)	0.028 cubic meters (m^3)
	1.31 cubic yards (yd^3)	1 cubic yard (yd^3)	0.765 cubic meters (m^3)
Weight			
1 gram (g)	0.035 ounces (oz)	1 ounce (oz)	28.35 gram (g)
1 kilogram (kg)	2.21 pounds (lb)	1 pound (lb)	0.454 kilograms (kg)
1 metric ton (mton)	1.10 short ton (2,000 lb)	1 short ton (2,000 lb)	0.90718 metric ton (mton)
Area			
1 hectare	2.47 acres	1 acre	0.40 hectares
1 square meter (m^2)	10.76 square feet (ft^2)	1 square foot (ft^2)	0.09 square meters (m^2)
Radioactivity			
1 becquerel (Bq)	2.7×10^{-11} curie (Ci)	1 curie (Ci)	3.7×10^{10} becquerel (Bq)
Radiation dose			
1 rem	0.01 sievert (Sv)	1 sievert (Sv)	100 rem
Temperature			
°C = (°F − 32)/1.8		°F = (°C × 1.8) + 32	

1.8.9 Mean and Standard Deviation

The mean of a set of data is the usual average of those data. The standard deviation (SD) of sample data relates to the variation around the mean of a set of individual sample results; it is defined as the square root of the average squared difference of individual data values from the mean. This variation includes both measurement variability and actual variation between monitoring periods (weeks, months, or quarters, depending on the particular analysis). The sample mean and standard deviation are estimates of the average and the variability that would be seen in a large number of repeated measurements. If the distribution shape were "normal" (i.e., shaped as ), about 67% of the measurements would be within the mean ± SD, and 95% would be within the mean ± 2 SD.

1.8.10 Standard Error of the Mean

Just as individual values are accompanied by counting uncertainties, mean values (averages) are accompanied by uncertainty. The standard deviation of the distribution of sample mean values is known as the standard error of the mean (SE). The SE conveys how accurate an estimate the mean value is based on the samples that were collected and analyzed. The ± value presented to the right of a mean value is equal to 2 × SE. The ± value implies that approximately 95% of the time, the average of many calculated means will fall somewhere between the reported value minus the 2 × SE value and the reported value plus the 2 × SE value.

1.8.11 Median, Maximum, and Minimum Values

Median, maximum, and minimum values are reported in some sections of this report. A median value is the middle value when all the values are arranged in order of increasing or decreasing magnitude. For example, the median value in the series of numbers, 1 2 3 3 4 5 5 5 6, is 4. The maximum value would be 6 and the minimum value would be 1.

1.8.12 Less Than (<) Symbol

The "less than" symbol (<) is used to indicate that the measured value is smaller than the number given. For example, <0.09 would indicate that the measured value is less than 0.09. In this report, < is often used in reporting the amounts of nonradiological contaminants in a sample when the measured amounts are less than the analytical laboratory's reporting limit for that contaminant in that sample. For example, if a measurement of benzene in sewage lagoon pond water is reported as <0.005 milligrams per liter, this implies that the measured amount of benzene present, if any, was not found to be above this level, given the sample and analysis methods used. For some constituents, the notation "ND" is also used to indicate that the constituent in question was not detected. For organic constituents, in particular, this could mean that the compound could not be clearly identified, the level (if any) was lower than the reporting limit, or (as often happens) both. The measurements of radionuclide concentrations are reported whether or not they are below the usual reporting limit called the ***minimum detectable concentration*** (see Glossary, Appendix B).

1.8.13 Negative Radionuclide Concentrations

There is always a small amount of natural radiation in the environment. The instruments used in the laboratory to measure radioactivity in environmental media are sensitive enough to measure the natural, or background, radiation along with any contaminant radiation in a sample. To obtain an unbiased measure of the contaminant level in a sample, the natural, or background, radiation level must be subtracted from the total amount of radioactivity measured by an instrument. Because of the randomness of radioactive emissions and the very low concentrations of some contaminants, it is possible to obtain a background measurement that is larger than the actual contaminant measurement. When the larger background measurement is subtracted from the smaller contaminant measurement, a negative result is generated. The negative results are reported because they are useful when conducting statistical evaluations of the data.

1.9 References

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Chapter 2: Compliance Summary

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Environmental regulations pertinent to operations on the Nevada National Security Site (NNSS), the North Las Vegas Facility (NLVF), and the Remote Sensing Laboratory–Nellis (RSL-Nellis) include federal, state, and local environmental regulations; site-specific permits; and binding interagency agreements. The environmental regulations dictate how the U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO) conducts operations to ensure the protection of the environment and the public. In 2016, NNSA/NFO operated in compliance with most of the requirements defined in these governing documents. Instances of noncompliance were reported to regulatory agencies and corrected.

As in previous years, radiological air emissions from NNSA/NFO current and past operations were well below U.S. Department of Energy (DOE) dose limits set for the public and for plants and animals on or adjacent to the NNSS. Emissions of non-radiological air pollutants from permitted equipment/facilities at NNSS, NLVF, and RSL-Nellis were all within permit limits.

No man-made ***radionuclides*** (see Glossary, Appendix B) were detected in any of the three state-permitted public water systems (PWSs) on the NNSS, which are serviced by six groundwater wells. Water samples from the NNSS PWSs met National Primary Drinking Water Standards (health standards) and met all Nevada Secondary Drinking Water Standards (related to taste, odor, and visual aspects).

Required groundwater monitoring at three NNSS wells near the Area 5 Radioactive Waste Management Site (RWMS) continued to demonstrate that the permitted low-level radioactive waste disposal operations at the site are not affecting groundwater quality. All wastewater discharges at NNSS, NLVF, and RSL-Nellis met site-specific state permit requirements, including those of a Pollutant Discharge Elimination System permit issued for groundwater pumping activities at the NLVF.

Three DOE-reportable environmental occurrences related to finding radioactive contamination outside of areas posted, controlled, and monitored for radiological contamination happened in 2016. All three consisted of finding pieces of contaminated debris outside posted radiological areas of legacy-contaminated Corrective Action Units (CAUs), two on the NNSS and one on the Tonopah Test Range. Areas surrounding the contaminated legacy debris at the CAUs were immediately posted as contamination areas. No personnel or equipment contamination occurred.

Corrective actions were taken in 2016 when a container of non-hazardous low-level waste, which was received from Nuclear Fuel Services (NFS) in August 2015 for burial at the NNSS, was subsequently identified by NFS in June 2016 as containing hazardous low-level waste. NNSA/NFO removed the container from the waste disposal cell permitted under the Resource Conservation Recovery Act (RCRA) for only non-hazardous low-level waste and then safely shipped the container back to the NFS. A DOE Occurrence Report was submitted to DOE as a Management Concern regarding the waste certification and shipping method used by NFS.

Nineteen spills of hazardous materials occurred in 2016; only two of the spills met regulatory agency reporting criteria. They involved the release of 25 gallons of oil from a transformer damaged while being loaded into a truck on the NNSS and the discovery of over 300 cubic yards of oil-contaminated soil at an NNSS transformer yard. The remainder of the non-reportable spills consisted of small-volume releases either to containment areas or to other surfaces. All releases were cleaned up.

Thirteen environmental inspections were conducted in 2016 by external regulatory agencies. These inspections included the NNSS hazardous waste management and disposal facilities, NLVF and RSL hazardous waste management operations, NNSS solid waste landfills, NNSS air quality, RSL-Nellis underground storage tanks, NNSS and NLVF wastewater facilities, and an NNSS facility that is registered under Nevada's Chemical Accident Prevention Program. No incidences of non-compliance were noted during the inspections.

2.1 Compliance with Requirements

The federal, state, and local environmental statutes and regulations under which NNSA/NFO operates are summarized in Table 2-1 along with a discussion of NNSA/NFO's compliance status with each. The "Report Section(s)" column of the table references other chapters in this document or other tables or subsections within this chapter where compliance activities for each requirement are more fully described and/or where data supporting compliance are presented.

Abbreviations for Regulators

Federal

ACHP Advisory Council on Historic Preservation
CEQ Council on Environmental Quality
DOE U.S. Department of Energy
DOI U.S. Department of Interior
EPA U.S. Environmental Protection Agency
FWS U.S. Fish and Wildlife Service

State/County

CCDAQ Clark County Department of Air Quality
NDEP Nevada Division of Environmental Protection
NDOA Nevada Department of Agriculture
NDOF Nevada Department of Forestry
NDOW Nevada Department of Wildlife
NSHPO Nevada State Historic Preservation Office

Table 2-1. Federal, state, and local environmental laws and regulations applicable to NNSA/NFO

Regulator: Regulation[a]	Description of Law/Regulation[b]	Compliance Status	Report Section(s)
General Environmental Protection, Management, and Sustainability			
CEQ: 40 CFR 1500–1508 DOE: 10 CFR 1021 DOE: DOE O 451.1B, Change 3	National Environmental Policy Act (NEPA), 42 USC 4321 et seq. (1969). This act requires federal agencies to consider environmental effects and reasonable alternatives before making a decision to implement a major federal action that may have a significant impact on the human environment. DOE codified its implementation of NEPA in 10 CFR 1021 and outlined its internal requirements and responsibilities for implementing NEPA in DOE O 451.1B, Change 3, *National Environmental Policy Act Compliance Program*.	NNSA/NFO has established procedures for implementing NEPA requirements in adherence with DOE O 451.1B, Change 3. The NNSA/NFO NEPA Compliance Officer reviews Environmental Evaluation Checklists, which are required for all proposed projects/activities on the NNSS and determines if the activity's environmental impacts require NEPA analysis and documentation. In 2016, all proposed projects/activities were reviewed under the NEPA compliance procedures.	Section 2.3
DOE: DOE O 436.1	Departmental Sustainability. This order implements the requirements of Executive Order EO 13423, *Strengthening Federal Environmental, Energy, and Transportation Management*, and EO 13514, *Federal Leadership in Environmental, Energy, and Economic Performance.* In March 2015, these EOs were replaced by EO 13963, *Planning for Sustainability in the Next Decade*. DOE's goals pertaining to the new EO are published annually in a *DOE Strategic Sustainability Performance Plan* (SSPP). This order requires DOE sites to set goals to help achieve the DOE SSPP goals, use an Environmental Management System (EMS) as the platform for establishing site-specific sustainability programs with objectives and measureable	National Security Technologies, LLC (NSTec), the current Management and Operating contractor for the NNSS, has implemented an EMS, which was re-certified in 2014 for another 3 years under International Organization for Standardization (ISO) 14001:2004. The EMS includes objectives and targets that contribute to achieving the DOE Sustainable Environmental Stewardship goals outlined in DOE's most current SSPP and incorporated into NNSA/NFO's Site Sustainability Plan. In December 2016, the fiscal year (FY) 2017 NNSA/NFO Site Sustainability Plan, which reports FY 2016 progress toward reaching goals, was completed. FY 2016 EMS progress was monitored and reported through the EMS	Chapter 3

Table 2-1. Federal, state, and local environmental laws and regulations applicable to NNSA/NFO (continued)

Regulator: Regulation[(a)]	Description of Law/Regulation[(b)]	Compliance Status	Report Section(s)
	targets, develop and implement Site Sustainability Plans, and use alternative financing to the maximum extent possible for sustainability projects. In June 2015, DOE issued a Notice of Intent to update DOE O 436.1 to align with the new EO 13963.	Compliance Reporting procedure using the FedCenter.gov database. NNSA/NFO met 19 of the 33 long-term DOE sustainability goals in 2016 and ranked 18th in the nation by the 2016 100 Best Green Fleet Awards Program.	
Air Quality			
EPA: 40 CFR 50 40 CFR 60 40 CFR 61 40 CFR 63 40 CFR 80 40 CFR 82 40 CFR 98 NDEP: NAC 445B	Clean Air Act (CAA), 42 USC 7401 et seq. (1970). This act and Nevada's Air Control Laws regulate the release of air pollutants through permits and air quality limits. Emissions of ***radionuclides*** (see Glossary, Appendix B) are regulated via the National Emission Standards for Hazardous Air Pollutants (NESHAP) authorizations of the CAA. Emissions of ***criteria pollutants*** (see Glossary, Appendix B) are regulated via the National Ambient Air Quality Standards (NAAQS) authorizations. Criteria and ***designated pollutants*** (see Glossary, Appendix B) emitted from various industrial categories of facilities are regulated via the New Source Performance Standards (NSPS) authorizations. The CAA also establishes production limits and a schedule for the phase-out of ***ozone-depleting substances (ODS)*** (see Glossary, Appendix B). Nevada law (Nevada Administrative Code [NAC] 445B, *Air Controls*) enforces the CAA regulations and also requires fugitive dust control and open burn authorizations.	At the NNSS, CAA and Nevada air quality regulations are met through adherence to a State of Nevada Class II Air Quality Operating Permit and various project-specific state-issued Open Burn and Surface Area Disturbance permits. NESHAP compliance activities include radionuclide air monitoring; reporting asbestos abatement; monitoring/reporting emissions from generators and boilers; and management of gasoline/diesel storage tanks. NAAQS emission limits (except ozone and lead) are based on published emission values for other similar industries and on operational data specific to the NNSS. Some screens, conveyor belts, bulk fuel storage tanks, and generators on the NNSS are subject to the NSPS. At the NLVF and RSL-Nellis, CAA and state air quality requirements are met through adherence to Clark County Minor Source permits. NNSA/NFO pays annual state fees based on all emission sources' "potential to emit." NNSA/NFO allows Nevada's Bureau of Air Pollution Control to conduct inspections of permitted NNSS facilities and allows the CCDAQ to conduct inspections of NLVF and RSL-Nellis permitted equipment. All approvals, notifications, requests for additional information, and reports required under the CAA are submitted to NDEP, Clark County, and/or EPA Region 9 in accordance with federal requirements. In 2016, monitored radioactive air emissions were below NESHAP limits. All non-radiological air emission limits as well as all monitoring, record keeping, training, and reporting requirements of state and county air permits were met.	Chapter 4, Sections 4.1.5, 4.2 Appendix A, Sections A.1.1, A.2.1

Table 2-1. Federal, state, and local environmental laws and regulations applicable to NNSA/NFO (continued)

Regulator: Regulation[(a)]	Description of Law/Regulation[(b)]	Compliance Status	Report Section(s)
Water Quality			
EPA: 40 CFR 109–140 40 CFR 230, 231 40 CFR 401, 403	Clean Water Act (CWA), 33 USC 1251 et seq. (1972). This act and Nevada's Water Pollution Control laws seek to improve surface water quality by establishing standards and a system of permits. They prohibit the discharge of contaminants from point sources to waters of the United States without a National Pollutant Discharge Elimination System (NPDES) permit.	Wastewater discharges are managed on the NNSS in accordance with NDEP-issued permits that include the E Tunnel Waste Water Disposal System, active and inactive sewage lagoons, septic tanks, septic tank pumpers, and a septic tank pumping contractor's license. Because there are no wastewater discharges to surface waters on or off the NNSS, there are no NPDES permits for the NNSS.	Chapter 5, Sections 5.1.3.7.2, 5.1.3.7.3, 5.2.2, 5.2.3, 5.2.4
NDEP: NAC 444 NAC 445A NAC 534	NACs 444, *Sanitation (Sewage Disposal)*, and 445A, *Water Controls (Water Pollution Control)*, regulate the collection, treatment, and disposal of wastewater and sewage. NAC 534, *Underground Water and Wells*, regulates the drilling, construction, and licensing of new wells and the reworking of existing wells to prevent the waste and contamination of groundwater.	NNSA/NFO reports any unplanned releases of hazardous substances to NDEP as required under NAC 445A. NNSA/NFO obtains underground injection control (UIC) permits from NDEP, as required under NAC 445A.810–925, for various investigations. In 2012, a UIC permit was issued for a noble gas migration study at borehole U-20az PS#1A. One injection activity occurred at this borehole in 2016; additional experiments are anticipated for 2017. The UIC permit was renewed in 2016 with a modification adding a similar gas migration study in Area 12 P Tunnel where experiments are anticipated in 2017. NNSA/NFO complies with NAC 534 for the rework of old wells and the drilling of new wells for the Underground Test Area (UGTA) activity. UGTA wells are regulated by the state through an agreement between NNSA/NFO and NDEP called the *UGTA Fluid Management Plan*, which ensures compliance with the CWA. In 2016, UGTA well drilling fluids were monitored and managed in accordance with the plan.	
		NLVF operates under a Class II Wastewater Control Permit issued by the City of North Las Vegas (CNLV) for sewer discharges and an NPDES permit issued by NDEP for the discharge of groundwater that is pumped to the surface to control rising groundwater levels at the facility (see Table 2-2). NLVF operates under a NDEP-issued No Exposure Waiver for exclusion from NPDES Storm Water permitting. Storm water discharged from the NLVF is not contaminated by exposure to industrial activities or materials.	Appendix A, Sections A.1.2, A.2.2 Table 2-2
		For RSL-Nellis operations, the Clark County Water Reclamation District (CCWRD) determined that a wastewater discharge permit is not necessary; only an annual submission of a Zero	

Table 2-1. Federal, state, and local environmental laws and regulations applicable to NNSA/NFO (continued)

Regulator: Regulation[a]	Description of Law/Regulation[b]	Compliance Status	Report Section(s)
		Discharge Form is required to verify compliance with the CWA. Both the NLVF and RSL-Nellis maintain and implement a Spill Prevention, Control, and Counter-measure Plan required by the EPA to ensure that petroleum and non-petroleum oil products do not pollute waters of the United States via discharge into the Las Vegas Wash.	
		In 2016, all water chemistry parameters and contaminants that required monitoring in wastewater discharges and sewage lagoons were within permit limits, all required inspections of wastewater systems were conducted. Two reportable transformer oil spills occurred on the NNSS (see Section 2.5).	Section 2.5
N/A	Energy Independence and Security Act of 2007 (EISA) (Pub. L. 110-140). Section 438 of this act addresses storm water management and requires that any development/redevelopment project involving a federal facility with a footprint over 5,000 gross square feet (gsf) maintain or restore, to the maximum extent feasible, the predevelopment hydrology of the property with regard to the rate, temperature, volume, and duration of storm water flow.	No new development/redevelopment projects of buildings greater than 5,000 gsf were identified for FY 2016 or FY 2017.	N/A
EPA: 40 CFR 141-149 NDEP: NAC 445A	Safe Drinking Water Act (SDWA), 42 USC 300f et seq. (1974). This act protects the quality of drinking water in the United States and authorizes the EPA to establish safe standards of purity. It requires all owners or operators of ***public water systems*** (PWSs) (see Glossary, Appendix B) to comply with National Primary Drinking Water Standards (health standards). State governments are authorized to set Secondary Standards related to taste, odor, and visual aspects. NAC 445A, *Water Controls*, requires that PWSs meet both primary and secondary water quality standards. The SDWA standards for radionuclides currently apply only to PWSs designated as ***community water systems*** (see Glossary, Appendix B).	The NNSS supplies drinking water from onsite wells that comply with all applicable SDWA and state water quality standards. Three PWSs on the NNSS are permitted by the state as ***non-community water systems*** (see Glossary, Appendix B). NDEP also permits two potable water hauler trucks on the NNSS. Although not required under the SDWA, all potable water supply wells on the NNSS are monitored for radionuclides in compliance with DOE O 458.1, *Radiation Protection of the Public and the Environment*. In 2016, no radionuclides from NNSA/NFO activities were detected in NNSS drinking water wells, the PWSs met all applicable primary and secondary drinking water standards, and all NNSS potable water hauling trucks tested negative for coliform bacteria.	Chapter 5, Sections 5.1.3.6 , 5.2.1
		Water used at both the NLVF and RSL-Nellis is supplied by the CNLV and meets or exceeds federal drinking water standards.	N/A

Table 2-1. Federal, state, and local environmental laws and regulations applicable to NNSA/NFO (continued)

Regulator: Regulation[(a)]	Description of Law/Regulation[(b)]	Compliance Status	Report Section(s)
Radiation Protection			
DOE: DOE O 458.1, Change 3 DOE-STD-1196-2011 DOE-STD-1153-2002	Radiation Protection of the Public and the Environment. This order requires DOE/NNSA sites to establish and document an environmental radiological protection program. It establishes requirements for (1) measuring radioactivity in the environment, (2) documenting the ALARA [as low as reasonably achievable] process for operations, (3) using mathematical models for estimating doses, (4) releasing property having residual radio-active material, and (5) maintaining records to demonstrate compliance. The ***Derived Concentration Standards (DCSs)*** (see Glossary, Appendix B), defined in U.S. Department of Energy Standard DOE-STD-1196-2011, *Derived Concentration Technical Standard*, are to be used in the design and conduct of environmental radiological protection programs. The order sets a radiation dose limit of 100 mrem/yr (1 mSv/yr) above background levels to individuals in the general public from all pathways of exposure combined. It also calls for the protection of populations of terrestrial plants and aquatic and terrestrial animals from radiological impacts through the use of DOE-STD-1153-2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota.*	NNSA/NFO has in place a radiological monitoring program and protection procedures that satisfy the requirements for a site-specific radiological protection program. Routine radiological monitoring of air, water, and biota as well as project-specific monitoring and NESHAP evaluations of projects, are conducted. Monitoring and evaluation results document NNSA/NFO's compliance with the radiological dose limits set by DOE for the public and biota from several exposure pathways that include predominately inhalation and the ingestion of hunted NNSS game animals. Results of radiological monitoring and protective measures are described in this report throughout several chapters. As in previous years, the calculated dose to the public and to the biota from NNSA/NFO operations in 2016 were below all DOE dose limits set by DOE O 458.1 and DOE-STD-1153-2002, respectively. DCSs defined in DOE-STD-1196-2011 were used to evaluate radiological monitoring results.	Chapter 4, Section 4.1 Chapter 5, Section 5.1 Chapter 6 Chapter 7 Chapter 8 Chapter 9
Waste Management and Environmental Restoration			
EPA: 40 CFR 300 40 CFR 302 40 CFR 355 40 CFR 370	Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 USC 9601 et seq (1980). These acts provide a framework for the cleanup of waste sites containing hazardous substances and an emergency response program in the event of a release of a hazardous substance to the environment (see Emergency Planning and Community Right-to-Know Act).	No hazardous waste cleanup operations on the NNSS are regulated under CERCLA. Instead, they are regulated under the Resource Conservation Recovery Act (listed below). NNSA/NFO complies with the Emergency Planning and Community Right-to-Know Act under CERCLA (listed below).	N/A
EPA: 40 CFR 259–282 NDEP: NAC 444.570–7499 NAC 444.850–8746	Resource Conservation Recovery Act (RCRA), 42 USC 6901 et seq. (1976). This act and the Nevada laws *Disposal of Hazardous Waste* (NAC 444.850–8746), *Solid Waste Disposal* (NAC 444.570–7499), and *Storage Tanks* (NAC 459.9921–999) regulate the generation, storage, transportation, treatment, and disposal of solid and hazardous wastes to prevent	NNSA/NFO generates HW and operates a permitted HW management facility under RCRA Part B Permit NEV HW0101 issued by NDEP. In accordance with the permit, NNSA/NFO monitors groundwater from three wells downgradient of mixed low level waste (MLLW) disposal cells, conducts post-closure monitoring for HW sites that were closed under RCRA prior to enactment of the Federal	Chapter 10, Sections 10.1.7, 10.2, 10.3, 10.4

Table 2-1. Federal, state, and local environmental laws and regulations applicable to NNSA/NFO (continued)

Regulator: Regulation[(a)]	Description of Law/Regulation[(b)]	Compliance Status	Report Section(s)
NAC 459.9921–999	contaminants from leaching into the environment from landfills, underground storage tanks, surface impoundments, and hazardous waste (HW) disposal facilities. RCRA also requires HW generators to have a program to reduce the amount and toxicity of HW, and federal facilities to have a procurement process to ensure that they purchase product types that satisfy the EPA-designated minimum percentages of recycled material.	Facility Agreement and Consent Order (FFACO), and prepares an EPA Hazardous Waste Report of all HW and MLLW volumes generated and disposed annually at the NNSS and all HW generated annually at the NLVF. All of these RCRA Part B Permit NEV HW0101 requirements were met in 2016.	
		An incident occurred in 2016, which necessitated the removal of a waste container from an NNSS disposal cell that had been mischaracterized as non-hazardous low level waste (LLW) and shipped to the NNSS in 2015 (see Table 2-8, Report No. EM-NNVSO-NST-2016).	Table 2-8
		NNSA/NFO operates and monitors four state-permitted solid waste landfills on the NNSS, and all permit requirements were met in 2016.	
		NNSA/NFO continued to implement a program to reduce the volume/quantity and toxicity of generated HW. A procurement process was used to help ensure that EPA-designated products are purchased containing the minimum content of recycled materials.	Chapter 3, Section 3.3.2
NDEP: FFACO	Federal Facility Agreement and Consent Order (FFACO), as amended. This consent order was agreed to by the State of Nevada, DOE Environmental Management, the U.S. Department of Defense, and DOE Legacy Management in1996. Pursuant to Section 120(a)(4) of CERCLA and to Sections 6001 and 3004(u) of RCRA, the FFACO addresses the environmental restoration of historically contaminated sites for which the NNSA/NFO is responsible for cleanup and closure.	Environmental Management Operations program is responsible for the cleanup and closure of over 3,000 corrective action sites (CASs) identified in Nevada. Environmental Restoration (ER) activities follow a formal work process described in the FFACO. The State of Nevada is a participant throughout the closure process, and the Nevada Site Specific Advisory Board is kept informed of the progress made. The board is a formal volunteer group of interested citizens who provide informed recommendations to NNSA/NFO.	Chapter 11
		In 2016, NNSA/NFO closed 14 CASs and met all of the 2016 FFACO milestones for the characterization, remediation, closures, and post-closure monitoring and inspection of historically contaminated CASs. To date, 2,129 of the 3,039 CASs have been closed.	
DOE: DOE O 435.1, Change 1	Radioactive Waste Management. This order requires that all DOE radioactive waste be managed in a manner that is protective of the worker, public health and safety, and the environment. It directs how radioactive waste management operations are conducted on the NNSS.	The Area 3 RWMS and the Area 5 RWMS operate as Category II Non-Reactor Nuclear Facilities. They are designed and operated to manage and safely dispose of LLW, MLLW, and HW generated by NNSA/NFO, other DOE and selected U.S. Department of Defense operations, and to manage and safely store transuranic and mixed transuranic wastes generated on the NNSS for eventual shipment	Chapter 10, Section 10.1
DOE M 435.1-1, Change 2	DOE M 435.1-1, Change 2, *Radioactive Waste Management Manual*, specifies that		

Table 2-1. Federal, state, and local environmental laws and regulations applicable to NNSA/NFO (continued)

Regulator: Regulation[(a)]	Description of Law/Regulation[(b)]	Compliance Status	Report Section(s)
	operations at radioactive waste management facilities must not contribute a dose to the general public in excess of 25Sh mrem/yr.	to the Waste Isolation Pilot Plant in New Mexico. In accordance with this order, ***Performance Assessments (PAs)*** (see Glossary, Appendix B) and ***Composite Analyses (CAs)*** (see Glossary, Appendix B) for both RWMSs are reviewed annually to assess their adequacy, and results are submitted annually to the DOE Office of Environmental Management. The Disposal Authorization Statements for both RWMSs also require that annual reviews be made and that secondary or minor unresolved issues be tracked and addressed. Waste Acceptance Criteria for radioactive wastes received at the RWMSs are maintained and the volumes of LLW and MLLW disposed at the RWMSs are tracked. Although not required by this DOE order, ***vadose zone*** (see Glossary, Appendix B) monitoring at both RWMSs is performed to validate the performance assessment criteria of the RWMSs. In 2016, all key documents and analyses were current and all required management practices were followed.	
Hazardous Materials Control and Management			
EPA: 40 CFR 300 40 CFR 302 40 CFR 355 40 CFR 370 40 CFR 372	Emergency Planning and Community Right-to-Know Act (EPCRA), 42 USC 11001 et seq. (1986). This act requires that federal, state, and local emergency planning authorities be provided information regarding the presence and storage of hazardous substances and their planned and unplanned environmental releases, including provisions and plans for responding to emergency situations involving hazardous materials.	Some NNSA/NFO facilities store or use chemicals in quantities exceeding threshold planning quantities under EPCRA. NNSA/NFO complies with all reporting and emergency planning requirements under EPCRA and with the requirements of several state-issued hazardous materials permits: a site-wide NNSS permit, one for the Nonproliferation Test and Evaluation Complex on the NNSS, one for NLVF, and one for RSL-Nellis. In 2016, NNSA/NFO adhered to all EPCRA reporting requirements. The Nevada Combined Agency Report, containing updated chemical inventories for NNSA/NFO facilities, was submitted to NDEP, and a Toxic Release Inventory Report was submitted to EPA identifying the types and quantities of toxic chemicals that were either released by NNSA/NFO operations into the environment or released for disposal or recycling.	Section 2.4.4.1 Appendix A, Sections A.1.5, A.2.4
NDEP: NAC 459.952–95528	State of Nevada Chemical Catastrophe Prevention Act (NRS 459.380–3874). This act directs NDEP to develop and implement a program called the Chemical Accident Prevention Program (CAPP). It requires	The Nonproliferation Test and Evaluation Complex (NPTEC) in Area 5 of the NNSS is registered as a CAPP facility. NNSA/NFO submits an annual CAPP Registration report to	Section 2.4.4.2

Table 2-1. Federal, state, and local environmental laws and regulations applicable to NNSA/NFO (continued)

Regulator: Regulation[(a)]	**Description of Law/Regulation**[(b)]	**Compliance Status**	**Report Section(s)**
	registration of facilities storing highly hazardous substances above listed thresholds.	the State of Nevada, whether or not a threshold was exceeded. In 2016, one highly hazardous substance was stored at NPTEC in quantities that exceeded reporting thresholds, and the annual compliance inspection at NPTEC conducted by NDEP found the facility was meeting regulatory requirements.	
EPA: 40 CFR 700–763 NDEP: NAC 444.842–8746	<u>Toxic Substances Control Act (TSCA), 15 USC 2601 et seq. (1976).</u> This act regulates the manufacture, use, and distribution of chemical substances that enter the consumer market. Because the NNSS does not produce chemicals, compliance is primarily directed toward the management of polychlorinated biphenyls (PCBs). NAC 444, *Sanitation*, enforces the federal requirements for the handling, storage, and disposal of PCBs and contains record keeping requirements for PCB activities.	At the NNSS, remediation activities and maintenance of fluorescent light ballasts can result in the onsite disposal of PCB-contaminated waste or the offsite disposal of larger quantities of PCB waste. NNSS also receives radioactive waste for onsite disposal that may contain regulated levels of PCBs. The onsite disposal of all PCB wastes and recordkeeping requirements for PCB activities are regulated on the NNSS by the State of Nevada. In 2016, PCBs were managed in compliance with TSCA and state regulations.	Section 2.4.2
EPA: 40 CFR 162–171 NDOA: NAC 555	<u>Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), 7 USC 136 et seq. (1996).</u> This act governs the manufacture, use, storage, and disposal of pesticides (including herbicides and other biocides) as well as the pesticide containers and residuals. It specifies procedures and requirements for pesticide registration, labeling, classification, and certification of applicators. NAC 555, *Nevada Control of Insects, Pests, and Noxious Weeds,* regulates the certification of registered pesticide and herbicide applicators in Nevada. The Nevada Department of Agriculture (NDOA) has the primary role to enforce FIFRA in Nevada.	The use of pesticides classified as "restricted-use pesticides" is regulated. Beginning in 2015, only non-restricted-use pesticides are applied under the direction of a State of Nevada–certified applicator. In 2016, NNSA/NFO complied with all FIFRA requirements.	Section 2.4.3
Cultural Resources			
ACHP: 36 CFR 800	<u>National Historic Preservation Act (NHPA), as amended, 54 USC 300101 et seq. (1966).</u> This act identifies, evaluates, and protects historic properties eligible for listing in the National Register of Historic Places (NRHP). Such properties can be archeological sites or historic structures, documents, records, or objects. The act requires federal agencies to develop and implement a Cultural Resources Management Plan, to identify and evaluate the eligibility of historic properties for long-term management as well as for future project-specific planning, and to maintain	NNSA/NFO has established a Cultural Resources Management (CRM) program at the NNSS, which is implemented by the Desert Research Institute (DRI). The CRM program ensures compliance with all regulations pertaining to cultural resources on the NNSS. Before initiating land-disturbing activities or building and structure modifications, archaeologists conduct surveys and historical evaluations to identify important cultural and historical resources, evaluate the cultural and historical significance, and assess potential impacts. Native American representatives also conduct cultural assessments of proposed land	Chapter 12, Sections 12.1, 12.2

Table 2-1. Federal, state, and local environmental laws and regulations applicable to NNSA/NFO (continued)

Regulator: Regulation[(a)]	Description of Law/Regulation[(b)]	Compliance Status	Report Section(s)
	archaeological collections and their associated records at professional standards.	disturbances to identify resources that may be of spiritual or cultural significance. NNSA/NFO's long-term management strategy includes (1) monitoring NRHP-listed and eligible properties to determine if environmental factors or NNSA/NFO activities are affecting the integrity or other aspects of eligibility, and (2) taking corrective actions or identifying alternative approaches that may be necessary. Determinations of NRHP eligibility, effect, and mitigation are conducted in consultation with the NSHPO, the Consolidated Group of Tribes and Organizations (CGTO) and, in some cases, the federal Advisory Council on Historic Preservation. To date, more than 1,400 NRHP eligible sites/ facilities on the NNSS have been identified. In 2016, field surveys and historical evaluations for 13 NNSS projects were conducted, 66 cultural resources were identified, 20 of which were determined eligible to the NRHP.	
DOI: 18 CFR 1312 36 CFR 79 43 CFR 7	Archaeological Resources Protection Act (ARPA), as amended (16 USC 470aa–mm). This act protects archaeological resources that remain in or on federal and American Indian lands and ensures that their confidentiality and characteristics are maintained. It requires the issuance of a federal archaeology permit to qualified archaeologists to inventory, excavate, or remove archaeological resources and requires notification to American Indian tribes of these activities.	Archaeologists working at the NNSS must have qualifications that meet federal standards and must work under a permit issued by NNSA/NFO. Procedures are in place to maintain the confidentiality of site locations and other information. In the event of vandalism, NNSA/NFO investigates any impacts that may occur. The CRM program curates archaeological collections from the NNSS in accordance with 36 CFR 79, *Curation of Federally Owned and Administered Archeological Collections*, and conducts American Indian consultations related to places and items of importance to the CGTO.	Chapter 12, Section 12.4
N/A	American Indian Religious Freedom Act, as amended (42 USC 1996). This law established the government policy to protect and preserve for American Indians their inherent right of freedom to believe, express, and exercise the traditional religions, including but not limited to access to sites, use and possession of sacred objects, and the freedom to worship through ceremonial and traditional rites.	Locations exist on the NNSS that have religious significance to Western Shoshone, Southern Paiute and Owens Valley Paiute and Shoshone. Access is provided by NNSA/NFO in accordance with safety and health standards. No requests for access were received in 2016.	Chapter 12, Section 12.5
DOI: 43 CFR 10	Native American Graves Protection and Repatriation Act (NAGPRA), as amended (25 USC 3001–3013). This act requires federal agencies to return certain types of Native American cultural items to lineal descendants and culturally affiliated American Indian tribes. The specified	The NNSS artifact collection is subject to NAGPRA. The required inventory and summary of NNSS cultural materials accessioned into the NNSS Archaeological Collection was completed in the 1990s. The inventory list and summary was distributed to the tribes affiliated with the NNSS and	Chapter 12, Sections 12.4, 12.5

Table 2-1. Federal, state, and local environmental laws and regulations applicable to NNSA/NFO (continued)

Regulator: Regulation(a)	Description of Law/Regulation(b)	Compliance Status	Report Section(s)
	cultural items include human remains, funerary objects, sacred objects, and objects of cultural patrimony.	adjacent lands. Consultations followed, and all artifacts the tribes requested were repatriated to them. This repatriation process was completed in 2002; it will be repeated for any new additions to the collection.	
Biological Resources			
FWS: 50 CFR 17 NDOW: NAC 503.0001–503.104 NDOF: NAC 527	Endangered Species Act (ESA), 16 USC 1531-1544 (1973). This act prohibits activities that would jeopardize the continued existence of an endangered or threatened species, or cause adverse modification to a critical habitat. Nevada Department of Wildlife (NDOW) regulations identify protected and unprotected Nevada animal species and prohibits the harm of protected species without special permit. NAC 503 also identifies game animals, which are managed by the state. Nevada Department of Forestry (NDOF) regulations prohibits removal or destruction of state protected plants without special permit.	The threatened desert tortoise is the only species protected under the ESA that may be impacted by NNSS operations. NNSS activities within tortoise habitat are conducted so as to comply with the terms and conditions of Biological Opinions (BOs) issued by the U.S. Fish and Wildlife Service (FWS) to NNSA/NFO. In 2016, all FWS requirements of BOs were met. One desert tortoise was accidentally killed on a road. Other state-managed and state-protected species are monitored under the Ecological Monitoring and Compliance (EMAC) Program. Some species are collected for ecological studies under an NDOW scientific collection permit.	Chapter 13, Section 13.1
FWS: 50 CFR 21 NDOW: NRS 503.050	Migratory Bird Treaty Act (MBTA), 16 USC 703-712 (1918). This act implements various treaties and conventions between the U.S. and Canada, Japan, Mexico, and the former Soviet Union for the protection of migratory birds. It prohibits the harming of any migratory bird, their nest, or eggs without authorization by the Secretary of the Interior. Nevada wildlife laws protect birds protected under the MBTA.	Compliance with the MBTA is documented under the EMAC Program. Proposed construction and demolition projects are reviewed and field surveys are conducted to prevent harm to migratory birds and their nests/eggs. Biologists periodically collect game birds for radiological analysis under an FWS-issued migratory bird scientific collection permit. Migratory birds found injured or dead are reported to regulators. Biologists transfer injured raptors, upon direction from the FWS, to a licensed rehabilitator, and mitigation measures to reduce accidental mortalities are pursued. In 2016, 11 migratory birds were found dead; seven of the deaths were due to human activities.	Chapter 13, Section 13.3
FWS: 50 CFR 22 NDOW: NRS 503.050	The Bald and Golden Eagle Protection Act (BGEPA), 16 USC 668a-d, 703-712. This act prohibits any form of possession or taking of both bald and golden eagles. Eagles are also protected under Nevada wildlife laws.	Compliance with the BGEPA is documented under the EMAC Program. Eagles that are occasionally electrocuted on NNSS powerlines are transferred to the FWS under an FWS special purpose possession permit. Bird guards and protective covers were installed at 13 power line poles. One golden eagle and five other raptors were electrocuted in 2016.	Chapter 13, Section 13.3
N/A	Wild Free-Roaming Horses and Burros Act (Pub. L. 92–195). This act makes it unlawful to harm wild horses and burros. It requires the U.S. Bureau of Land Management (BLM) and the U.S. Forest	The NNSS is not within a BLM active herd management area. A Five-Party Cooperative Agreement exists, however, between NNSA/NFO, Nevada Test and Training Range (NTTR), FWS, BLM, and the State of Nevada,	Chapter 13, Section 13.3

Table 2-1. Federal, state, and local environmental laws and regulations applicable to NNSA/NFO (continued)

Regulator: Regulation[(a)]	Description of Law/Regulation[(b)]	Compliance Status	Report Section(s)
	Service (FS) to protect, manage, and control wild horses and burros on BLM and FS lands in a manner that is designed to achieve and maintain a thriving natural ecological balance.	which calls for cooperation in conducting resource inventories and developing resource management plans for wild horses and burros, and maintaining favorable habitat for them on federally withdrawn lands. NNSA/NFO consults with BLM on issues of NNSS horse management, and NNSS biologists conduct periodic horse census surveys on the NNSS.	
EO 13112	Invasive Species. This EO directs federal agencies to act to prevent the introduction of, or to monitor and control, invasive (non-native) species; to provide for restoration of native species; and to exercise care in taking actions that could promote the introduction or spread of invasive species.	Land-disturbing activities on the NNSS have resulted in the spread of numerous invasive plant species. Habitat reclamation and other controls are evaluated and conducted, when feasible, to control such species and meet the purposes of this EO.	Chapter 13, Section 13.4
Environmental Activities and Occurrence Reporting			
DOE: DOE O 231.1B Manual 231.1-1A	Environment, Safety and Health Reporting. This order requires the timely collection, reporting, analysis, and dissemination of information on environment, safety, and health issues as required by law or regulations or as needed to ensure that DOE is kept fully informed on a timely basis about events that could adversely affect the health and safety of the public, workers, the environment, the intended purpose of DOE facilities, or the credibility of the DOE. It requires DOE and NNSA sites to prepare an annual calendar year report, referred to as the Annual Site Environmental Report (ASER).	NNSA/NFO prepares an ASER called the NNSS Environmental Report (NNSSER) and provides data for DOE to prepare annual NEPA summaries and other Safety, Fire Protection, and Occupational Safety and Health Administration (OSHA) reports. The NNSSER (i.e., this report) demonstrates compliance with DOE internal standards and requirements, such as the radiation protection requirements of DOE O 458.1, and documents DOE's environmental performance to members of the public living near the NNSS and to other stakeholders.	All chapters
DOE: DOE O 232.2	Occurrence Reporting and Processing of Operations Information. This order requires that DOE and NNSA be informed about events that could adversely affect the health and safety of the public, workers, environment, DOE missions, or the credibility of the DOE. It sets reporting criteria for unplanned environmental releases of pollutants, hazardous substances, extremely hazardous substances, petroleum products, and sulfur hexafluoride at DOE/ NNSA sites and facilities. It also requires sites/facilities to report to DOE/NNSA any written notification received from an outside regulatory agency that the site/facility is in non-compliance with a schedule or requirement.	NNSA/NFO contractors enter environmental occurrences, identified as reportable in accordance with this order, into DOE's Occurrence Reporting and Processing System (ORPS). Reported information includes significance of the identified event, notifications, development of causal factors, and corrective actions designed to prevent recurrences using a graded approach based on the significance of the event. Reportable environmental events that occurred in 2016 are presented in Table 2-8.	Section 2.5, Table 2-8
Quality Assurance			
DOE: DOE O 414.1D, Change 1 DOE:	Quality Assurance. The objective of this order is to establish an effective management system using the performance requirements of this order, coupled with consensus	NNSA/NFO has QAPs in place to implement quality management methodology in adherence to this DOE order. The QAPs ensure that all environmental monitoring data	Chapter 14, Chapter 15

Table 2-1. Federal, state, and local environmental laws and regulations applicable to NNSA/NFO (continued)

Regulator: Regulation[a]	Description of Law/Regulation[b]	Compliance Status	Report Section(s)
10 CFR 830, Subpart A	standards, where appropriate, to ensure 1) products and services meet or exceed customers' expectations; 2) there is management support for planning, organization, resources, direction, and control; 3) performance and quality improvements occur by means of thorough, rigorous assessments and corrective actions; and 4) environmental, safety, and health risks and impacts associated with work processes are minimized while maximizing reliability and performance of work products. Using a graded approach, DOE/NNSA sites must develop a quality assurance plan (QAP) to establish additional process-specific quality requirements and implement the approved QAP.	meet quality assurance and quality control requirements. Samples are collected to meet quality assurance and quality control requirements. Samples are collected and analyzed using standard operating procedures to ensure representative samples and reliable, defensible data. Quality control in subcontracted analytical laboratories is maintained through instrument calibration, efficiency and background checks, and testing for precision and accuracy. Data are verified and validated according to project-specific quality objectives before they are used to support decision making.	

(a) For federal laws, a reference to its implementing regulation, which was written by the identified federal regulatory agency, is given. The regulation is identified by its Code of Federal Regulations (CFR) Title and Part (e.g., 10 CFR 1021 means, "Title 10 Part 1021"). CFR references can be accessed here. If no implementing regulations have been written, then N/A (not applicable) is entered. For more explanatory information on ***federal citations***, see Glossary, Appendix B).

For Nevada State laws, either the Nevada Administrative Code (NAC) or the Nevada Revised Statute (NRS) reference is given. NACs can be accessed here. NRSs can be accessed here.

For DOE directives (e.g., Orders, Manuals, Standards), the directive's number is given. DOE directives can be accessed here.

(b) For federal laws, the name of the law and its reference in the United States Code (USC) by Title and Section is given (e.g., 42 USC 4321 et seq. means, "Title 42 Section 4321 and the following." USC references can be accessed here. If there is not a USC reference, the public law (Pub. L.) number is given.

Table 2-2. Summary of NPDES Permit NV0023507 compliance at the NLVF in 2016 for Outfalls 001 and 002

Parameter	Number of Permit Exceedances	Number of Samples Taken	Number of Compliant Samples	Percent Compliance	Date(s) Exceeded	Description/ Solution
Daily maximum flow	0	365 (continuous)	365	100	NA[a]	NA
Total petroleum hydrocarbons	0	1 (1/year)	1	100	NA	NA
Total suspended solids	0	4 (1/quarter)	4	100	NA	NA
Total dissolved solids	0	4 (1/quarter)	4	100	NA	NA
Total inorganic nitrogen	0	4 (1/quarter)	4	100	NA	NA
pH	0	4 (1/quarter)	4	100	NA	NA
Tritium	MR[b]	1 (1/year)	1	100	NA	NA
Metals	MR	1 (1/two years)	1	100	NA	NA
Total cyanide	MR	1 (1/two years)	1	100	NA	NA
Volatile organics	MR	1 (1/two years)	1	100	NA	NA
Pesticides	MR	1 (1/two years)	1	100	NA	NA
Polychlorinated biphenyls	MR	1 (1/two years)	1	100	NA	NA
Acid extractables	MR	1 (1/two years)	1	100	NA	NA
Base neutral extractables	MR	1 (1/two years)	1	100	NA	NA
Dioxins	MR	1 (1/two years)	1	100	NA	NA
Asbestos	MR	1 (1/two years)	1	100	NA	NA

(a) NA = not applicable
(b) MR = monitor and report, no specified daily maximum or 30-day average limit, just the requirement that there shall be no discharge of substances that would cause a violation of state water quality standards

2.2 Environmental Permits

Table 2-3 presents the complete list of all federal and state permits active during 2016 for NNSS, NLVF, and RSL-Nellis operations. The table includes those pertaining to air quality monitoring, operation of drinking water and sewage systems, hazardous materials and HW management and disposal, and endangered species protection. Some permit names retain the older "NTS" acronym for the NNSS because they have not been officially changed with the regulatory agencies. Reports associated with permits are submitted to the appropriate designated state or federal office. Copies of reports may be obtained upon request.

Table 2-3. Environmental permits required for NNSA/NFO operations at NNSS, NLVF, and RSL-Nellis

Permit Number	Permit Name or Description	Expiration Date	Reporting
Air Quality	**NNSS**		
AP9711-2557	NNSS Class II Air Quality Operating Permit	June 25, 2014 (permit renewal submitted April, 2014 and not yet issued)	Annually
15-30 and 16-27	NNSS Open Burn Authorization, Fire Extinguisher Training (Various Locations)	March 22, 2016/ March 22, 2017	None
15-31 and 16-28	NNSS Open Burn Authorization, Simulated Vehicle Burns, A-23, Facility #23-T00200 (NNSS Fire & Rescue Training Center)	March 21, 2016/ March 22, 2017	None
	UGTA Offsite		
AP9711-2659.01	NTTR Class II Air Quality Operating Permit, Surface Area Disturbance, Wells ER-EC-13 and ER-EC-15	March 4, 2020	Annually
AP9711-2824	NTTR Class II Air Quality Operating Permit, Surface Area Disturbance, Well ER-EC-14	June 14, 2021	Annually
	NLVF		
Source 657	Clark County Minor Source Permit	August 11, 2020	Annually
	RSL-Nellis		
Source 348	Clark County Minor Source Permit	July 5, 2017	Annually
Drinking Water	**NNSS**		
NY-0360-12NTNC	Areas 6 and 23	September 30, 2016/2017	None
NY-4098-12NC	Area 25	September 30, 2016/2017	None
NY-4099-12NC	Area 12	September 30, 2016/2017	None
NY-0835-12NP	NNSS Water Hauler #84846	September 30, 2016/2017	None
NY-0836-12NP	NNSS Water Hauler #84847	September 30, 2016/2017	None
Septic Systems/Pumpers	**NNSS**		
NY-1054	Septic System, Area 3, Waste Management Offices – inactive	None	None
NY-1069	Septic System, Area 18 (Pahute Airstrip)[(a)]	None	None
NY-1077	Septic System, Area 27 (Baker Compound)[(a)]	None	None
NY-1079	Septic System, Area 12, U12g Tunnel - inactive	None	None
NY-1080	Septic System, Area 23 (Building 23-1103)[(a)]	None	None
NY-1081	Septic System, Area 6, Control Point-170 - inactive	None	None
NY-1082	Septic System, Area 22 (Building 22-1)[(a)]	None	None
NY-1083	Septic System, Area 5 (Area 5 RWMC)[(a)]	None	None
NY-1084	Septic System, Area 6, Device Assembly Facility - inactive	None	None
NY-1085	Septic System, Area 25 (Central Support Area)[(a)]	None	None
NY-1086	Septic System, Area 25 (Reactor Control Point)[(a)]	None	None
NY-1087	Septic System, Area 27 (Able Compound)[(a)]	None	None
NY-1089	Septic System, Area 12 (Area 12)[(a)]	None	None
NY-1090	Septic System, Area 6 (LANL)[(a)]	None	None

Table 2-3. Environmental permits required for NNSA/NFO operations at NNSS, NLVF, and RSL-Nellis (continued)

Permit Number	Permit Name or Description	Expiration Date	Reporting
NY-1091	Septic System, Area 23 (Gate 100)[(a)]	None	None
NY-1103	Septic System, Area 22 (Desert Rock Airstrip)[(a)]	None	None
NY-1106	Septic System, Area 5 (NPTEC)[(a)]	None	None
NY-1110-HAA-A	Individual Sewage Disposal System, A-12, Building 12-910 - inactive	None	None
NY-1112	Commercial Sewage Disposal System (U1a Complex)[(a)]	None	None
NY-1113	Commercial Sewage Disposal System, Area 1, Building 121 - inactive	None	None
NY-1124	Commercial Individual Sewage Disposal System (RNCTEC)[(a)]	None	None
NY-1128	Commercial Individual Sewage Disposal System (Yucca Lake Airfield)[(a)]	None	None
NY-1130	Commercial Individual Sewage Disposal System (Building 06-950)[(a)]	None	None
NY-17-06839	Septic Tank Pumper E 106785	July 31, 2016/2017	None
NY-17-06839	Septic Tank Pumper E 107105	July 31, 2016/2017	None
NY-17-06839	Septic Tank Pumper E-105918	July 31, 2016/2017	None
NY-17-06839	Septic Tank Pumping Contractor (one unit)	July 31, 2016/2017	None
NY-17-06839	Septic Tank Pumper E-106169	July 31, 2016/2017	None
NY-17-06839	Septic Tank Pumper E-107103	July 31, 2016/2017	None
Wastewater Discharge	**NNSS**		
GNEV93001Rv X	Water Pollution Control General Permit	August 5, 2020	Quarterly
NEV96021	Water Pollution Control for E Tunnel Waste Water Disposal System and Monitoring Well ER-12-1	October 1, 2018	Quarterly
	NLVF		
MSC-833 and 036555-02	NLVF Wastewater Contribution Permit and NLVF Authorization to Discharge	December 23, 2016 and no expiration date	As Needed
NV0023507	National Pollutant Discharge Elimination System Permit	June 24, 2017	Quarterly
	RSL-Nellis		
Not applicable	Annual certification statement of zero discharge	None	January
Underground Injection Control	**NNSS**		
UNEV2012203	NNSS Underground Injection Control Permit	July, 6, 2017	Semi-annually
Hazardous Materials	**NNSS**		
57689	NNSS Hazardous Materials Permit	February 28, 2017	Annually
58913	Nonproliferation Test and Evaluation Complex Hazardous Materials Permit	February 28, 2017	Annually
	NLVF		
58908	NLVF Hazardous Materials Permit	February 28, 2017	Annually
	RSL-Nellis		
58910	RSL-Nellis Hazardous Materials Permit	February 28, 2017	Annually
Hazardous Waste	**NNSS**		
NEV HW0101	RCRA Permit for NNSS Hazardous Waste Management (Area 5 Mixed Waste Disposal Unit, Area 5 Mixed Waste Storage Unit, Hazardous Waste Storage Unit, and Explosive Ordnance Disposal Unit)	December 10, 2020	Biennially and annually
Waste Management	**NNSS**		
SW 523	Area 5 Asbestiform Low-Level Solid Waste Disposal Site	Post-closure[(b)]	Annually
SW 13 097 02	Area 6 Hydrocarbon Disposal Site	Post-closure	Annually
SW 13 097 03	Area 9 U10c Solid Waste Disposal Site	Post-closure	Annually
SW 13 097 04	Area 23 Solid Waste Disposal Site	Post-closure	Biannually
	RSL-Nellis		
PR0064276	RSL-Nellis Waste Management Permit-Underground Storage Tank	December 31, 2017	None

Table 2-3. Environmental permits required for NNSA/NFO operations at NNSS, NLVF, and RSL-Nellis (continued)

Permit Number	Permit Name or Description	Expiration Date	Reporting
Endangered Species/Wildlife			
File Nos. 84320-2008-F-0416 and 84320-2008-B-0015	U.S. Fish and Wildlife Service Desert Tortoise Incidental Take Authorization (Biological Opinion for Programmatic NNSS Activities)	February 12, 2019	Annually
MB-008695-0	U.S. Fish and Wildlife Service Migratory Bird Salvage and Collection	February 9, 2017	Annually
TE84209B-0	U.S. Fish and Wildlife Service Native Threatened Species Recovery	August 22, 2021	Annually
261454	Nevada Department of Wildlife Scientific Collection of Wildlife Samples	December 31, 2016	Annually

(a) Name in parenthesis is name of the septic system shown on Figure 5-6 of Chapter 5.
(b) Permit expires 30 years after closure of the landfill

2.3 NEPA Assessments

The National Environmental Policy Act (NEPA) regulations require federal agencies to evaluate the environmental effects of proposed major federal activities. The prescribed evaluation process ensures that the proper level of environmental review is performed before an irreversible commitment of resources is made. NNSA/NFO performs environmental reviews with the aid of a NEPA Environmental Evaluation Checklist (Checklist), which is required for all proposed projects or activities on the NNSS. The Checklist is reviewed by the NNSA/NFO NEPA Compliance Officer to determine if the activity's environmental impacts have been addressed in a previous NEPA assessment. If a proposed project has not been covered under any previous NEPA analysis and it does not qualify for a "Categorical Exclusion" (per 10 CFR 1021), then a new NEPA analysis is initiated. The analysis may result in preparation of a new Environmental Assessment, Environmental Impact Statement, or supplemental document to the existing programmatic *Site-Wide Environmental Impact Statement for the Nevada National Security Site and Offsite Locations in Nevada* (NNSS SWEIS) (U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office 2013). The NEPA Compliance Officer must approve each Checklist before a project proceeds. Table 2-4 presents a summary of how NNSA/NFO complied with NEPA in 2016.

In 2016, NNSA/NFO completed the NNSA/NFO NEPA Annual Planning Document, and submitted it to DOE HQ in January 2017. It provides the status of all Environmental Assessments (EAs) and Environmental Impact Statements (EISs) being developed or planned in the next 12–24 months.

Table 2-4. NNSS NEPA compliance activities conducted in FY 2016

Results of NEPA Checklist Reviews/NEPA Compliance Activities
41 NEPA Checklists were reviewed
12 projects were exempted from further NEPA analysis because they were of Categorical Exclusion (CX) status
29 projects were exempted from further NEPA analysis due to their inclusion under previous analysis in the NNSS SWEIS

2.4 Hazardous Materials Control and Management

2.4.1 Hazardous Substance Inventory

Hazardous materials used or stored on the NNSS are controlled and managed through the use of a chemical inventory module of an enterprise asset management software system called Maximo, which was implemented in 2015. The development of this new electronic chemical management system was identified as a target under NSTec's Environmental Management System (see Chapter 3). Hazardous substances used or stored by contractors and subcontractors of the NNSA/NFO are entered into this database. They are required to comply with the operational and reporting requirements of the Toxic Substances Control Act; the Federal Insecticide, Fungicide, and Rodenticide Act; the Emergency Planning and Community Right-to-Know Act; and the Nevada Chemical Catastrophe Prevention Act. Chemicals to be purchased are subject to a requisition compliance review process. Hazardous substance purchases are reviewed to ensure that toxic chemicals and products were not purchased when less hazardous substitutes were commercially available. Requirements and responsibilities for the use and management of hazardous/toxic chemicals are provided in company documents.

The inventory management system allows the tracking of chemicals from the moment they arrive at NNSS, NLVF, or RSL-Nellis to when they are disposed, and provides an accurate account of chemicals on site at any point in time. It provides chemical owners with additional information including purchase dates, Safety Data Sheets, storage locations, and expiration dates. The system allows for real time chemical inventories to be utilized for emergency planning and planning for operational needs. The tracking system reduces the quantities of chemicals purchased and stored through the chemical custodian's awareness of the chemicals currently in inventory. Chemical compatibility and proper storage is routinely evaluated and has improved NNSA/NFO's safety posture in regards to the control and management of chemicals. In 2016, over 4,000 chemicals in over 40,000 containers were managed.

2.4.2 Polychlorinated Biphenyls

The storage, handling, and use of ***polychlorinated biphenyls (PCBs)*** (see Glossary, Appendix B) are regulated under the Toxic Substance and Control Act (TSCA). There are no known pieces of PCB–containing electrical equipment (transformers, capacitors, or regulators) at the NNSS. The TSCA program consists mainly of properly characterizing, storing, and disposing of various PCB wastes generated on site through remediation activities at corrective action sites (see Chapter 11) and maintenance of fluorescent lights. PCB bulk product waste (i.e., contaminated building materials) from corrective action sites and light ballasts removed during normal maintenance are disposed of in the Area 9 U10c Solid Waste Disposal Site with prior State of Nevada approval. Soil and other remediation wastes contaminated with PCBs and large volumes of light ballasts are sent off site to an approved PCB disposal facility. Radioactive waste received from offsite waste generator facilities that contain regulated quantities of PCBs are disposed of at the Area 5 Radioactive Waste Management Site (see Section 10.1.1) in accordance with RCRA hazardous waste management permit NEV HW0101. Offsite waste generators bringing PCB wastes to the NNSS for disposal are issued a Certificate of Disposal for PCBs. Onsite PCB records are maintained as required by the EPA, and PCB management activities are documented herein annually. If any generated PCB wastes that are above threshold levels are released, they are also reported in the Toxic Release Inventory (TRI) Report (see Section 2.4.4.1, Table 2-7).

During 2016, NNSS routine maintenance activities generated one drum of non-leaking PCB ballasts, which weighed 90 kilograms (kg) (197 pounds [lb]). It was shipped off site from the Area 5 Hazardous Waste Storage Unit (HWSU) for disposal. The EPA did not conduct any TSCA inspections at the NNSS in 2016.

2.4.3 Pesticides

The storage and application of pesticides (e.g., insecticides, rodenticides, and herbicides) are regulated under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA). Several oversight functions are performed each year to ensure FIFRA compliance. They include the screening of all purchase requisitions for restricted-use pesticides; the review of operating procedures for handling, storing, and applying pesticide products; and monthly inspections of stored pesticides. On the NNSS, pesticides are applied under the direction of a State of Nevada–certified applicator. This service is provided by Solid Waste Operations (SWO). Pesticide applications in NNSS food service facilities are also conducted by SWO. Beginning in mid-2014, the application of restricted-use pesticides was discontinued on the NNSS. Only pesticides categorized as non-restricted-use (i.e., available for purchase and application by the general public) are used. Monthly inspections conducted in 2016 found that all pesticides were stored in accordance with their labeling. The State of Nevada did not conduct an inspection of pesticide storage facilities in 2016.

2.4.4 Release and Inventory Reporting

2.4.4.1 EPCRA

The Emergency Planning and Community Right-to-Know Act (EPCRA) requires that facilities report inventories and releases of certain chemicals that exceed specific thresholds. Table 2-5 identifies the reporting requirements under EPCRA Sections 302, 303, 311, 312, and 313. Table 2-6 summarizes the applicability of the regulations to NNSA/NFO operations in 2016.

Table 2-5. Reporting criteria of the Emergency Planning and Community Right-to-Know Act

Section	CFR Part	Reporting Criteria	Agencies Receiving Report
302	40 CFR 355: Emergency Planning Notifications	The presence of an extremely hazardous substance (EHS) in a quantity equal to or greater than the threshold planning quantity at any one time.	SERC[(a)], LEPC[(b)]
		Change occurring at a facility that is relevant to emergency planning.	LEPC
304	40 CFR 355: Emergency Release Notifications	Release of an EHS or a CERCLA hazardous substance[(c)] in a quantity equal to or greater than the reportable quantity.	SERC, LEPC
311	40 CFR 370: Material Safety Data Sheet Reporting	The presence at any one time at a facility of an OSHA hazardous chemical[(d)] in a quantity equal to or greater than 4,500 kg (10,000 lb) or an EHS in a quantity equal to or greater than the threshold planning quantity or 230 kg (500 lb), whichever is less.	SERC, LEPC, Local Fire Departments
312	40 CFR 370: Tier Two Report	Same as Section 311 reporting criteria above.	SERC, LEPC, Local Fire Departments
313	40 CFR 372: Toxic Release Inventory (TRI) Report	Manufacture, process, or otherwise use at a facility, any listed TRI chemical in excess of its threshold amount during the course of a calendar year. Thresholds are 11,300 kg (25,000 lb) for manufactured or processed or 4,500 kg (10,000 lb) for otherwise used, except for persistent, bio-accumulative, toxic chemicals, which have thresholds of 45 kg (100 lb) or less.	EPA, NDEP

(a) SERC = State Emergency Response Commission
(b) LEPC = Local Emergency Planning Commission
(c) Hazardous substance as defined in CERCLA, 40 CFR 302.4
(d) Hazardous chemical as defined in the Occupational Safety and Health Act, 29 CFR 1910.1200

Table 2-6. Compliance with EPCRA reporting requirements

EPCRA Section	Description of Reporting	2016 Status[(a)]
Section 302	Emergency Planning Notification	Yes
Section 304	EHS Release Notification	Not required
Section 311–312	MSDS/Chemical Inventory	Yes
Section 313	TRI Reporting	Yes

(a) "Yes" indicates that NNSA/NFO reported under the requirements of the EPCRA section specified (see Table 2-3).

NNSA/NFO produces the Nevada Combined Agency (NCA) Report, which satisfies EPCRA Section 302, 311, and 312 reporting requirements. The State Fire Marshal issues permits to store hazardous chemicals at the NNSS, NPTEC, NLVF, and RSL-Nellis based on the NCA Report. The 2016 chemical inventory for NNSS facilities was updated and submitted to the State of Nevada in the NCA Report on February 13, 2017. No EPCRA Section 304 reporting was required in 2016 because no accidental or unplanned release of an extremely hazardous substance occurred at the NNSS, NLVF, or RSL-Nellis.

NNSA/NFO produces an annual TRI Report, as necessary, to comply with EPCRA Section 313 reporting. It identifies the reportable quantities of TRI chemicals released to the environment through air emissions, landfill disposal, and recycling. TRI chemicals that are recovered during NNSS remediation activities or become "excess" to operational needs (e.g., lead bricks, lead shielding) are sent off site for recycling, reuse, or proper disposal. Mixed wastes generated at other DOE facilities that contain TRI chemicals and are sent to the NNSS for disposal are included in the TRI Report. In 2016, reportable quantities of lead, mercury, and PCBs were released as a result of NNSS activities (Table 2-7). No releases at NLVF or RSL-Nellis exceeded reportable thresholds in 2016. In June 2017, NNSA/NFO submitted the TRI Report for calendar year 2016 to the EPA and the State Emergency Response Commission. No EPCRA inspections were performed by outside regulators in 2016.

Table 2-7. Summary of 2016 reported releases under EPCRA Section 313

	Quantity[(a)] (pounds [lb])		
Reported Release	**Lead**	**Mercury**	**PCB**
Air Emissions[(b)]	1.77	0.05	0
Onsite Disposal[(c)]	29,271.24	5,153.91	15.58
Onsite Release[(d)]	2,015.49	0	0
Offsite Recycling[(e)]	89,419.80	0.05	0
Offsite Disposal[(f)]	12.19	0.02	0.10
Cleanup Activities or One-time Events	0	0	0
Totals	120,720.49	5,154.03	15.68
EPCRA Reporting Thresholds	**100**	**10**	**10**

(a) The weight of the chemical released, not the weight of the waste material containing the toxic chemical. All weights have been standardized to two decimal places, whereas weights in the TRI Report vary from two to four decimal places.
(b) Fugitive airborne releases of lead include 1.64 lb during weapons firing at the Mercury Firing Range and 0.13 lb from stack air emissions. All airborne releases of mercury were from stack air emissions.
(c) MLLW or HW containing lead, mercury, or PCB that was received and disposed in Cell 18 at the Area 5 RWMS (see Section 10.1.1).
d) Spent ammunition left on the ground during firing at the Mercury Firing Range. When the firing range is closed, ammunition will be collected for recycling.
(e) Lead was from three waste streams: 89,249 lb of lead-acid batteries, and 170.80 lb of miscellaneous lead items. Mercury was from fluorescent lamps.
(f) Lead was from lead-contaminated soil and other routinely generated waste. Mercury was from lamps and test kits. PCBs were from light ballasts.

2.4.4.2 Nevada Chemical Catastrophe Prevention Act

This act directs NDEP to develop and implement a program called the Chemical Accident Prevention Program (CAPP). It requires registration of facilities storing or processing highly hazardous substances above listed thresholds. The NPTEC in Area 5 of the NNSS is registered as a CAPP facility because of its use of the highly hazardous chemical oleum. On January 26, 2016, NDEP conducted an annual compliance inspection of NPTEC and concluded that its operations met the Nevada regulatory requirements of the CAPP. NNSA/NFO is required to submit an annual CAPP Registration report to the State of Nevada for the NPTEC. The CAPP Registration report for NPTEC operations from June 2016 through May 2017 was submitted to NDEP on June 7, 2017, and it reported the use of oleum at quantities which exceeded its reporting threshold.

2.4.4.3 Continuous Releases

Section 103(a) of CERCLA, and EPA's implementing regulation (40 CFR 302.8), require that federal authorities be notified immediately whenever a reportable quantity of a hazardous substance is released into the environment, so that government response officials can evaluate the need for a response action. CERCLA Section 103(f)(2) provides relief from these immediate reporting requirements for releases of hazardous substances from facilities or vessels that are ***continuous*** (see Glossary, Appendix B) and are predictable and regular in the amount and rate of emission. No continuous releases of hazardous substances are known to occur at the NNSS, NLVF, or RSL-Nellis.

2.5 Environmental Occurrences

DOE O 232.2A, *Occurrence Reporting and Processing of Operations Information*, sets reporting criteria for unplanned environmental releases of pollutants, hazardous substances, extremely hazardous substances, petroleum products, and sulfur hexafluoride at DOE sites and facilities. It also requires sites/facilities to report to DOE any written notification received from an outside regulatory agency that the site/facility is in noncompliance with a schedule or requirement.

In 2016, there were four NNSA/NFO environmental occurrences that were reportable under the requirements of this DOE order (Table 2-8). Nineteen hazardous substance spills occurred in 2016, which were not reportable under DOE O 232.2A: 17 at the NNSS, 1 at the NLVF, and 1 at RSL-Nellis. Only 2 of these 19 spills were reportable under State of Nevada NAC 445A, which sets lower reportable quantity thresholds for hazardous substance releases than does DOE O 232.2A. On January 28, 2016 at the Area 6 Transformer Yard (NDEP Spill No. 160128-03), over 300 cubic yards of oil contaminated soil were discovered and traced to a loose plug in the drain on a transformer. On May 24, 2016 in Area 7 (NDEP Spill No. 160524-05), approximately 25 gallons of oil were spilled while loading a transformer onto a truck. For both incidents, NDEP was notified, the appropriate soil analyses were performed, the contaminated soils were properly removed and disposed of on site, and spill reports were submitted to NDEP. The remainder of the spills consisted of small–volume releases either to containment areas or to other surfaces. All spills were cleaned up. There are no continuous releases on the NNSS or at the NLVF and RSL-Nellis.

Table 2-8. Environmental occurrences in 2016 reportable under DOE O 232.2

Description of Occurrence	Reporting Criteria[a]	Corrective Actions Taken
Report Number/Date of Occurrence: EM--NVSO-NAVR-NTS-2016-0002, February 24, 2016 Occurrence Title: Legacy Contaminated Debris Found Outside of a Posted Radiological Area		
Navarro Radiological Control Technicians (RCTs) identified legacy contaminated concrete outside of the Clean Slate III (CAU 414) posted contamination area on the TTR. One approximately 4 x 5-inch (in.) piece of concrete was identified with a maximum total contamination of approximately 3,000,000 dpm/ 100cm^2 alpha and 3,000,000 dpm/100 cm^2 beta/gamma. Removable contamination was detected at 40,000 dpm/100 cm^2 alpha and 5,000 dpm/100 cm^2 beta/gamma. Ongoing investigation activities conducted between 2/24/16 and 3/24/16 identified approximately 90 additional similar items in the same general area with elevated radiological readings. The maximum total contamination measured was approximately 3,300,000 dpm/100 cm^2 alpha and 3,000,000 dpm/ 100 cm^2 beta/gamma. Removable contamination was detected at 40,000 dpm/100 cm^2 alpha and 5,000 dpm/100 cm^2 beta/gamma.	6B(4) Identification of onsite radioactive contamination greater than 10 times the total contamination values in 10 CFR 835 Appendix D (exclusive of footnote 3), and that is found outside of areas routinely posted, controlled and monitored for radiological contamination, and areas controlled in accordance with 10 CFR 835.1102(c). For tritium, the reporting threshold is 10 times the removable contamination values in 10 CFR 835, *Occupational Radiation Protection Program*, Appendix D.	RCTs verified that there was no personnel or equipment contamination. RCTs and the Site Supervisor posted the area surrounding the contaminated debris to comply with the NNSS Radiological Control Manual and with 10 CFR 835. All appropriate notifications were made.
Report Number/Date of Occurrence: NA--NVSO-NAVR-NTS-2016-0003, May 25, 2016 Report Title: Legacy Contaminated Debris Found Outside of a Posted Radiological Area		
Navarro RCTs identified legacy contaminated debris (metal fragment) outside of the GMX posted contamination area while performing site characterization surveys at CAU 573 on the NNSS. One approximately 1 x 3 in. piece of metal was identified with a maximum total contamination of approximately 1,700,000 dpm/100cm^2 removable alpha and 200,000 dpm/100 cm^2 removable beta/gamma. Ongoing investigation activities conducted 6/6/16 and 6/7/16 identified approximately eight additional similar items in the	6B(4) Identification of onsite radioactive contamination greater than 10 times the total contamination values in 10 CFR 835 Appendix D (exclusive of footnote 3), and that is found outside of areas routinely posted, controlled and monitored for radiological contamination, and areas controlled in accordance with 10 CFR 835.1102(c).	RCTs verified that there was no personnel or equipment contamination. RCTs and the Site Supervisor posted the area surrounding the contaminated debris to comply with the NNSS Radiological Control Manual and with 10 CFR 835. All appropriate notifications were made.

Table 2-8. Environmental occurrences in 2016 reportable under DOE O 232.2 (continued)

Description of Occurrence	Reporting Criteria[(a)]	Corrective Actions Taken
Report Number/Date of Occurrence: NA--NVSO-NAVR-NTS-2016-0003, May 25, 2016 Report Title: Legacy Contaminated Debris Found Outside of a Posted Radiological Area (continued)		
same general area with elevated radiological readings. These items ranged in size from 0.5–2 in. The maximum total contamination measured was approximately 10,000,000 dpm/100cm^2 alpha and 10,000,000 dpm/100 cm^2 beta/gamma. During CAU 573 remediation activities conducted at Hamilton from 6/13/16 to 6/23/16, additional items were discovered outside of the posted contamination area with elevated radiological readings. The maximum total contamination measured was approximately 3,700,000 dpm/100cm^2 alpha.	For tritium, the reporting threshold is 10 times the removable contamination values in 10 CFR 835, *Occupational Radiation Protection Program*, Appendix D.	
Report Number/Date of Occurrence: EM-NVSO-NAVR-NTS-2016-0004, July 14, 2016 Report Title: Legacy Contaminated Debris Found Outside of a Posted Radiological Area		
During radiological characterization surveys associated with the GMX site in Area 5 of the NNSS (part of CAU 573), Navarro RCTs identified legacy contaminated debris outside of the GMX posted contamination area. This was in an area not previously surveyed in May 2016. Nine pieces of metal fragments were located in nine separate locations ranging in size from 0.25 x 1 in. to 3 x 3 in. The items ranged between 14,000 dpm/ 100 cm^2 total alpha, and 490,000 dpm/100 cm^2 total beta to greater than 10,000,000 dpm/100 cm^2 total alpha, and greater than 10,000,000 dpm/100 cm^2 total beta.	6B(4) Identification of onsite radioactive contamination greater than 10 times the total contamination values in 10 CFR 835 Appendix D (exclusive of footnote 3), and that is found outside of areas routinely posted, controlled and monitored for radiological contamination, and areas controlled in accordance with 10 CFR 835.1102(c). For tritium, the reporting threshold is 10 times the removable contamination values in 10 CFR 835, *Occupational Radiation Protection Program*, Appendix D.	RCTs verified that there was no personnel or equipment contamination. RCTs and the Site Supervisor posted the area surrounding the contaminated debris to comply with the NNSS Radiological Control Manual and with 10 CFR 835. All appropriate notifications were made.
Report Number/Date of Occurrence: EM--NVSO-NST-NTS-2016-0016, March 2, 2016 Report Title: Notification of Low Level Waste Drums Containing Inadequate Waste Characterization		
NSTec received a shipment on August 11, 2015 from Nuclear Fuel Services (NFS), which appeared to be in full compliance of the approved waste profile and subsequently shipped and received in accordance with the Waste Acceptance Criteria (WAC). The container was placed in Cell 21, a non-hazardous LLW disposal cell at the Area 5 RWMS. In March 2016, NFS notified the Radioactive Waste Acceptance Program (RWAP) through Navarro that its initial characterization of the container was inaccurate and that the container could contain free liquids. In June 2016, NFS reported that further sample analyses of the shipped waste was hazardous for chrome and corrosivity, requiring it to be handled as RCRA offsite generated MLLW.	10(2d) - An event, condition, or series of events that does not meet any of the other reporting criteria, but is determined by the Facility Manager or line management to be of safety significance or of concern for that facility or other facilities or activities in the DOE complex.	NSTec and Navarro (RWAP) requested a Uniform Hazardous Waste Manifest Report from NFS in June 2016. The cargo was moved from Cell 21 to a 90-day area, and all required surveillances were completed as required. NSTec and Navarro received the NFS manifest on 8/16/16, and the container was shipped back to NFS on 8/24/16; it safely arrived at NFS on 8/29/16. A similar situation occurred with NFS in 2014 and an ORPS Report (EM--NVSO-NST-NTS-2014-0022) for a Management Concern was submitted by NSTec. This ORPS Report was submitted as a second Management Concern regarding the waste certification and shipping method used by NFS.

(a) Reporting requirements provided in DOE O 232.2 can be found at https://www.directives.doe.gov/directives-documents/200-series/0232.2-BOrder-admchg1, as accessed on June 19, 2017.

2.6 Environmental Reports Submitted to Regulators

Numerous reports were prepared in 2016 or 2017 to meet CY 2016 regulation requirements or to document compliance for NNSA/NFO activities conducted in 2016. These reports and the federal or state regulators to whom they were submitted are listed in Table 2-9. Full references for those reports which were published can be found in the References section of each applicable chapter of this report.

Table 2-9. List of environmental reports submitted to regulators for 2016 NNSA/NFO activities

Regulator(s)	Report
Air Quality	
EPA Region 9	*National Emission Standards for Hazardous Air Pollutants – Radionuclide Emissions, Calendar Year 2016*
NDEP, EPA Region 9	*Annual Asbestos Abatement Notification Form*, submitted to NDEP and to EPA Region 9
NDEP	*Calendar Year 2016 Actual Production/Emissions Reporting Form*, submitted to NDEP
	Quarterly Class II Air Quality Reports, submitted to NDEP
	Nonproliferation Test and Evaluation Complex (NPTEC) Pre-test and Post-test Reports
CCDAQ	*Department of Air Quality Annual Emission Inventory Reporting Form for North Las Vegas Facility*
	Department of Air Quality Annual Emission Inventory Reporting Forms for Remote Sensing Laboratory
Water Quality	
NDEP	Quarterly Monitoring Reports for Nevada National Security Site Sewage Lagoons
	Results of water quality analyses for PWSs, sent to the state throughout the year as they were obtained from the analytical laboratory
	Water Pollution Control Permit NEV 96021, Quarterly Monitoring Reports (for first, second, and third quarters of 2016 for E Tunnel effluent monitoring)
	Water Pollution Control Permit NEV 96021, Quarterly Monitoring Report and Annual Summary Report for E Tunnel Wastewater Disposal System
Waste Management	
NDEP	*Nevada National Security Area 5 Solid Waste Disposal Annual Report for CY 2016*
	NNSS Quarterly Volume Reports (for all active LLW and MLLW disposal cells), April, July, and October 2016, and January 2017
	4th Quarter Transportation Report FY2016, Radioactive Waste Shipments to and from the Nevada National Security Site
	RCRA Permit for a Hazardous Waste Management Facility Permit Number NEV HW0101 – Annual Summary/Waste Minimization Report Calendar Year 2016
	Nevada National Security Site 2016 Data Report: Groundwater Monitoring Program Area 5 Radioactive Waste Management Site
	Nevada National Security Site 2016 Waste Management Monitoring Report - Area 3 and Area 5 Radioactive Waste Management Site
	Post-Closure Report for Closed Resource Conservation and Recovery Act Corrective Action Units, Nevada National Security Site, Nevada, for Fiscal Year 2016 (October 2015–September 2016)
	Annual Soil Moisture Monitoring Report for the Area 9 U10c Landfill, Nevada National Security Site, Nevada, for the Period March 2016 – February 2017
	January–June 2016 Biannual Solid Waste Disposal Site Report for the Nevada National Security Site Area 23 Sanitary Landfill
	July–December 2016 Biannual Solid Waste Disposal Site Report for the Nevada National Security Site Area 23 Sanitary Landfill
	Annual Soil Moisture Monitoring Report for the Area 6 Hydrocarbon Landfill, Nevada National Security Site, Nevada, for the Period March 2016–February 2017
Environmental Restoration	
NDEP	*CAU 90: Area 2 Bitcutter Containment – Closure Report (CR) – Record of Technical Change (ROTC) -1*
	CAU 91: Area 3 U-3fi Injection Well - CR – ROTC -1
	CAU 92: Area 6 Decon Pond Facility - CR – ROTC -1
	CAU 98: Frenchman Flat – CR – ROTC – 1
	CAUs 101/102: Central and Western Pahute Mesa – Final Well Completion Report for Well ER-20-12
	CAU 110: Area 3 WMD U-3ax/bl Crater - CR – ROTC -1
	CAU 111: Area 5 WMD Retired Mixed Waste Pits - CR – ROTC -1

Table 2-9. List of environmental reports submitted to regulators for 2016 NNSA/NFO activities (continued)

Regulator(s)	Report
Environmental Restoration (continued)	
NDEP	*CAU 112: Area 23 Hazardous Waste Trenches - CR – ROTC -1*
	CAU 411: Double Tracks Plutonium Dispersion (Nellis) – CR
	CAU 411: Double Tracks Plutonium Dispersion (Nellis) – CR Addendum
	CAU 412: Clean Slate I Plutonium Dispersion (TTR) –CR
	CAU 413: Clean Slate II Plutonium Dispersion (TTR) – Corrective Action Investigation Plan (CAIP)
	CAU 414: Clean Slate III Plutonium Dispersion (TTR) – CAIP
	CAU 568: Area 3 Plutonium Dispersion Sites – Corrective Action Plan (CAP)
	CAU 568: Area 3 Plutonium Dispersion Sites – CAP – ROTC -1
	CAU 573: Alpha Contaminated Sites – Corrective Action Decision Document/Corrective Action Plan (CADD/CAP)
	CAU 576: Miscellaneous Radiological Sites and Debris - CAIP
	Underground Test Area Activity Preemptive Review Guidance
	Underground Test Area Activity Communications/Interface Plan
	Underground Test Area Calendar Year 2014 Annual Sampling Analysis Report
	Underground Test Area Fiscal Year 2015 Annual Quality Assurance Report
Hazardous Materials Management	
State Fire Marshal	*Nevada Combined Agency Hazmat Facility Report – Calendar Year (CY) 2016*
EPA, NDEP	*Toxic Release Inventory Report, Form R for CY 2016*
NDEP	*Chemical Accident Prevention Program 2016 Registration*
Cultural and Natural Resources	
NSHPO	*A Cultural Resources Inventory of the RWMC Expansion, Area 5, Nevada National Security Site, Nye County, Nevada.*
	A Cultural Resources Inventory of the DOE Point Roundabout, Area 12, Nevada National Security Site, Nye County, Nevada
	A Cultural Resources Inventory for the Proposed DAG Test Pad Project, Area 2, Nevada National Security Site, Nye County, Nevada
	A Cultural Resources Inventory of the Proposed Backfill Project, Area 27, Nevada National Security Site, Nye County, Nevada
	Monitoring of Site 26NY15513, A Recording/Instrument Station at UGTA Well ER-4-1, Area 4, Nevada National Security Site, Nye County, Nevada
	A Cultural Resources Inventory of the Proposed LLNL Field Experiment Location, Area 2, Nevada National Security Site, Nye County, Nevada
	A Cultural Resources Inventory of the Proposed Performance Optimized Data Center, Area 6, Nevada National Security Site, Nye County, Nevada
	A Cultural Resources Inventory of the Proposed Dense Plasma Focus Facility Research and Development Project, Area 11, Nevada National Security Site, Nye County, Nevada
	A Cultural Resources Inventory for the Removal of the Debris Pile at the Hamilton Atmospheric Test Location, Area 5, Nevada National Security Site, Nye County, Nevada
	Cultural Resources Preliminary Assessment of Corrective Action Unit 576, Miscellaneous Radiological Sites and Debris, Areas 2,3,5,8 and 9, Nevada National Security Site, Nye County, Nevada
	A Cultural Resources Inventory of the Proposed Wildland Fire Training Area, Area 23, Nevada National Security Site, Nye County, Nevada
	A Cultural Resources Inventory of the Proposed UNESE Drill Hole Project, Area 12, Nevada National Security Site, Nye County, Nevada
	A Cultural Resources Inventory for the Proposed Frey 2 Project, Areas 3 and 7, Nevada National Security Site, Nye County, Nevada
	A Section 106 Evaluation of Building CP-1, Area 6, Nevada National Security Site, Nye County, Nevada
	A Section 106 Evaluation of the Mercury Bowling Alley, Area 23, Nevada National Security Site, Nye County, Nevada
FWS	*Annual Report of Actions Taken under Authorization of the Biological Opinion on NNSS Activities (File Nos. 84320-2008-F-0416 and 84320-2008-B-0015) – January 1, 2016, through December 31, 2016*
	Annual Report for Federal Migratory Bird Scientific Collecting Permit SCCL-008695-0
NDOW	*Annual Report for Handling Permit S36422*
Public Notifications/Reports	
DOE	*Nevada National Security Site Environmental Report 2015*
Environmental Occurrences	
	See Table 2-8 for ORPS Reports

2.7 References

U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office, 2013. *Final Site-Wide Environmental Impact Statement for the Continued Operation of the Department of Energy/National Nuclear Security Administration Nevada National Security Site and Off-Site Locations in the State of Nevada*. DOE/EIS-0426, Las Vegas, NV.

Chapter 3: Environmental Management System

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The U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO) conducts activities on the Nevada National Security Site (NNSS) while ensuring the protection of the environment, the worker, and the public. This is accomplished, in part, through the implementation of an Environmental Management System (EMS). An EMS is a business management practice that incorporates concern for environmental performance throughout an organization, with the ultimate goal being continual reduction of the organization’s impact on the environment. An EMS ensures that environmental issues are systematically identified, controlled, and monitored, and it provides mechanisms for responding to changing environmental conditions and requirements, reporting on environmental performance, and reinforcing continual improvement. National Security Technologies, LLC (NSTec), the current Management and Operating contractor for the NNSS, designed an EMS to meet the 17 requirements of the globally recognized International Organization for Standardization (ISO) 14001:2004 Environmental Management Standard. The NSTec EMS initially received ISO 14001:2004 certification in June 2008, and was re-certified in 2014 for another 3-year period. This chapter describes the 2016 progress made towards improving overall environmental performance under the NSTec EMS. Reported progress applies to operations on the NNSS as well as support activities conducted at the NNSA/NFO-managed North Las Vegas Facility (NLVF) and Remote Sensing Laboratory–Nellis (RSL-Nellis). NNSA/NFO uses this annual environmental report as the mechanism to communicate to the public the components and status of the EMS, which is a requirement for ISO 14001:2004 certification.

3.1 Environmental Policy

The cornerstone of an EMS is a commitment to environmental protection at the highest levels of an organization. NSTec’s environmental commitments are incorporated into an Environmental Policy approved by NNSA/NFO. The policy applies to all NSTec operations, projects, facilities, and personnel, including subcontractors. The NSTec EMS implements this policy and is incorporated into NSTec’s Integrated Safety Management System (ISMS). The NSTec policy is to:

- Protect environmental quality and human welfare by implementing EMS practices.
- Identify and comply with all applicable U.S. Department of Energy (DOE) orders and federal, state, and local environmental laws and regulations.
- Identify and mitigate environmental aspects early in project planning.
- Establish environmental objectives, targets, and performance measures.
- Collaborate with employees, customers, subcontractors, and key suppliers on sustainable development and pollution prevention efforts.
- Communicate and instill an organizational commitment to environmental excellence in company activities through processes of continual improvement.

3.2 Planning

The planning requirements of the ISO 14001:2004 Standard require NNSA/NFO to identify the environmental aspects and impacts of its activities, products, and services; to evaluate applicable legal and other requirements; to establish objectives and targets; and to create action plans or management programs to achieve the objectives and targets.

3.2.1 Environmental Aspects

An “environmental aspect” is any element of an organization’s activities, products, and services that can impact the environment. As required by the ISO 14001 Standard, NSTec evaluates its operations, identifies the aspects that can impact the environment, and determines which of those impacts are significant.

Operations are evaluated to determine if they have any environmental aspects by performing Hazard Assessments, preparing Health and Safety Plans and Execution Plans, and preparing and reviewing National Environmental Policy Act documents. A list of aspects is compiled, and they are ranked in order of importance to determine which aspects are significant. The factors that are considered during ranking are the potential to cause adverse environmental impact; the potential for noncompliance with regulations; the ability to meet permit requirements, contract and performance objectives, and DOE order requirements; and the potential to result in bad publicity. The likelihood of occurrence and severity of each of these factors is considered. This process is done annually to account for changing activities, regulations/DOE orders, and management priorities. For 2016, the following environmental aspects were identified:

Significant environmental aspects:

- Air quality
- Drinking water quality
- Energy and fuel use
- Environmental restoration
- Industrial chemical storage and use
- Non-hazardous waste generation and management
- Resource protection
- Groundwater protection
- Hazardous, radioactive, and mixed waste generation and management
- Wastewater management
- Sustainable acquisition of goods and services

Other environmental aspects:

- Building demolition
- Recycling of materials and equipment
- Surface and storm water runoff
- Water usage
- Greenhouse gas emissions
- Building construction and renovation

3.2.2 Legal and Other Requirements

NSTec has a system in place to review changes in federal, state, or local environmental regulations and to communicate those changes to affected staff. Executive Order EO 13693, "Planning for Federal Sustainability in the Next Decade," sets reduction targets for energy use intensity, water use intensity, and greenhouse gas (GHG) emissions, and prescribes other sustainability goals for the DOE through fiscal year (FY) 2025 (October 1, 2024–September 20, 2025). DOE publishes these new goals and targets in a DOE Strategic Sustainability Performance Plan, which is updated each year. These DOE goals are pursued and tracked under the NSTec Energy Management Program (Section 3.2.4.1 below).

3.2.3 Environmental Objectives and Targets

To address the identified significant environmental aspects of NNSA/NFO operations, an Environmental Working Group (EWG) selects objectives and targets, which are determined on an FY basis. Targets are tracked by the various responsible operational groups and reported quarterly to NNSA/NFO. Five FY 2016 EMS targets were identified and tracked (Table 3-1). Two of the targets overlapped with DOE's sustainability goals (Table 3-2).

Table 3-1. EMS goals and FY 2016 performance status

Environmental Aspect(s)	FY 2016 EMS Target	FY 2016 Performance Status
Air quality; Non-hazardous waste generation and management	Increase NSTec Environmental Program's oversight of air quality and waste aspects of NNSA/NFO operations.	Target met. Air quality and waste regulators identified no findings in FY 2016; 11 non-compliances were self-identified and corrected, which represented a 10% increase in the number of self-identified issues found and corrected compared to FY 2015.
Industrial chemical storage and use	Reduce the number of chemical containers across the NNSS, NLVF, and RSL-Nellis facilities by 5% compared to FY 2015.	Target met. The chemical footprint was reduced through consolidating chemical storage areas and ensuring the use of chemicals in storage prior to ordering new chemicals.
Sustainable acquisition of goods and services	Evaluate products in select "Just-in-Time" (JIT) product catalogs and identify opportunities to increase purchases of sustainable and biobased products.	Target met. Opportunities to replace non-biobased and non-sustainable products were identified.

Table 3-1. EMS goals and FY 2016 performance status (continued)

Environmental Aspect(s)	FY 2016 EMS Target	FY 2016 Performance Status
Energy use	Reduce energy intensity by 2.5% from FY 2015.	Target not met. Energy intensity increased by 13% from FY 2015.
Energy use; Water usage; Building renovation	Achieve High Performance Sustainable Buildings (HPSBs) certification for buildings representing 86,464 gross square feet (gsf).	Target not met. Two facilities representing 16,205 gsf are pending certification; two representing 22,378 gsf are in an improvement identification/planning phase.

3.2.4 Environmental Management Programs

3.2.4.1 Energy Management

The Energy Management Program (EMP), under the NSTec Operations and Infrastructure Directorate, has the specific mission to support and track DOE's complex-wide sustainability goals. The EMP strives to ensure continuous life-cycle, cost-effective improvements to increase energy efficiency; increase the effective management of energy, water, and transportation fleets; and increase the use of clean energy sources for NNSA/NFO operations. NNSA/NFO currently uses electricity, fuel oil, and propane at the NNSS and RSL-Nellis facilities. At the NLVF, electricity, fuel oil, and natural gas are used. NNSA/NFO vehicles and equipment are powered by unleaded gasoline, diesel, bio-diesel, E-85, and jet fuel. All water used at the NNSS is groundwater, and water used at the NLVF and RSL-Nellis is predominately surface water from Lake Mead.

Each FY, the EMP produces a fiscal year NNSA/NFO Site Sustainability Plan (SSP) (NSTec 2016). The SSP identifies how NNSA/NFO will help meet DOE's sustainability goals (DOE, 2016a), which were first published in the 2010 Strategic Sustainability Performance Plan (SSPP) (DOE 2010). The SSP also satisfies the requirement of EO 13693 for an Energy Management Plan. The SSP describes the program, planning, and budget assumptions as well as NNSA/NFO's performance status for the previous year for each DOE SSPP goal, and planned actions to meet each goal during the next year. To implement the SSP, an Energy Management Council (EMC) meets bimonthly to discuss the requirements and track and facilitate their completion. The EMC and the EWG coordinate to ensure that all EMS-tracked objectives and targets mirror overlapping annual goals in the SSP. Table 3-2 includes a summary of the DOE SSPP goals and NNSA/NFO's FY 2016 status in reaching them.

Table 3-2. DOE sustainability goals and FY 2016 performance status

DOE Goal[(a)]	NNSA/NFO FY 2016 Performance Status
Goals highlighted in green have been met or exceeded	
GHG Reduction	
50% reduction of Scope 1 and 2 GHG emissions[(b)] by FY 2025, from an FY 2008 baseline (FY 2016 target is 22% reduction).	Emissions were 46,000 $MtCO_2e$[(c)], a 45% decrease from the FY 2008 baseline of 84,339 $MtCO_2e$[(d)], exceeding the FY 2016 goal.
25% reduction in Scope 3[(b)] GHG emissions by FY 2025, from an FY 2008 baseline (FY 2016 target is 7% reduction).	Emissions were 17,096 $MtCO_2e$, a 21% decrease from the FY 2008 baseline of 21,757 $MtCO_2e$[(d)], exceeding the FY 2016 goal.
Sustainable Buildings	
25% reduction of energy intensity (British Thermal Units [BTUs] per [gsf]) in goal-subject buildings, achieving 2.5% reductions annually by FY 2025 from an FY 2015 baseline. ***Also identified as an FY 2016 EMS target***	Energy intensity increased by 13% from the FY 2015 baseline.
Energy and water assessments conducted for 25% of all facilities covered under Section 432 of the Energy Independence and Security Act to ensure that 100% of covered facilities are assessed every 4 years.	35 energy audits/assessments were conducted, meeting this goal. The audits/assessments identified energy conservation measures for the facilities evaluated.
Meter all individual buildings for electricity, natural gas, water, and steam where cost-effective and appropriate.	Based on a 2016 assessment of appropriate buildings, 71% (171 of 240 buildings) are metered for electricity, 82% (18 of 22) for natural gas, 0% (0 of 3) for chilled water, 15% (35 of 226) for potable water, and 100% (2 of 2) for hot water. No steam is used.

Table 3-2. DOE sustainability goals and FY 2016 performance status (continued)

DOE Goal[(a)]	NNSA/NFO FY 2016 Performance Status
Targets highlighted in green have been met or exceeded	
Sustainable Buildings (continued)	
At least 17%[(e)] (by building count or gsf) of existing buildings at or greater than 5,000 gsf to be compliant with the revised Guiding Principles (GPs) for Sustainable Federal Buildings by FY 2025, with progress to 100% thereafter. ***Also identified as an FY 2016 EMS target***	6% (7 of 113) of NNSA/NFO's enduring buildings larger than 5,000 gsf are certified as HPSBs by meeting the GPs. Two additional buildings are pending HPSB certification.
Identify efforts to increase regional and local planning coordination and involvement.	Continued coordination with the Regional Transportation Center Park and Ride Facilities and with the Club Ride program for NNSS employees. Began to identify future sustainability initiatives for the NNSS with the Southern Nevada Regional Planning Coalition.
1% of existing buildings above 5,000 gsf to be energy, waste, or water net-zero buildings by FY 2025.	No NNSA/NFO existing buildings are net zero. Evaluated and planned the installation of a solar photovoltaic (PV) system at Mercury Fire Station No. 1 in order to become an energy net-zero building. NNSA/NFO is partnering with DOE's National Renewable Energy Laboratory (NREL) to develop and deploy net zero frameworks applicable to NNSA/NFO facilities.
All new buildings larger than 5,000 gsf entering the planning process designed to achieve energy net zero beginning in FY 2020.	Planning was initiated for a new NNSS Consolidated Mercury Campus to begin construction in the FY 2018-2021 timeframe. NREL is assisting NNSS in developing an optimized design/construction process to attain net-zero facilities.
Clean and Renewable Energy	
Not less than 10% of DOE's total electric and thermal energy consumption in FY 2016–2017 shall be accounted for by renewable and alternative sources, working towards 25% by FY 2025 ("Clean Energy" requirement).	No major renewable systems exist on the NNSS (1% of power produced on site is from small solar or reused oil sources). Renewable energy credits were purchased, representing 8% of NNSA/NFO's annual electrical consumption.
Not less than 10% of DOE's total electric consumption in FY 2016-2017 shall be renewable electric energy, working towards 30% by FY 2025 ("Renewable Electric Energy" requirement).	No major renewable electrical energy systems exist on the NNSS. NREL conducted a solar assessment to analyze the efficacy of PV array installations at Mercury facilities. Mercury Fire Station No. 1 was selected as the best location for a solar demonstration project. NNSS weather stations were modernized with new solar panels.
Water Use Efficiency and Management	
36% reduction in potable water intensity (gallons used per square foot [gal/ft^2]) by FY 2025 from an FY 2007 baseline (FY 2016 target is 18% reduction).	Water intensity across all NNSA/NFO facilities was 46.88 gal/ft^2, a 33% reduction from the FY 2007 baseline of 70.42 gal/ft^2, exceeding the FY 2016 goal.
30% reduction in water consumption of industrial, landscaping, and agricultural (ILA) water by FY 2025 from an FY 2010 baseline (FY 2016 target is 12% reduction).	ILA water production was 42,469,600 gal, a 22.7% reduction from the FY 2010 baseline of 54,913,300 gal, exceeding the FY 2016 goal.
Fleet Management	
20% reduction in fleet annual petroleum consumption by FY 2015, relative to an FY 2005 baseline; maintain 20% reduction thereafter (FY 2016 target is 20%).	Petroleum consumption was 494,807 gal, a 63% reduction from the FY 2005 baseline of 1,328,957 gal, exceeding the FY 2016 goal.
10% increase in annual fleet alternative fuel consumption by FY 2015, relative to an FY 2005 baseline; maintain 10% increase thereafter (FY 2016 target is 10%).	Alternative fuel consumption was 367,268 gal, a 194% increase above the FY 2005 baseline of 125,090 gal, exceeding the FY 2016 goal.
30% reduction in fleet-wide, per-mile GHG emissions by FY 2025 from an FY 2014 baseline (FY 2016 target is 3% reduction).	Fleet-wide GHG emissions in FY 2016 were 381.2 gCO_2e/mile[(f)], a 22% reduction from the FY 2014 baseline of 489.09 gCO_2e/mile, exceeding the FY 2016 goal.
20% reduction in fleet annual petroleum consumption by FY 2015, relative to an FY 2005 baseline; maintain 20% reduction thereafter (FY 2016 target is 20%).	Petroleum consumption was 494,807 gal, a 63% reduction from the FY 2005 baseline of 1,328,957 gal, exceeding the FY 2016 goal.

Table 3-2. DOE sustainability goals and FY 2016 performance status (continued)

DOE Goal[(a)]	NNSA/NFO FY 2016 Performance Status
Targets highlighted in green have been met or exceeded	
Fleet Management (continued)	
75% of light duty vehicle acquisitions must consist of alternative fuel vehicles (AFVs).	96% of all light duty vehicle acquisitions (114 vehicles) were AFVs, meeting this goal.
50% of passenger vehicle acquisitions to consist of zero emission or plug-in hybrid electric vehicles by FY 2025 (FY 2016 target is 4%).	NNSA/NFO has been acquiring such vehicles since 2012 and currently has 13. Of the 114 vehicles acquired in 2016, none were plug-in hybrid electric.
Sustainable Acquisition	
Promote sustainable acquisition and procurement to the maximum extent practicable, ensuring biopreferred and biobased provisions and clauses are included in 95% of applicable contracts.	100% of applicable contracts contained provisions for biopreferred and biobased products; in FY 2016, existing non-biobased and non-recycled products were evaluated for replacement with sustainable products.
Pollution Prevention and Waste Reduction	
Divert at least 50% of non-hazardous solid waste, excluding construction and demolition materials and debris, from disposal.	28% of non-hazardous solid waste was diverted from disposal.
Divert at least 50% of construction and demolition materials and debris from disposal.	23% of construction waste was diverted from disposal.
Energy Performance Contracts	
Identify annual targets for acquiring ***Energy Savings Performance Contracts (ESPCs)*** (see Glossary, Appendix B) and Utility Energy Service Contracts to be implemented in FY 2017 and annually thereafter.	No new ESPCs were pursued. Provided measurement and verification support to an existing ESPC project. Developed a prioritized list of potential candidates for building control projects in order to prepare for another ESPC.
Electronic Stewardship	
95% of eligible electronics acquisitions are U.S. Environmental Protection Agency (EPA) Electronic Product Environmental Assessment Tool (EPEAT)-registered products.	All eligible electronic acquisitions continue to be EPEAT-registered, meeting this goal.
100% of eligible computers and imaging equipment have automatic duplexing enabled.	All multi-function printing devices are configured for automatic duplexing and a new policy stating this requirement is in place.
100% of used electronics are reused or recycled using environmentally sound disposition options.	All electronic equipment that passed excess screening in 2016 was sold for reuse, meeting this goal.
Establish a power usage effectiveness (PUE) [(g)] target in the range of 1.2-1.4 for new data centers, and less than 1.5 for existing data centers.	PUE estimates range from 2.6–3.4 for the three data centers (two at the NNSS, one at the NLVF). Metering of all building systems to accurately measure PUEs is not cost-effective and each center uses non-precision cooling systems. In FY 2017, a Performance Optimized Data Center will be deployed at the NNSS in order to meet this goal.
Climate Change Resilience	
Update policies to incentivize planning for, and addressing the impacts of, climate change.	EMP reviewed applicable DOE climate change/resilience orders and reports, received climate change training, and identified/evaluated projects in the planning phase associated with resiliency. Will continue work to establish a climate change stakeholder working team, complete vulnerability assessment, and identify areas for improvement.
Update emergency response procedures and protocols to account for projected climate change, including extreme weather events	Response policies and procedures have been updated to include extreme weather events and other natural phenomena.
Ensure workforce protocols and policies reflect projected human health and safety impacts of climate change.	Procedures are in place to notify workers of potential weather related hazards; NNSS policies and procedures related to health, safety, and the environment have been updated.

Table 3-2. DOE sustainability goals and FY 2016 performance status (continued)

DOE Goal[(a)]	NNSA/NFO FY 2016 Performance Status
Targets highlighted in green have been met or exceeded	
Climate Change Resilience (continued)	
Ensure site/lab management demonstrates commitment to adaptation efforts through internal communications and policies.	Coordination meetings with the EMP and the climate change subject matter expert were held; will continue to develop and update policies.
Ensure that site/lab climate adaptation and resilience policies and programs reflect best available current climate change science, updated as necessary.	NNSA/NFO partners with the NOAA ARL/SORD[(h)] through an Interagency Agreement to provide a comprehensive meteorology program for the NNSS that includes monitoring current climate, storing climate data, and updating NNSS climatology reports. Through ARL/SORD, NNSA/NFO works with additional NOAA climate monitoring organizations to provide information to a broader regional, national, and global climate scope.
Complete the Sustainability Dashboard climate change resiliency survey.	Survey was completed.

(a) The DOE goals listed are identified in the DOE 2017 Site Sustainability Plan Guidance (DOE 2016b) which is based on DOE's SSPP (DOE 2010) and EO 13693.

(b) The GHGs targeted for emission reductions are carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride (SF6). Scope 1 GHG emissions include direct emissions from sources that are owned or controlled by a federal agency. Scope 2 includes direct emissions resulting from the generation of electricity, heat, or steam purchased by a federal agency. Scope 3 includes emissions from sources not owned or directly controlled by a federal agency but related to agency activities, such as vendor supply chains, delivery services, employee business air and ground travel, employee commuting, contracted solid waste disposal, contracted waste water discharge, and transmission and distribution losses related to purchased electricity. Fugitive GHG emissions are uncontrolled or unintentional releases from equipment leaks, storage tanks, loading, and unloading.

(c) MtCO2e = metric tons of carbon dioxide equivalent.

(d) In 2016, the EMP requested approval from DOE's Sustainability Performance Office (SPO) to rebaseline the 2008 GHG emissions due to changes in data collection and recording methods. The FY 2008 baselines for Scope 1 and 2 GHGs and for Scope 3 GHGs were determined to be 84,339 and 21,757 MtCO2e, respectively. Both baselines were approved by the SPO.

(e) In 2016, DOE increased its FY 2025 target for this goal from 15% to 17%.

(f) gCO_2e/mile = grams of carbon dioxide equivalents per mile (emitted on a fleet-wide basis).

(g) PUE is determined by dividing the amount of power entering a data center by the power used to run the computer infrastructure within it. PUE is expressed as a ratio; efficiency improves as the quotient approaches 1.

(h) NOAA ARL/SORD stands for the National Oceanic and Atmospheric Administration Air Resources Laboratory, Special Operations and Research Division, which operate a network of mobile meteorological towers on the NNSS.

3.2.4.2 Pollution Prevention and Waste Minimization (P2/WM)

The P2/WM Program has initiatives to eliminate or reduce the generation of waste, the release of pollutants to the environment, and the use of Class I and Class II ***ozone-depleting substances (ODS)*** (see Glossary, Appendix B). These initiatives are pursued through source reduction, reuse, segregation, and recycling, and by procuring recycled-content materials and environmentally preferable products and services. They also ensure that proposed methods of treatment, storage, and disposal of waste minimize potential threats to human health and the environment. These initiatives address the DOE SSPP goals and the requirements of DOE orders, federal laws, and state regulations applicable to operations at the NNSS, NLVF, and RSL-Nellis (see Table 2.1 of Chapter 2). The following strategies are employed to meet P2/WM goals.

Source Reduction – The preferred method of waste minimization is source reduction, i.e., to minimize or eliminate waste before it is generated by a project or operation. NNSA/NFO's ISMS requires that every project/operation address waste minimization issues during the planning phase and ensure that adequate funds are allocated to perform any identified waste minimization activities.

Source reduction was the strategy used to implement a requirement to reduce Class I and Class II ODS at all DOE sites and to comply with the EPA's phase-out of ODS production and import by 2030. Class I ODS have been completely phased out, and the current Class II ODS phase-out schedule allows their use only in equipment manufactured before January 1, 2020. By the end of 2009, NNSA/NFO had discontinued the procurement of Class I

ODS for all non-exempted uses, and halon-containing fire extinguishers and equipment were removed from the NNSS and NLVF facilities by 2010. All halons have been removed from RSL-Nellis, with the exception of halon fire extinguishers in the aircraft. Since 2009, environmentally preferable alternatives to Class I and Class II ODS have been purchased whenever possible. Existing ODS refrigerants in equipment are being phased out as equipment is drained for repair or replaced by new equipment with approved alternative refrigerants. At the NLVF, failed air conditioning units using R-22, a Class II ODS, are replaced with units using a non-ozone depleting refrigerant, R-427A.

Recycling/Reuse – NNSA/NFO maintains a recycling program for some recyclable waste streams generated. Items routinely recycled include cardboard; mixed paper (office paper, shredded paper, newspaper, magazine, color print, glossy paper); plastic bottles; plastic grocery bags; elastic/plastic stretch pack; milk jugs; styrofoam; tin and aluminum cans; glass containers; toner cartridges; cafeteria food waste; computers; software; scrap metal; rechargeable batteries; lead-acid batteries; electric lamps (fluorescent, mercury vapor, metal halide, and high-pressure sodium); used oil, antifreeze, and tires.

An Excess Property Program also exists to provide excess property to NNSA/NFO employees or subcontractors, laboratories, other DOE sites, other federal agencies, state and local government agencies, universities, and local schools. If new users are not found, excess property is made available to the public for recycle/reuse through periodic Internet sales. In 2011, an Excess Integrated Project Team was formed with members from radiological operations, materials management, and property management. The team continues to evaluate useable equipment and facilities that can be diverted from the landfill and excessed or reused. As needed, this team pulls in additional subject matter experts. In 2016, the Sustainability Team was formed to remove old refrigerant equipment and Class I and II ODS. Members came together from Asset and Material Management, Excess & Sales, Radiation Control, Forward Area Maintenance, Environmental Programs, Procurement, and Facility Management. The Sustainability Team reclaimed refrigerants, refurbished much-needed refrigerant cylinders, and reused/excessed recycled equipment. If NSTec had removed the refrigerant, sent it for reclamation, and disposed of these appliances, the costs would have exceeded $250,000. Since it began, this integrated campaign has generated substantial revenues and extended the life of the NNSS landfill by over 3 years at a cost savings of $835,000.

Environmentally Preferable Purchasing – The Resource Conservation and Recovery Act (RCRA), as amended, requires federal agencies to develop and implement an affirmative procurement program (APP). NNSA/NFO maintains an APP that stimulates a market for recycled-content products and closes the loop on recycling. The EPA maintains a list of items containing recycled materials that should be purchased. The EPA determines what the minimum content of recycled material should be for each item. Federal facilities must have a process in place for purchasing the EPA-designated items containing the minimum content of recycled materials. Federal facilities are required to ensure, where possible, that 100% of purchases of items on the EPA-designated list contain recycled materials at the specified minimum content. The U.S. Department of Agriculture (USDA) designates types of materials that have a required minimum amount of bio-based chemicals. Products that meet this requirement are being added to procurement lists and tracked.

A 2016 EMS target was to evaluate products in select JIT product catalogs and identify opportunities to increase purchases of sustainable and biobased products. A survey was conducted of janitorial and office-related products used in 2016 and acquired through JIT catalogs. The survey identified product replacements that are biobased or that have any another other sustainable attribute. Biobased carpet cleaning and other floor care products, however, were not readily available through the JIT system because the large national manufacturers are not producing such versions. As a result of the survey, the primary janitorial and office supply vendors were requested to offer sustainable products. In October 2016, a USDA BioPreferred report was prepared and documented that during FY 2016, $2,004.81 was spent on janitorial biobased products. The amount spent on these products in FY 2016 was about 1% less than the amount spent in FY 2015.

3.3 EMS Competence, Training, and Awareness

EMS awareness is included as part of the orientation training required for all new NSTec employees. Ongoing EMS awareness is accomplished by publishing environmental articles in electronic employee newsletters. Focused environmental briefings are given at tail-gate meetings in the field prior to work with high or non-routine environmental risk.

3.4 Audits and Operational Assessments

The ISO 14001 certifying organization, Lloyd's Register Quality Assurance (LRQA), conducts annual surveillances on focused portions of the EMS. The frequency of the surveillances was changed from semi-annual to annual on the recommendation of LRQA due to the overall robustness of the NSTec EMS. Findings and recommendations are tracked in the companywide issues tracking system, caWeb. Corrective actions taken to close the issues help to continually improve the EMS program. In March 2016, LRQA conducted a surveillance, and no major nonconformities were identified. The EMS Description document states that an independent internal audit of portions of the EMS program will be performed each year. An internal audit of waste management was conducted in November 2016 and identified one opportunity for improvement. This issue was entered into caWeb for tracking, and was resolved and closed in 2016.

Additionally, NSTec's Occupational Safety and Health Division conducts internal management assessments and compliance evaluations. These assessments and evaluations determine the extent of compliance with environmental regulations and identify areas for overall improvement. In 2016, NSTec conducted one internal management assessment and 43 compliance evaluations.

3.5 EMS Effectiveness and Reporting

The ISO 14001:2004 certification of the EMS program has enabled NNSA/NFO to declare that they have met executive and DOE order requirements. The ISO 14001:2004 certifying organization stated after the April 2014 recertification assessment that the EMS program remains effective, and the EMS program's certification was renewed in June 2014 for another 3 years.

EMS training and awareness has improved the overall environmental knowledge of the workforce. Many employees identify problems and recommend preventive or corrective actions. These actions, driven by the EMS program, have improved performance and reduced costs.

The establishment of annual environmental EMS targets assist in reducing water, fuel, and energy usage; avoiding waste production; recycling wastes generated from environmental restoration activities; purchasing EPP products; and making infrastructure improvements on environmental systems such as water lines and boilers.

One of the benefits of the EMS program is communication between NSTec and NNSA/NFO regarding current environmental issues and the status of EMS objectives and targets. NSTec prepares and distributes EMS slide presentations to facilitate communication and support, and topics include assessment findings, status of corrective actions, emerging concerns, environmental metrics, and opportunities for improvement. The EMS program is continuously being evaluated, and improvements are implemented and documented. A summary report is presented to senior management annually, documenting performance and improvements, and documenting the determination that the program continues to be suitable, adequate and effective.

In January 2017, the 2016 Facility EMS Annual Report Data for the NNSS was entered into the DOE Headquarters EMS database, accessed through the FedCenter.gov website (http://www.fedcenter.gov/programs/ems/). This database gathers information in several EMS areas from all DOE sites to produce a combined report reflecting DOE's overall performance compared to other federal agencies. The report includes a scorecard section, which is a series of questions regarding a site's EMS effectiveness in meeting the objectives of federal EMS directives. The NNSS scored "green," the highest score.

3.6 Awards and Recognition

NNSA/NFO's Fleet, Fuel and Equipment Service Operations was rated eighteenth in the nation by the 2016 100 Best Fleets, Green Fleet Awards Organization (see http://www.the100bestfleets.com/gf_winners_2016.htm). This organization tracks and rates the performance of vehicle fleets throughout the continent. NFO's Fleet was recognized for having one of the cleanest, most fuel-efficient vehicle fleets.

3.7 References

DOE, see U.S. Department of Energy.

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Chapter 4: Air Monitoring

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Section 4.1 of this chapter presents the results of radiological air monitoring conducted on the Nevada National Security Site (NNSS) by the U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO) to verify compliance with radioactive air emission standards. Measurements of radioactivity in air are also used to assess the radiological dose to the general public from inhalation. The assessed dose to the public from all exposure pathways is presented in Chapter 9. Section 4.2 presents the results of nonradiological air quality assessments that are conducted to ensure compliance with NNSS air quality permits.

NNSA/NFO has also established an independent Community Environmental Monitoring Program to monitor radionuclides in air in communities adjacent to the NNSS. It is managed by the Desert Research Institute (DRI) of the Nevada System of Higher Education. DRI's offsite air monitoring results are presented in Chapter 7.

4.1 Radiological Air Monitoring

The sources of radioactive air emissions on the NNSS include the following: (1) evaporation of tritiated water from containment ponds; (2) diffusion of tritiated water vapor from soil at the Area 3 Radioactive Waste Management Site (RWMS), the Area 5 Radioactive Waste Management Complex (RWMC), and historical surface or near-surface nuclear device test locations (particularly Sedan and Schooner Craters); (3) resuspension of contaminated soil at historical surface or near-surface nuclear device test locations; and (4) release of radionuclides from current operations. Figure 4-1 shows the locations of all known historical and 2016 radiological air emission sources. Areas of soil contamination related to historical weapon tests are depicted in Figure 4-1 as "Grouped Area Sources." The NNSS air monitoring network consists of samplers placed near sites of soil contamination, at facilities that may produce radioactive air emissions, and along the NNSS boundaries. The objectives and design of the network are described in the *Routine Radiological Environmental Monitoring Plan* (Bechtel Nevada 2003).

Data from NNSS sampling locations are analyzed to meet the specific goals listed below. The analytes monitored include radionuclides most likely to be present in air as a result of past or current NNSS operations, based on inventories of radionuclides in surface soil (McArthur 1991) and on the volatility and availability of radionuclides for resuspension (see Table 1-5 in Chapter 1 for the half-lives of these radionuclides). Uranium is included because uranium (primarily depleted uranium [DU]) has been, or currently is, used during exercises in specific areas of the NNSS. Samples from locations near these areas are analyzed for uranium. Gross alpha and gross beta readings are used in air monitoring as a relatively rapid screening measure.

Radiological Air Monitoring Goals	*Analytes Monitored*
Monitor air at or near historical or current operation sites to (1) detect and identify local and site-wide trends, (2) quantify radionuclides emitted to air, and (3) detect accidental and unplanned releases. Conduct ***point-source*** (see Glossary, Appendix B) operational monitoring required under National Emission Standards for Hazardous Air Pollutants (NESHAP) for any facility that has the potential to emit radionuclides to the air and cause a dose greater than 0.1 millirem per year (mrem/yr) (0.001 millisievert per year [mSv/yr]) to any member of the public. Determine if the air pathway dose to the public from past or current NNSS activities complies with the Clean Air Act (CAA) NESHAP standard of 10 mrem/yr (0.1 mSv/yr). Determine if the total radiation dose to the public from all pathways (air, water, and food) complies with the 100 mrem/yr standard set by U.S. Department of Energy (DOE) Order DOE O 458.1, "Radiation Protection of the Public and the Environment."	Americium-241 (^{241}Am) Gamma ray emitters (includes Cesium-137 [^{137}Cs]) Tritium (^{3}H) Plutonium-238 (^{238}Pu) Plutonium-239+240 ($^{239+240}$Pu) Uranium-233+234 ($^{233+234}$U) Uranium-235+236 ($^{235+236}$U) Uranium-238 (^{238}U) Gross alpha radioactivity Gross beta radioactivity

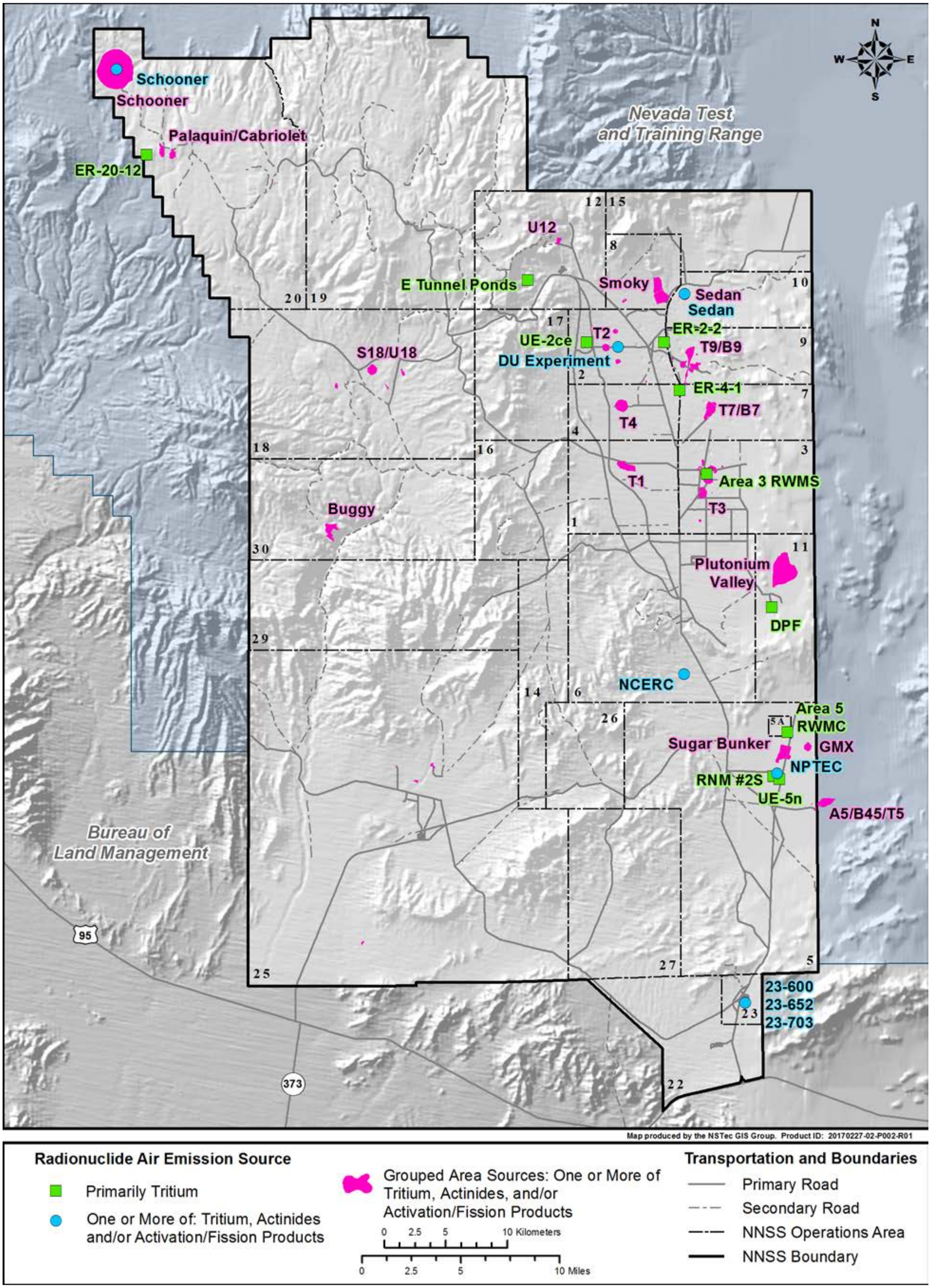

Figure 4-1. Sources of radiological air emissions on the NNSS in 2016

4.1.1 Monitoring System Design

Environmental Samplers – A total of 17 environmental sampling locations operated on the NNSS during 2016 (Figure 4-2). Of these, 15 have both air particulate and tritium (atmospheric moisture) samplers, 1 has only an air particulate sampler, and 1 has only a tritium sampler (Figure 4-2). The NNSS air samplers are positioned in predominant downwind directions from sources of radionuclide air emissions and/or are positioned between NNSS contaminated locations and potential offsite receptors. (Wind rose data, showing predominant wind directions on the NNSS, are presented in Section A.3 of *Attachment A: Site Description*, which is included as a separate file on the compact disc of this report). Most radionuclide air emission sources are ***diffuse sources*** (see Glossary, Appendix B) that include areas with (1) radioactivity in surface soil that can be resuspended by the wind, (2) tritium in water (tritiated water) transpiring or evaporating from plants and soil at the sites of past nuclear tests, and (3) tritiated water evaporating from ponds receiving water either from contaminated wells or from tunnels that cannot be sealed. Sampling and analysis of air particulates and tritium were performed at these locations as described in Section 4.1.2. Radionuclide concentrations measured at these samplers are used for trending, determining ambient background concentrations in the environment, and monitoring for unplanned releases of radioactivity.

Critical Receptor Samplers – Six of the environmental sampling locations that have both air particulate and tritium samplers are approved by the U.S. Environmental Protection Agency (EPA) Region 9 as ***critical receptor samplers*** (see Glossary, Appendix B). They are located near the boundaries and in the center of the NNSS (Figure 4-2). Radionuclide concentrations measured at these samplers are used to assess compliance with the NESHAP public dose limit of 10 mrem/yr (0.1 mSv/yr). The annual average concentrations from each sampler are compared with the NESHAP Concentration Levels for Environmental Compliance (compliance levels [CLs]) listed in Table 4-1. Compliance with NESHAP is demonstrated when the sum of the fractions, determined by dividing each radionuclide's concentration by its CL and then adding the fractions together, is less than 1.0 at all samplers.

Table 4-1. Regulatory concentration limits for radionuclides in air

	Concentration ($\times 10^{-15}$ microcuries/milliliter [µCi/mL])	
Radionuclide	NESHAP Concentration Level for Environmental Compliance (CL)[a]	10% of Derived Concentration Standard (DCS)[b]
^{241}Am	1.9	4.1
^{137}Cs	19	9,800
^{3}H	1,500,000	1,400,000
^{238}Pu	2.1	3.7
^{239}Pu	2	3.4
^{233}U	7.1	39
^{234}U	7.7	40
^{235}U	7.1	45
^{236}U	7.7	44
^{238}U	8.3	47

(a) From Table 2, Appendix E of Title 40 Code of Federal Regulations (CFR) Part 61, 2010
(b) From DOE-STD-1196-2011, "Derived Concentration Technical Standard"

In addition to CLs, air concentrations measured at all locations are also compared with Derived Concentration Standard (DCS) values. They represent the annual average air concentrations that would result in a ***total effective dose equivalent (TEDE)*** (see Glossary, Appendix B) of 100 mrem/yr (the federal dose limit to the public from all radiological exposure pathways). Ten percent of the DCS (third column of Table 4-1) represents a 10 mrem/yr dose and is analogous to the CLs. Differences between the CL and 10% of the DCS are due to the fact that the DCS values are based on only inhalation of radionuclides in air while the CL consider external dose and ingestion of radionuclides deposited from air. Because of this, the CLs are generally the more conservative of the two and are used to demonstrate compliance. Air concentrations approaching 10% of the CLs are investigated for causes that may be mitigated in order to ensure that regulatory dose limits are not exceeded.

Point-Source (Stack) Sampler – Continuous stack monitoring has been conducted in the past at one facility on the NNSS, the Joint Actinide Shock Physics Experimental Research (JASPER) facility in Area 27 (Figure 4-2). During 2013, the potential air emissions from the facility were re-evaluated and determined to result in a potential

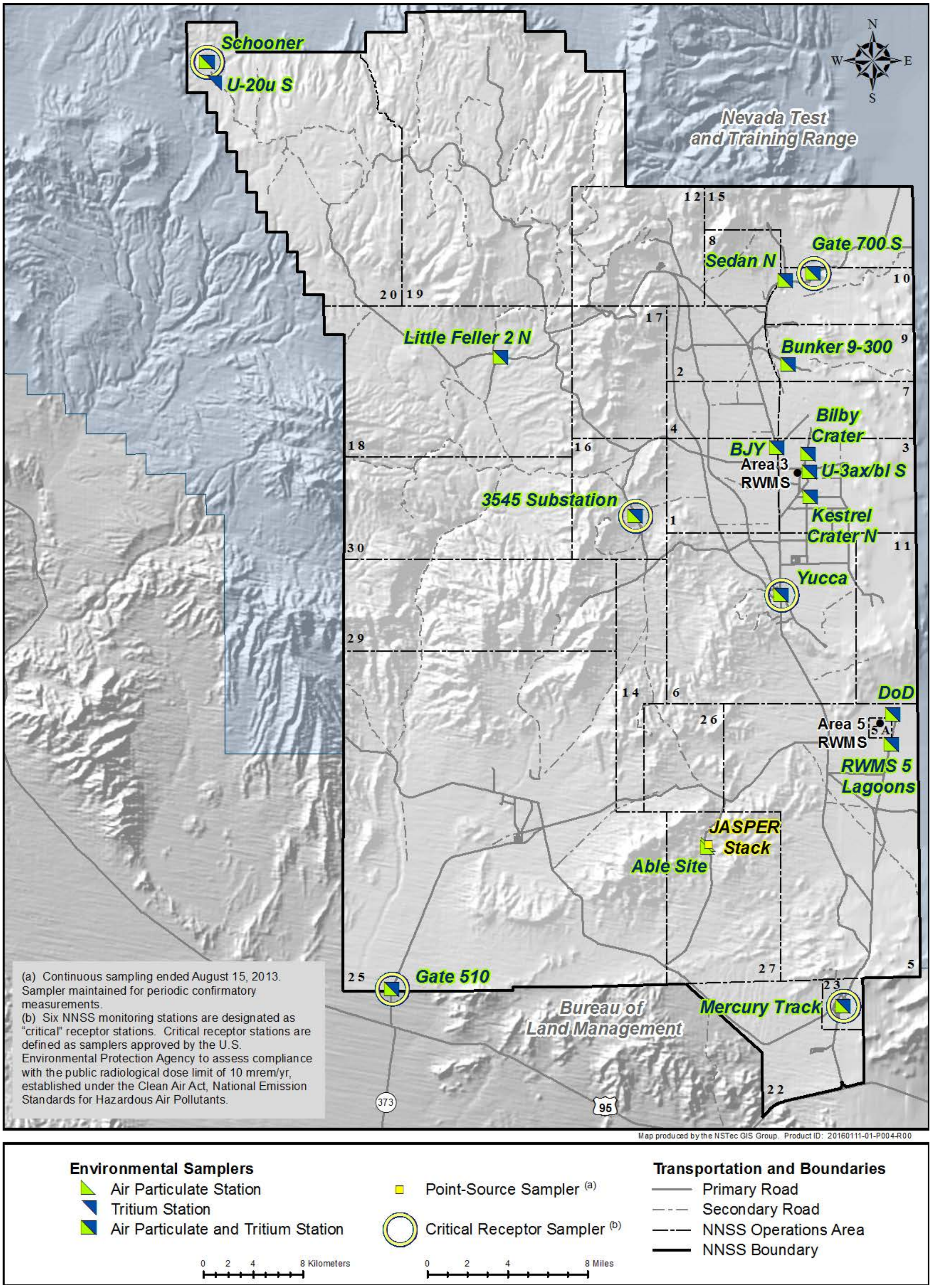

Figure 4-2. Radiological air sampling network on the NNSS in 2016

dose that is much less than the 0.1 mrem/yr threshold at which stack monitoring is required under NESHAP. Therefore, only periodic sampling is recommended to verify low emissions. During 2016, one sample was taken from February 1 to February 3 for this purpose. No man-made radionuclides were detected in the sample, which confirms continued low emissions.

4.1.2 Air Particulate and Tritium Sampling Methods

A sample is collected from each air particulate sampler by drawing air through a 10-centimeter (cm) (4-inch [in.]) diameter glass-fiber filter at a flow rate of about 85 liters (3 cubic feet [ft^3]) per minute. The particulate filter is mounted in a filter holder that faces downward at a height of 1.5 meters (m) (5 feet [ft]) above ground. A timer measures the operating time. The run time multiplied by the flow rate yields the volume of air sampled, which is about 1,720 cubic meters (m^3) (60,000 ft^3) during a typical 14-day sampling period. The air sampling rates are measured using mass-flow meters that are calibrated annually. The filters are collected every 2 weeks.

Filters are analyzed for gross alpha and gross beta radioactivity after an approximate 5-day holding time to allow for the decay of naturally occurring radon progeny. They are then composited quarterly for each sampler. The composite samples are analyzed for gamma-emitting radionuclides (which includes ^{137}Cs) by gamma spectroscopy and for ^{238}Pu, $^{239+240}$Pu, and ^{241}Am by alpha spectroscopy after chemical separation. Samples from locations relatively near potential sources of uranium emissions are also analyzed for uranium isotopes by alpha spectroscopy. These sampling locations have been RWMS 5 Lagoons (Area 5), Yucca (Area 6), Gate 700 S (Area 10), 3545 Substation (Area 16), Gate 510 (Area 25), and Able Site (Area 27). Starting with the third quarter of 2016 three additional locations were added: BJY (Area 1), Bunker 9-300 (Area 9), and Sedan Crater N (Area 10).

Tritiated water vapor in the form of $^3H^3HO$ or ^3HHO (collectively referred to as HTO) is sampled continuously at each tritium sampling location. Tritium samplers are operated with elapsed time meters at a flow rate of about 566 cubic centimeters per minute (1.2 ft^3 per hour). The total volume sampled is determined from the product of the sampling period and the flow rate (about 11 m^3 [388 ft^3] over a 2-week sampling period). The HTO is removed from the airstream by a molecular sieve desiccant that is exchanged biweekly. An aliquot of the total moisture collected is extracted from the desiccant and analyzed for tritium by liquid scintillation counting. In all cases, measured activity in units per sample is converted to units per volume of air prior to reporting in the following sections.

Quality control air samples (e.g., duplicates, blanks, and spikes) are also routinely incorporated into the analytical suites. Chapter 16 contains a discussion of quality assurance/quality control protocols and procedures used for radiological air monitoring.

4.1.3 Presentation of Air Sampling Data

The 2016 annual average radionuclide concentrations at each air sampling location are presented in the following sections. The annual average concentration for each radionuclide is estimated from uncensored analytical results for individual samples; i.e., values less than their analysis-specific ***minimum detectable concentrations (MDCs)*** (see Glossary, Appendix B) are included in the calculation. $^{239+240}$Pu, $^{233+234}$U, and $^{235+236}$U are reported as the sum of isotope concentrations because the analytical method cannot readily distinguish the individual isotopes. Where field duplicate measurements are available, plots and summaries use the average of the regular and field duplicate measurements.

In graphs of concentration data in the following figures, the CL (second column of Table 4-1) or a fraction of the CL is included as a dashed green horizontal line. For graphs displaying individual measurements, the CL or fraction thereof is shown for reference only; assessment of NESHAP compliance is based on annual average concentrations rather than individual measurements.

4.1.4 Air Sampling Results

Radionuclide concentrations in the air samples shown in the following tables and graphs are attributed to the resuspension of legacy contamination in surface soils and to the upward flux of tritium from the soil at sites of past nuclear tests and buried low-level radioactive waste.

4.1.4.1 Gross Alpha and Gross Beta

Gross alpha and ***gross beta*** (see Glossary, Appendix B) radioactivity measurements in air samples collected in 2016 are summarized in Tables 4-2 and 4-3. Because these radioactivity measurements include naturally occurring radionuclides (such as ^{40}K, ^{7}Be, uranium, thorium, and the daughter isotopes of uranium and thorium) in uncertain proportions, a meaningful CL cannot be constructed. These analyses are useful in that results can be economically obtained just 5 days after sample collection to identify any increases requiring investigation.

Overall, the distribution of mean gross alpha results across the network is comparable with those of the past few years. These measurements reflect the somewhat higher values seen at some locations, particularly Bunker 9-300, with ^{241}Am and $^{239+240}$Pu (see Sections 4.1.4.2 and 4.1.4.4). The gross beta measurements also resemble those of prior years, excluding the briefly elevated values in March 2011 due to the Fukushima Daiichi nuclear power plant event. There are no sampling locations with gross beta data that stand out from the rest.

Table 4-2. Gross alpha radioactivity in air samples collected in 2016

			Gross Alpha (x 10^{-16} µCi/mL)			
Area	**Sampling Location**	**Number of Samples**	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**
1	BJY	26	25.00	16.94	6.64	81.93
3	Bilby Crater	26	25.84	14.31	0.63	77.53
3	Kestrel Crater N	26	24.73	16.62	-2.54	80.94
3	U-3ax/bl S	26	30.19	21.71	-2.52	97.66
5	DoD	26	26.56	17.92	3.17	95.84
5	RWMS 5 Lagoons	26	27.45	18.81	1.93	98.26
6	Yucca*	26	24.31	16.70	-1.99	86.23
9	Bunker 9-300	26	46.66	42.86	-2.65	171.49
10	Gate 700 S*	26	23.01	17.69	-3.25	81.48
10	Sedan N	26	25.40	18.41	1.31	86.65
16	3545 Substation*	26	19.27	16.30	-8.54	77.68
18	Little Feller 2 N	26	23.23	18.02	-6.41	90.12
20	Schooner*	26	23.04	18.64	-4.53	85.05
23	Mercury Track*	26	22.61	17.45	-1.27	91.30
25	Gate 510*	26	27.40	17.23	7.85	90.57
27	Able Site	26	22.45	17.78	-9.13	88.95
All Environmental Locations		**416**	**26.07**	**20.69**	**-9.13**	**171.49**
*** EPA-approved Critical Receptor Sampler**						

Table 4-3. Gross beta radioactivity in air samples collected in 2016

			Gross Beta (x 10^{-15} µCi/mL)			
Area	**Sampling Location**	**Number of Samples**	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**
1	BJY	26	21.43	7.13	14.43	48.60
3	Bilby Crater	26	23.30	7.38	15.11	52.04
3	Kestrel Crater N	26	22.74	7.52	15.28	52.23
3	U-3ax/bl S	26	21.62	6.98	13.17	44.34
5	DoD	26	21.22	7.37	13.58	48.81
5	RWMS 5 Lagoons	26	21.58	8.50	12.31	46.97
6	Yucca*	26	21.09	7.19	13.17	47.07
9	Bunker 9-300	26	21.25	6.81	13.50	45.14
10	Gate 700 S*	26	19.65	7.05	12.08	45.70
10	Sedan N	26	22.23	7.10	14.96	50.09
16	3545 Substation*	26	22.63	8.15	13.85	53.95

Table 4-3. Gross beta radioactivity in air samples collected in 2016 (continued)

Area	Sampling Location	Number of Samples	Gross Beta (x 10^{-15} µCi/mL) Mean	Standard Deviation	Minimum	Maximum
18	Little Feller 2 N	26	21.15	6.46	13.38	44.07
20	Schooner*	26	21.70	7.12	13.72	50.20
23	Mercury Track*	26	21.89	6.55	13.49	43.35
25	Gate 510*	26	22.14	6.83	13.02	48.01
27	Able Site	26	24.08	7.78	14.90	53.93
All Environmental Locations		**416**	**21.86**	**7.20**	**12.08**	**53.95**

*** EPA-approved Critical Receptor Sampler**

4.1.4.2 *Americium-241*

The mean ^{241}Am concentration for environmental sampler locations was 13.91 × 10^{-18} µCi/mL during 2016. This is not a significant change from recent years; the annual means were 11.67, 8.55, 10.09, 12.74, 15.99, 6.99, and 6.33 × 10^{-18} µCi/mL in 2015 through 2009, respectively. The 2016 average concentration is 0.7% of the CL (shown at the bottom of Table 4-4). As usual, the highest concentrations were found at the Bunker 9-300 sampler location in Area 9 (Table 4-4, Figure 4-3). This sampler is located within areas of known soil contamination from past nuclear tests, available for re-suspension on windy days; see similar results for $^{239+240}$Pu in Section 4.1.4.4. The annual mean concentration at Bunker 9-300 is 122.6 × 10^{-18} µCi/mL, 6.5% of the CL. Other sampler locations with elevated concentrations are U-3ax/bl S (Area 3) and Gate 700 S (Area 10). Figure 4-3 shows measurements at these and other locations (other Area 1 and 3 locations, and Sedan N), which often have higher ***actinide*** (see Glossary, Appendix B) values individually. Figure 4-3 also shows the means of quarterly concentrations at those sampler locations that have been grouped together (“Areas 1 & 3” and “Other Stations”). The third quarter value for the group “Areas 1 & 3” is primarily from the U-3ax/bl S sample result.

Table 4-4. Concentrations of ^{241}Am in air samples collected in 2016

Area	Sampling Location	Number of Samples	^{241}Am (× 10^{-18} µCi/mL) Mean	Standard Deviation	Minimum	Maximum
1	BJY	4	8.65	5.63	0.69	13.95
3	Bilby Crater	4	5.31	1.70	3.71	7.60
3	Kestrel Crater N	4	7.90	7.89	1.82	19.13
3	U-3ax/bl S	4	27.11	32.92	5.01	75.96
5	DoD	4	1.75	2.06	-0.57	4.23
5	RWMS 5 Lagoons	4	2.28	2.25	0.00	4.93
6	Yucca*	4	5.09	2.77	2.50	7.51
9	Bunker 9-300	4	122.60	120.49	11.67	260.19
10	Gate 700 S*	4	15.96	21.29	1.13	47.55
10	Sedan N	4	8.57	5.32	2.01	15.03
16	3545 Substation*	4	2.12	1.51	0.42	4.02
18	Little Feller 2 N	4	2.84	0.87	2.16	4.07
20	Schooner*	4	3.38	3.44	0.00	7.84
23	Mercury Track*	4	2.70	2.00	0.15	4.78
25	Gate 510*	4	-0.33	2.79	-4.28	1.81
27	Able Site	4	6.62	8.48	-0.24	18.03
All Environmental Locations		**64**	**13.91**	**40.23**	**-4.28**	**260.19**

CL = 1,900 × 10^{-18} µCi/mL
*** EPA-approved Critical Receptor Sampler**

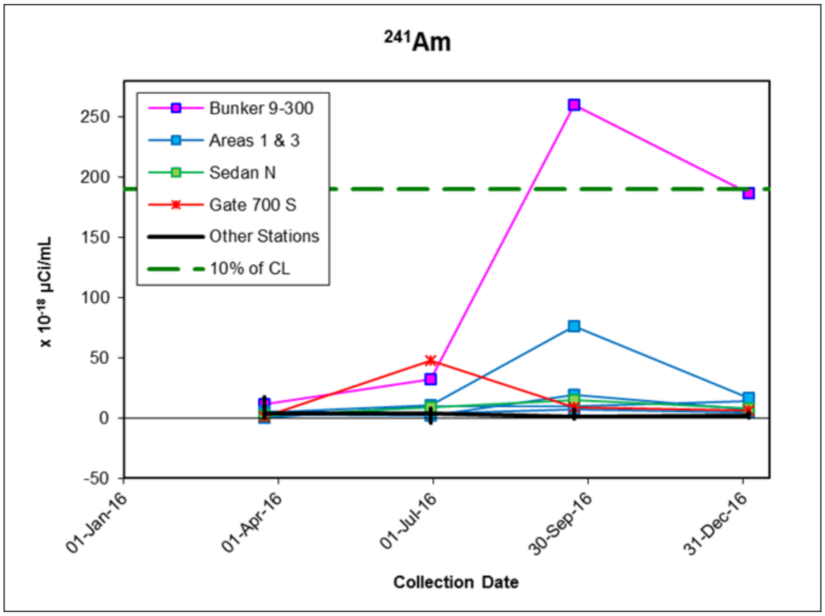

Figure 4-3. Concentrations of ^{241}Am in air samples collected in 2016

4.1.4.3 Cesium-137

^{137}Cs was detected in two samples during 2016 at levels slightly above their MDCs. These were in the first quarter composite sample collected at Gate 510 and the third quarter sample at Sedan N. All measured concentrations were very low (Table 4-5, Figure 4-4). Figure 4-4 shows the quarterly mean concentrations across all locations and vertical bars extending from the lowest to highest quarterly measurements. The highest single sample measurement (at Gate 510) was 0.2% of the CL; the highest annual mean (at Sedan N) was 0.1% of the CL.

Table 4-5. Concentrations of ^{137}Cs in air samples collected in 2016

			^{137}Cs (× 10^{-17} µCi/mL)			
Area	**Sampling Location**	**Number of Samples**	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**
1	BJY	4	-0.28	2.24	-3.63	1.02
3	Bilby Crater	4	-0.11	1.45	-2.24	0.94
3	Kestrel Crater N	4	0.17	0.57	-0.58	0.80
3	U-3ax/bl S	4	0.67	0.32	0.34	1.08
5	DoD	4	0.15	0.77	-0.98	0.68
5	RWMS 5 Lagoons	4	-0.92	1.30	-2.59	0.39
6	Yucca*	4	-0.83	2.09	-3.91	0.55
9	Bunker 9-300	4	1.04	0.29	0.72	1.43
10	Gate 700 S*	4	-0.35	1.62	-2.77	0.68
10	Sedan N	4	1.20	0.94	-0.18	1.94
16	3545 Substation*	4	-1.41	2.96	-5.85	0.17
18	Little Feller 2 N	4	-0.38	0.84	-1.62	0.15
20	Schooner*	4	0.08	0.72	-0.69	0.95
23	Mercury Track*	4	0.09	1.08	-0.97	1.52
25	Gate 510*	4	0.40	3.41	-3.44	4.68
27	Able Site	4	-0.06	0.60	-0.91	0.42
All Environmental Locations		**64**	**-0.03**	**1.55**	**-5.85**	**4.68**

CL = 1,900 × 10^{-17} µCi/mL
*** EPA-approved Critical Receptor Sampler**

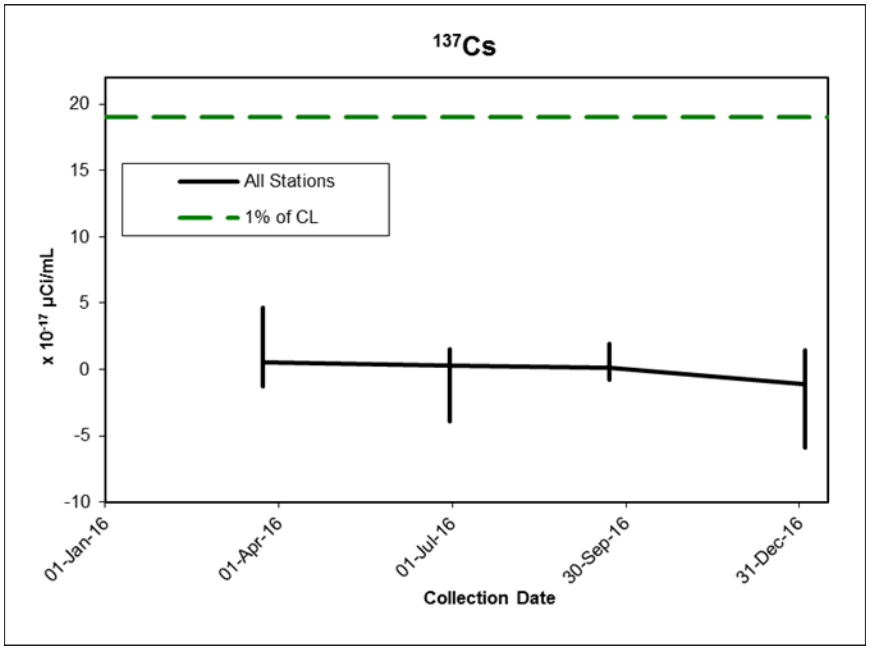

Figure 4-4. Concentrations of ^{137}Cs in air samples collected in 2016

4.1.4.4 Plutonium Isotopes

The overall mean concentration for ^{238}Pu at environmental samplers in 2016 (5.54 × 10^{-18} µCi/mL) is somewhat above the range of values (1.15 to 3.72 × 10^{-18} µCi/mL) observed since 2009. The highest annual mean (30.54 × 10^{-18} µCi/mL) was at ABLE Site in Area 27 due to an abnormally high first quarter measurement. This measurement is questionable; usually a high value of one of the actinides is accompanied by elevated values of the others (^{241}Am and $^{239+240}$Pu in this case) and gross alpha, but not for this sample. Also, subsequent values were not elevated. Other stations with relatively high annual means are Bunker 9-300 (Area 9) and Sedan N (Area 10). The highest annual mean concentration at environmental samplers is 1.5% of the CL.

The $^{239+240}$Pu isotopes are of greater abundance and hence greater interest. The overall mean of 74.6 × 10^{-18} µCi/mL in 2016 (Table 4-7) is within the range of values measured over the past 8 years. The location with the highest mean, as usual, is Bunker 9-300 (781 × 10^{-18} µCi/mL, 39.1% of the CL; Table 4-7 and Figure 4-6). The higher plutonium values at this sampler are primarily due to diffuse sources of radionuclides from historical nuclear testing in Area 9. Other samplers with relatively higher values are Sedan N and samplers in Areas 1 and 3; these are represented individually in the plots, as is Gate 700 S.

The concentrations of ^{241}Am, $^{239+240}$Pu, and to some extent ^{238}Pu in air show similar patterns through time at Bunker 9-300 (Figures 4-3, 4-6, and 4-5, respectively). This is because ^{241}Am is the long-lived daughter product obtained when ^{241}Pu (a short-lived isotope created along with the more common Pu isotopes) decays by beta emission. Hence, $^{239+240}$Pu and ^{241}Am (and also ^{238}Pu somewhat) tend to be found together in particles of Pu remaining from past nuclear tests. The half-life of ^{241}Pu is 14.4 years, whereas that of ^{241}Am is 432 years. Consequently, the amount of ^{241}Am will gradually increase temporarily as ^{241}Pu decays, and then it will decrease.

Figure 4-7 shows long-term trends in $^{239+240}$Pu annual mean concentrations at locations with at least 15-year data histories since 1970. Rather than showing the time histories for all 47 locations, Figure 4-7 shows the average (geometric mean) trend lines for Areas 1 and 3; Area 5; Areas 7, 9, 10, and 15; and other areas. Areas 1, 3, 7, 9, 10, and 15, in the northeast portion of the NNSS, have a legacy of soil contamination from surface and atmospheric nuclear tests and safety shots. The average annual rates of decline for these groups range from 2.2% (Areas 1 and 3) and 2.4% (Areas 7, 9, 10, and 15) to over 10% (the "Other Areas" group). This equates to an estimated environmental half-life for $^{239+240}$Pu in air of 31.1 years for Areas 1 and 3; 28.3 years for Areas 7, 9, 10, and 15; 7.2 years for Area 5; and 6.1 years for the "Other Areas" group. Declining rates are not attributed to radioactive decay, as the physical half-lives of ^{239}Pu and ^{240}Pu are 24,110 and 6,537 years, respectively. The decreases are due primarily to immobilization and dilution of Pu particles in soil, resulting in reduced concentrations re-suspended in air. The half-life of the less abundant ^{238}Pu is 88 years.

Table 4-6. Concentrations of ^{238}Pu in air samples collected in 2016

			^{238}Pu (× 10^{-18} µCi/mL)			
Area	**Sampling Location**	**Number of Samples**	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**
1	BJY	4	4.76	2.66	2.42	8.52
3	Bilby Crater	4	3.97	6.03	0.00	12.93
3	Kestrel Crater N	4	3.04	0.82	2.17	3.80
3	U-3ax/bl S	4	4.83	3.16	2.45	9.33
5	DoD	4	4.95	5.36	1.51	12.84
5	RWMS 5 Lagoons	4	1.03	3.06	-2.99	4.44
6	Yucca*	4	1.27	2.01	-1.66	2.93
9	Bunker 9-300	4	10.83	7.69	0.98	18.30
10	Gate 700 S*	4	3.02	1.73	1.04	4.70
10	Sedan N	4	10.09	5.11	5.48	17.26
16	3545 Substation*	4	1.91	1.58	0.33	3.85
18	Little Feller 2 N	4	0.18	2.30	-2.65	2.44
20	Schooner*	4	2.72	2.17	0.00	4.99
23	Mercury Track*	4	2.50	2.01	0.68	4.31
25	Gate 510*	4	3.05	2.91	0.97	7.24
27	Able Site	4	30.54	55.81	1.85	114.24
All Environmental Locations		**64**	**5.54**	**14.45**	**-2.99**	**114.24**

CL = 2,100 × 10^{-18} µCi/mL
*** EPA-approved Critical Receptor Sampler**

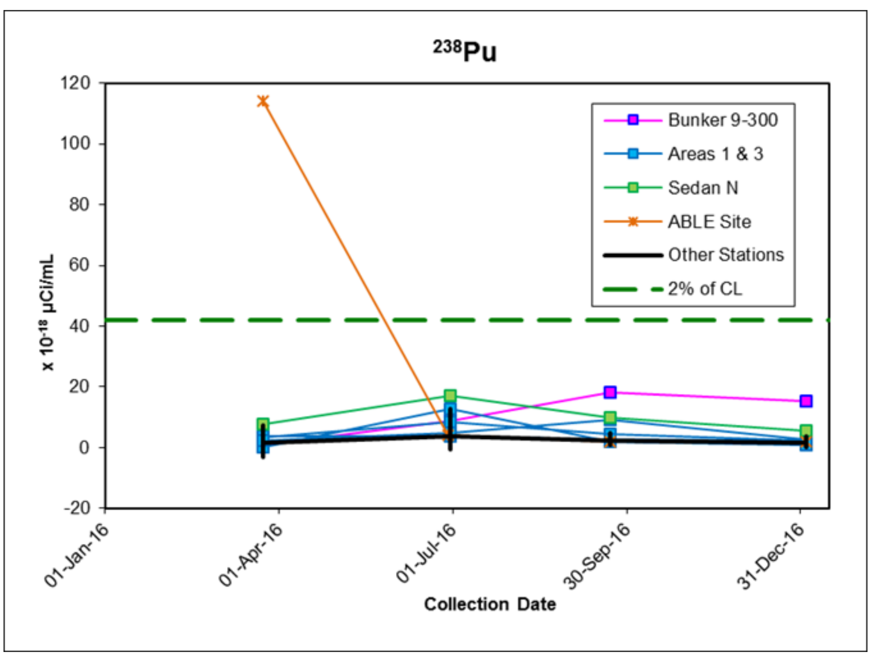

Figure 4-5. Concentrations of ^{238}Pu in air samples collected in 2016

Table 4-7. Concentrations of $^{239+240}$Pu in air samples collected in 2016

Area	Sampling Location	Number of Samples	$^{239+240}$Pu (× 10^{-18} µCi/mL) Mean	Standard Deviation	Minimum	Maximum
1	BJY	4	52.44	44.30	5.80	97.34
3	Bilby Crater	4	42.79	33.84	5.40	87.02
3	Kestrel Crater N	4	49.14	60.51	3.67	138.33
3	U-3ax/bl S	4	156.91	202.31	9.80	456.13
5	DoD	4	2.72	2.35	0.25	5.89
5	RWMS 5 Lagoons	4	7.71	6.59	3.61	17.47
6	Yucca*	4	14.10	17.01	1.65	38.92
9	Bunker 9-300	4	781.20	797.22	29.27	1701.62
10	Gate 700 S*	4	14.70	17.98	2.60	41.42
10	Sedan N	4	48.96	54.07	4.64	127.53
16	3545 Substation*	4	0.35	2.90	-3.84	2.55
18	Little Feller 2 N	4	11.57	10.05	3.97	26.38
20	Schooner*	4	2.79	2.74	0.00	5.66
23	Mercury Track*	4	2.94	2.29	0.68	5.54
25	Gate 510*	4	3.25	3.18	0.00	7.63
27	ABLE Site	4	1.83	0.98	0.47	2.82
All Environmental Locations		**64**	**74.59**	**260.79**	**-3.84**	**1701.62**

CL = 2,000 × 10^{-18} µCi/mL
*** EPA-approved Critical Receptor Sampler**

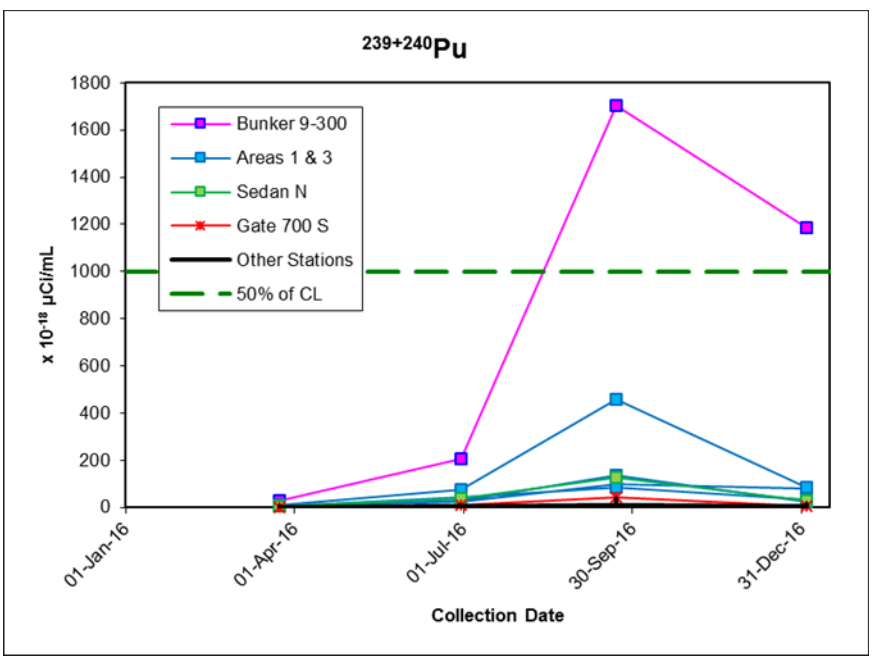

Figure 4-6. Concentrations of $^{239+240}$Pu in air samples collected in 2016

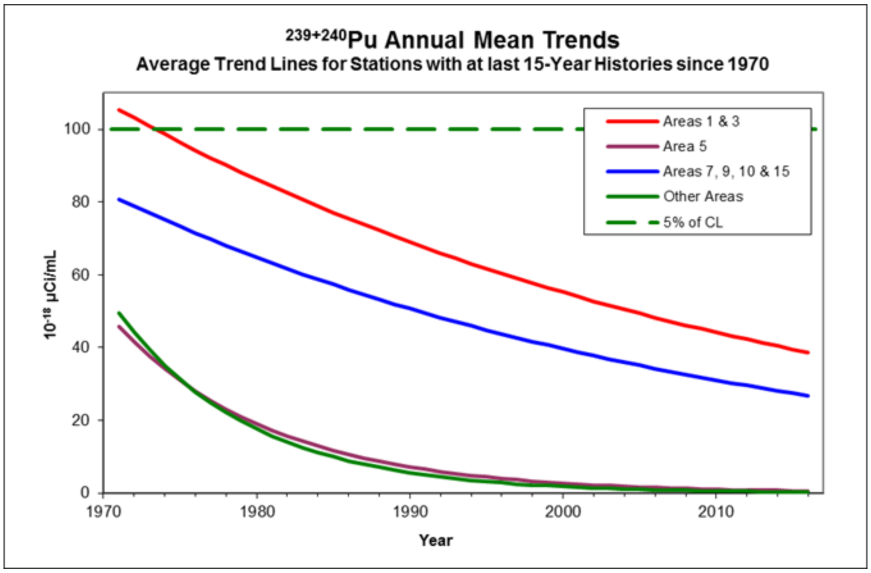

Figure 4-7. Average trends in $^{239+240}$Pu in air annual means, 1971–2016

4.1.4.5 Uranium Isotopes

Uranium analyses were performed in 2016 for samples collected near sites where exercises using uranium (predominately DU) have been conducted. Quarterly samples from six samplers and third- and fourth-quarter samples from three samplers were analyzed. Concentrations and ratios of the U isotopes (233+234U / 238U and 235+236U / 238U) were compared among the samplers and compared with ratios found in blank filters. From this, no evidence of elevated uranium or presence of DU in air was observed.

4.1.4.6 Tritium

Tritium concentrations in air vary widely across the NNSS (Table 4-8). As usual, the highest mean concentration was at the Schooner sampler (83.3×10^{-6} picocuries per milliliter [pCi/mL]). The next highest are 1.8×10^{-6} pCi/mL at Sedan N, 1.0×10^{-6} pCi/mL at RWMS 5 Lagoons, and 0.7×10^{-6} pCi/mL at DoD. Figure 4-8 shows these data with the Schooner data plotted at one-tenth of their actual values to allow the variation at other locations to be visible. The Schooner annual mean is 5.6% of the CL; mean concentrations at other locations are at most 0.12% of the CL.

The tritium found at Schooner and Sedan N comes from past nuclear tests. Tritium associated with these tests quickly oxidizes into tritiated water, which remains in the surrounding soil and rubble until it moves to the surface and evaporates. Higher tritium concentrations in air are generally observed during the summer months. Increased tritium emissions are likely due to the movement of relatively deep soil moisture (> 2 m) containing relatively high concentrations of tritium to the surface when temperatures are the highest and when shallow (< 2 m) soil moisture is the lowest. Rainfall can temporarily suppress these emissions by diluting tritium in the atmosphere and in the shallow soil moisture. Figure 4-8 shows the relationship between tritium and average daily temperature at Schooner Crater. Figure 4-9 shows the amount of precipitation occurring during monitoring periods in and around Pahute Mesa. The summer peak at Schooner Crater was a bit delayed in 2016, consistent with the spring rains; note also the dips in tritium emissions around early August, late September to early October, and late October to early November, at times of increased precipitation. The points plotted in these figures show the total ^{3}H emissions for the 2-week periods, the average temperature at the Schooner Crater meteorological station for the period, and the highest total period precipitation recorded at any of three meteorological stations in the Pahute Mesa area, all plotted against the collection date for that period.

Figure 4-10 shows average (geometric mean) long-term trends for the annual mean tritium levels at locations with at least 7-year histories since 1989, by Area groups. Tritium measurements have been decreasing fairly rapidly at most locations; the overall average decline rate for samplers other than Schooner is around 17% per year. The decline rate for Schooner has been about 11.1% per year since 2002.

Table 4-8. Concentrations of ^{3}H in air samples collected in 2016

Area	Sampling Location	Number of Samples	^{3}H Concentration (× 10^{-6} pCi/mL) Mean	Standard Deviation	Minimum	Maximum
1	BJY	26	0.49	0.50	-0.55	1.53
3	Bilby Crater	26	0.26	0.33	-0.38	0.82
3	Kestrel Crater N	26	0.56	0.58	-0.26	1.78
3	U-3ax/bl S	26	0.46	0.47	-0.30	1.84
5	DoD	26	0.71	0.63	-0.33	2.18
5	RWMS 5 Lagoons	26	1.00	1.00	0.02	3.26
6	Yucca*	26	0.25	0.43	-0.93	0.95
9	Bunker 9-300	26	0.65	0.61	-0.28	1.94
10	Gate 700 S*	26	0.23	0.46	-0.40	1.43
10	Sedan N	26	1.82	1.83	-0.77	5.01
16	3545 Substation*	26	0.11	0.37	-0.51	1.38
18	Little Feller 2 N	26	0.22	0.58	-0.78	1.33
20	Schooner*	26	83.29	81.63	3.03	236.28
20	U-20u S	26	0.46	0.49	-0.29	1.44
23	Mercury Track*	26	0.05	0.46	-0.76	1.41
25	Gate 510*	26	0.16	0.29	-0.49	0.74
All Environmental Locations		**416**	**5.67**	**28.37**	**-0.93**	**236.28**

CL = 1,500 × 10^{-6} pCi/mL

*** EPA-approved Critical Receptor Sampler**

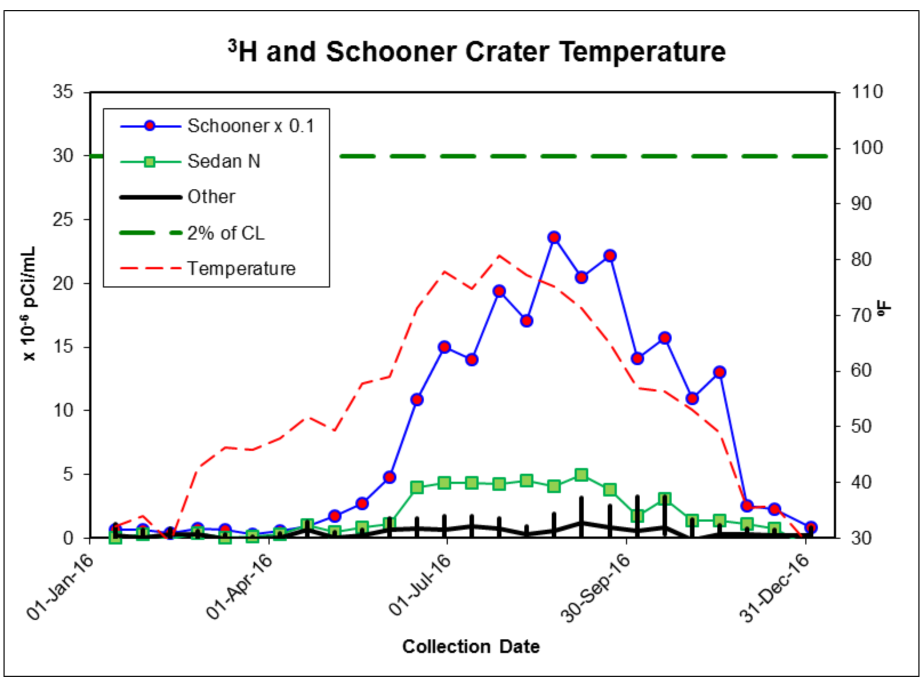

Figure 4-8. Concentrations of ^{3}H in air samples collected in 2016 with Schooner Crater average air temperature per collection period

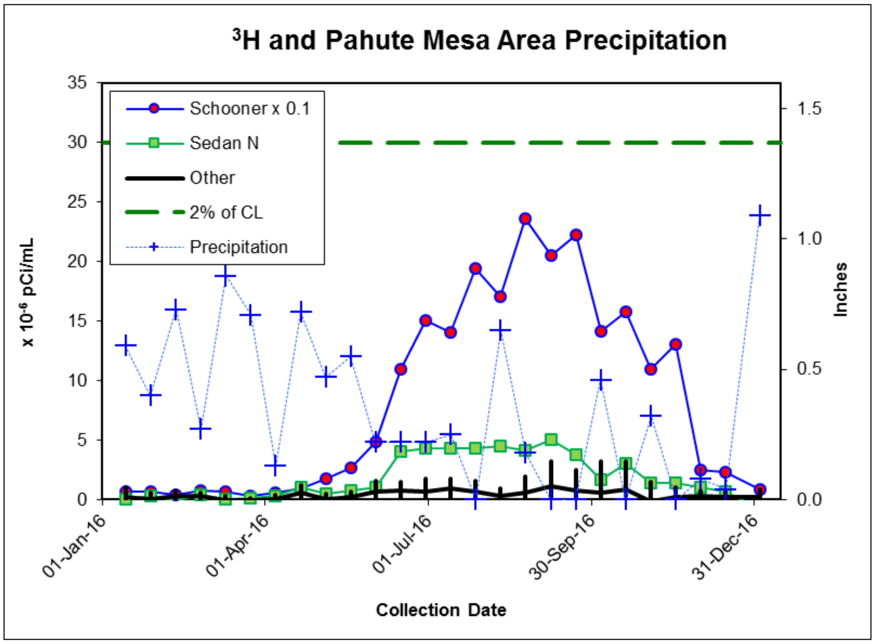

Figure 4-9. Concentrations of ^{3}H in air samples collected in 2016 with Pahute Mesa precipitation

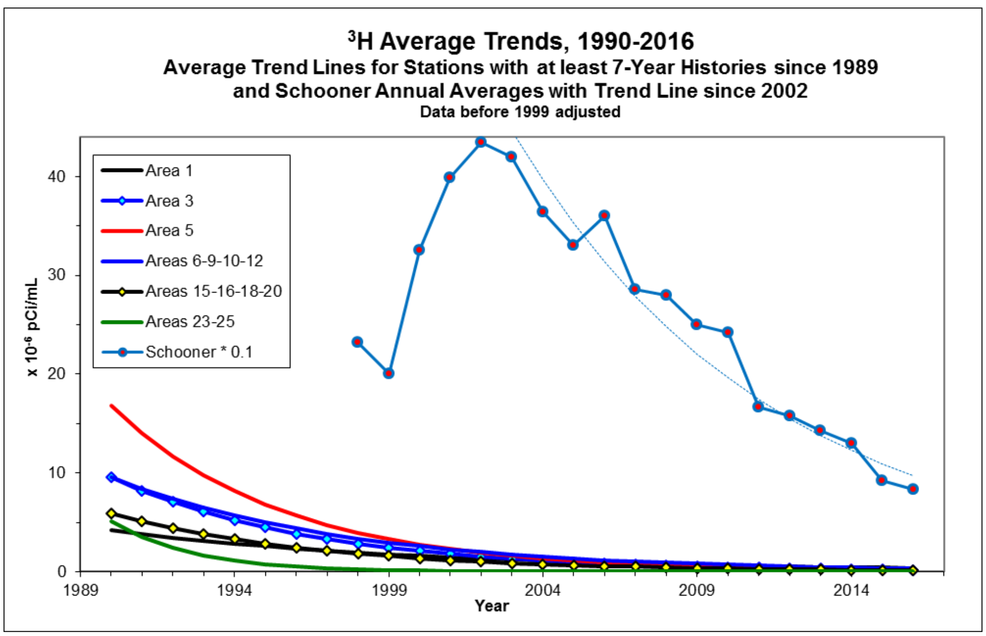

Figure 4-10. Trends in annual mean ^{3}H air concentrations for Area groups, 1990–2016 and Schooner Crater annual means with trend since 2002. Sampling changed in mid-1999 to the more efficient molecular sieve method; prior data are adjusted to provide a more accurate comparison with current data.

4.1.5 2016 Air Sampling Results from Critical Receptor Samplers

The following radionuclides from NNSS-related activities were detected at one or more of the critical receptor samplers: ^{3}H, ^{137}Cs, ^{238}Pu, $^{239+240}$Pu, and ^{241}Am. All of their measured concentrations were well below their CLs. No man-made uranium was detected above levels found in blank filters (see Section 4.1.4.5). The concentration of each measured man-made radionuclide at each of the six critical receptor samplers is divided by its respective CL (see Table 4-1) to obtain a "fraction of CL." These are then summed for each sampler. The sum of these fractions at each critical receptor sampler is far less than 1; the highest sum was 0.060 at Schooner Crater. This demonstrates that the NESHAP dose limit of 10 mrem/yr at these critical receptor locations was not exceeded (Table 4-9). Scaling the CL fraction to the 10 mrem/yr dose limit would mean that a hypothetical individual residing at Schooner for the entire calendar year would receive 0.60 mrem from the air exposure pathway. A more realistic estimate of dose to the offsite public would come from using the 0.0034 sum of fractions from the Gate 510 sampler, which is closest to the nearest public receptor (about 3.5 kilometers [km] or 2.2 miles (mi)]). Scaling this fraction to the 10 mrem/yr dose limit would result in an estimated TEDE from the air pathway of 0.034 mrem/yr to a hypothetical individual at the Gate 510 sampler.

Table 4-9. Sum of fractions of compliance levels for man-made radionuclides at critical receptor samplers in 2016

Radionuclides Included in Sum of Fractions	NNSS Area	Sampling Location	Sum of Fractions of Compliance Levels (CLs)
^{241}Am, ^{238}Pu, $^{239+240}$Pu, and ^{3}H	6	Yucca	0.0106
	10	Gate 700 S	0.0173
	16	3545 Substation	0.0023
	20	Schooner	0.0600
	23	Mercury Track	0.0041
	25	Gate 510	0.0034

4.1.6 Emission Evaluations for Planned Projects

During 2016, five NESHAP evaluations for radionuclide emissions were conducted. All were for research projects of laboratory operations using radioactive material. These evaluations were conducted to determine if the activities had the potential to release airborne radionuclides that would expose the public to a dose equal to or greater than 0.1 mrem/yr. For any project or facility with this potential, the EPA requires monitoring of the emissions and possibly the submittal of an application for EPA approval prior to active operations. The predicted dose at the nearest NNSS boundary for each activity evaluated during 2016 was much less than the 0.1 mrem/yr level specified under NESHAP regulations. Therefore, it was concluded that these activities constituted minor sources and did not require point-source operational monitoring. The detailed air emission dose evaluations for each project are reported in the NESHAP annual report for 2016 (National Security Technologies, LLC [NSTec], 2017).

4.1.7 Unplanned Releases

There were no known unplanned radionuclide releases in 2016. Two wildland fires were documented on the NNSS during 2016. All of these were less than one acre (0.4 ha) in size and all were extinguished quickly by NNSS Fire and Rescue personnel. None of these fires occurred in radiologically contaminated areas.

4.1.8 Estimate of Total NNSS Radiological Atmospheric Releases in 2016

Each year, existing operations, new construction projects, and modifications to existing facilities that have the potential for airborne emissions of radioactive materials are reviewed. Quantities of radionuclides released during these operations and from legacy contamination sites are measured or calculated to obtain the total annual quantity of radiological atmospheric releases from the NNSS. The methods used are described in detail in NSTec (2017). Total emissions in 2016, by radionuclide, are shown in Table 4-10. Radionuclide emissions by source are shown in Table 4-11. Their locations in relation to critical receptor air monitoring locations are shown in Figure 4-1.

In 2016, an estimated 518 Ci of radionuclides were released as air emissions. Of this amount, about 58.8% (305 Ci) is from the short-lived activation and fission products ^{16}N, ^{19}O, ^{38}Cl, ^{41}Ar, ^{85m}Kr, ^{115m}In, ^{135}I, ^{135m}Xe, and ^{135}Xe (see Table 4-10 for radionuclide name, half-life, and amount emitted). All of these decay away very quickly and so are essentially not available to contribute dose to the public at the 31 to 62 km (19 to 38 mi) distances over which they have to travel. Tritium makes up about 40.5% of the total emission. The remaining radionuclides make up only 0.7% of the total emission.

Table 4-10. Total estimated NNSS radionuclide emissions for 2016

Radionuclide	Symbol	Half-life[a]	Total Quantity (Ci)
Primary Radionuclides			
Tritium	^{3}H	12.32 years (yr)	210
Plutonium-238	^{238}Pu	87.7 yr	0.041
Plutonium-239+240	$^{239+240}Pu$	24,110 yr	0.29
Americium-241	^{241}Am	432 yr	0.069
Noble Gases			
Argon-41	^{41}Ar	109.6 minutes (min)	0.73
Krypton-85	^{85}Kr	10.76 yr	0.00016
Krypton-85 (metastable)	^{85m}Kr	4.48 hours (h)	15
Xenon-133 (metastable)	^{133m}Xe	2.19 days (d)	0.19
Xenon-133	^{133}Xe	5.24 d	2.7
Xenon-135 (metastable)	^{135m}Xe	15.29 min	250
Xenon-135	^{135}Xe	9.14 h	37
Other			
Carbon-14	^{14}C	5700 yr	0.000013
Nitrogen-16	^{16}N	7.13 seconds (s)	1.9
Oxygen-19	^{19}O	26.46 s	0.0034
Sodium-22	^{22}Na	2.60 yr	0.0000003
Phosphorus-32	^{32}P	14.26 d	0.000001
Chlorine-38	^{38}Cl	37 min	0.000000026
Potassium-42	^{42}K	12.36 h	0.00000001
Cobalt-60	^{60}Co	5.27 yr	0.0003
Copper-64	^{64}Cu	12.7 h	0.00000045
Strontium-90	^{90}Sr	28.79 yr	0.055
Indium-115 (metastable)	^{115m}In	4.49 h	0.00000045
Iodine-131	^{131}I	8.02 d	0.00091
Iodine-133	^{133}I	20.8 h	0.016
Iodine-135	^{135}I	6.57 h	0.051
Cesium-137	^{137}Cs	30.17 yr	0.053
Europium-152	^{152}Eu	13.54 yr	0.011
Europium-154	^{154}Eu	8.59 yr	0.0001
Europium-155	^{155}Eu	4.76 yr	0.0001
Gold-196	^{196}Au	6.18 d	0.00000045
Depleted uranium	DU	>150,000 yr	0.019

(a) Source: International Commission on Radiological Protection (2008)

Table 4-11. Radiological atmospheric releases from the NNSS for 2016

	Emission Source[a]	Type of Emissions Control	Radionuclide	Annual Quantity (Ci)
Legacy Weapon Test and Plowshare Crater Locations	Sedan	None	^{3}H	18
	Schooner	None	^{3}H	23
	Grouped Area Sources – All NNSS Areas	None	^{60}Co	0.00030
			^{90}Sr	0.055
			^{137}Cs	0.053
			^{152}Eu	0.011
			^{154}Eu	0.00010
			^{155}Eu	0.00010
			^{238}Pu	0.041
			$^{239+240}Pu$	0.29
			^{241}Am	0.069
Emanation from Building Materials	Building A-01, basement ventilation, NLVF	None	^{3}H	0.0021

Table 4-11. Radiological atmospheric releases from the NNSS for 2016 (continued)

	Emission Source[a]	Type of Emissions Control	Radionuclide	Annual Quantity (Ci)
Groundwater Characterization/ Control or Remediation Activities	Environmental Restoration Projects			
	E-Tunnel Ponds	None	^{3}H	5.1
	UGTA Well Sumps			
	ER-2-2	None	^{3}H	0.78
	UE-2ce	None	^{3}H	0.030
	ER-4-1	None	^{3}H	0.00042
	RNM #2s	None	^{3}H	0.036
	UE-5n	None	^{3}H	0.020
	ER-20-12	None	^{3}H	0.0057
Defense, Security, and Stockpile Stewardship	DPF	None	^{3}H	150
	NCERC	HEPA[b]	^{3}H	0.0000052
			^{14}C	0.000013
			^{16}N	1.9
			^{19}O	0.0034
			^{41}Ar	0.73
			^{85}Kr	0.00016
			^{85m}Kr	15
			^{131}I	0.00091
			^{133}I	0.016
			^{135}I	0.051
			^{131}Xe	0.0067
			^{133}Xe	2.7
			^{133m}Xe	0.19
			^{135}Xe	37
			^{135m}Xe	250
	NPTEC	None	DU	0.00002
	DU Experiment	None	DU	0.019
Radioactive Waste Management	Area 3 RWMS	Soil cover over waste	^{3}H	3.2
	Area 5 RWMC	Soil cover over waste	^{3}H	3.5
Support Facility Operations	Building 23-652	None	^{3}H	0.0000016

(a) All locations are on the NNSS except for Building A-01

(b) ***High-efficiency particulate air (HEPA) filter*** (see Glossary, Appendix B)

4.1.9 Environmental Impact

The concentrations of man-made radionuclides in air on the NNSS are all less than the regulatory concentration limits specified by federal regulations. Also, air monitoring data at the six critical receptor samplers indicate that the radiological dose to the general public from the air pathway is below the NESHAP standard of 10 mrem/yr (see Chapter 9 for a discussion of dose to the public from all pathways). Nearly all radionuclides detected by environmental air samplers in 2016 appear to be from two sources: (1) legacy deposits of radioactivity on and in the soil from past nuclear tests, and (2) the upward flux of tritium from the soil at sites of past nuclear tests and low-level radioactive waste burial. Long-term trends of $^{239+240}Pu$ and tritium in air continue to show a decline with time. Radionuclide concentrations in plants and animals on the NNSS and their potential impact are discussed in Chapter 8.

4.2 Nonradiological Air Quality Assessment

NNSS operations that are potential sources of air pollution include aggregate production, surface disturbance (e.g., construction), release of fugitive dust from driving on unpaved roads, use of fuel-burning equipment, open burning, venting from bulk fuel storage facilities, explosives detonations, and releases of various chemicals during testing. Air quality assessments are conducted to document compliance with the current State of Nevada air quality permit that regulates specific operations or facilities on the NNSS. The assessments mainly address nonradiological air pollutants. The State of Nevada has adopted the CAA standards, which include NESHAP, National Ambient Air Quality Standards (NAAQS), and New Source Performance Standards (NSPS). NESHAP compliance with radionuclide emissions monitoring and with the air pathway public dose limits are presented in Section 4.1 of this chapter. Compliance with all other CAA air quality standards is addressed in this section. Data collection, opacity readings, recordkeeping, and reporting activities on the NNSS are conducted to meet the specific program goals in the table below.

Air Quality Assessment Program Goals
Ensure that NNSS operations comply with all the requirements of the current air quality permit issued by the State of Nevada.
Ensure that emissions of criteria air pollutants (sulfur dioxide [SO_2]), nitrogen oxides [NO_X], carbon monoxide [CO], volatile organic compounds [VOCs], and particulate matter) and emissions of hazardous air pollutants do not exceed limits established under NAAQS and NESHAP, respectively.
Ensure that emissions of permitted NNSS equipment meet the opacity criteria to comply with NAAQS and NSPS.
Ensure that NNSS operations comply with the asbestos abatement reporting requirements under NESHAP.
Document usage of ***ozone-depleting substances (ODS)*** (see Glossary, Appendix B) to comply with Title VI of the CAA.

4.2.1 Permitted NNSS Facilities

NNSA/NFO maintains a Class II Air Quality Operating Permit (AP9711-2557) for NNSS activities. State of Nevada Class II permits are issued for sources of air pollutants considered "minor," i.e., where annual emissions must not exceed 100 tons of any one ***criteria pollutant*** (see Glossary, Appendix B), 10 tons of any one ***hazardous air pollutant (HAP)*** (see Glossary, Appendix B), or 25 tons of any combination of HAPs. The NNSS facilities regulated by permit AP9711-2557 include the following:

- Approximately 14 facilities/131 pieces of equipment in Areas 1, 5, 6, 12, 23, 25, 26, 27, and 29
- Chemical Releases at the Nonproliferation Test and Evaluation Complex (NPTEC) in Area 5 and in Port Gaston in Area 26
- Site-Wide Chemical Releases (conducted throughout the NNSS)
- Big Explosives Experimental Facility (BEEF) in Area 4
- Explosives Ordnance Disposal Unit (EODU) in Area 11
- Explosives Activities Sites at NPTEC in Area 5; High Explosives Simulation Test (HEST) in Area 14; Test Cell C, Calico Hills, and Army Research Laboratory (ARL) in Area 25; Port Gaston in Area 26; and Baker in Area 27

4.2.2 Permit Maintenance Activities

An application to renew the NNSS air permit (AP9711-2557) was submitted to the Nevada Division of Environmental Protection (NDEP) in April 2014 prior to the permit's expiration in June 2014. By the end of 2016, the new permit had still not been issued, but because the application was submitted prior to the state's deadline, 2016 operations at the NNSS continued under a permit "shield." Also, the PM10 (particulate matter equal to or less than 10 microns in diameter) Sampling and Meteorological Monitoring Systems Plan, required as part of permit renewal application, was reformatted to incorporate all facilities into a single plan. New operational allowances requested in the 2014 permit renewal application included:

- Elimination of the PM10 monitoring requirement for chemical releases (which do not contain particulates).
- Modification of the EODU reporting requirement to coincide with the submittal of other facility quarterly reports.
- Reduction of the site-wide HAP emissions cap for a single pollutant from 8 tons/year down to 7 tons/year. Actual emissions are typically < 1 ton/year.

Also, all operational allowances previously requested as modifications to the old permit were requested again as part of the 2014 renewal application. Because these allowances are not directly covered by the Nevada Administrative Code (NAC) but are enacted with the Director's approval, they must be requested with each permit renewal. The requested allowances for the 2014 renewal included:

- Revision of the recordkeeping requirements for seven remotely located fuel-fired generators.
- Removal of the requirement to report the Community Environmental Monitoring Program offsite air monitoring results from the permit.
- Elimination of the performance emissions test ("stack test") requirement for five diesel-fired generators and for eight baghouses associated with the aggregate plant, batch plant, and cementing services facilities.

It is expected that the majority of the requested allowances will appear in the renewed permit.

4.2.3 Emissions of Criteria Air Pollutants and Hazardous Air Pollutants

A source's regulatory status is determined by the maximum number of tons of criteria air pollutants and nonradiological HAPs it may emit in a 12-month period if it were operated for the maximum number of hours and at the maximum production amounts specified in the source's air permit. This maximum emission quantity, known as the ***potential to emit (PTE)*** (see Glossary, Appendix B), is specified in an Air Emissions Inventory of all emission units. Each year, NNSA/NFO submits Actual Production/Emissions Reporting Forms to NDEP as required by the NNSS air permit. These forms are used to report the actual annual operational information and the calculated emissions of the criteria air pollutants and HAPs for permitted emission units. The state uses the information to determine permit fees and to verify that emissions do not exceed the PTEs. Quarterly reports of HAP emission quantities were also submitted to NDEP in April, July, and October 2016, and January 2017. Quarterly reporting is required due to an NNSS-wide emissions limit or "cap" on HAPs. In February 2017, the Calendar Year 2016 Actual Production/Emissions Reporting Form was also submitted to NDEP.

All records examined in 2016 for permitted facilities and equipment indicated that operational parameters were being properly tracked and no PTEs were exceeded. An estimated 12.14 tons of criteria air pollutants were released (Table 4-12). The majority of the emissions were NO_X from diesel generators. An estimated 0.02 tons of HAPs were released in 2016 (Table 4-13). Table 4-13 also shows the calculated tons of air pollutants released on the NNSS over the past 10 years. Fluctuations in emissions over time reflect changes in project activities and in facility operations.

Field measurements of particulate matter equal to or less than 10 microns in diameter (PM10) are required for all permitted explosives activities. The sampling systems must operate and record ambient PM10 concentrations at least each day a detonation or chemical release occurs. The PM10 emissions are reported to the state in reports specific to each series of detonations or chemical releases.

Unless specifically exempted, the open burning of any combustible refuse, waste, garbage, or oil is prohibited. Open burning for other purposes is allowed if approved in advance by the state through issuance of an Open Burn Authorization prior to each burn. Open Burn Authorizations must be renewed annually. At the NNSS, they are issued for fire extinguisher training and for support-vehicle live-fire training activities. In 2016, 26 fire extinguisher training sessions and 12 vehicle burns were conducted at the NNSS. Most of the fire extinguisher sessions used a new system that burns propane rather than diesel fuel, resulting in greatly reduced hydrocarbon emissions. Quantities of criteria air pollutants produced by open burns are not required to be calculated or reported.

Table 4-12. Tons of criteria air pollutant emissions released on the NNSS from permitted facilities operational in 2016

	Calculated Tons[(a)] per Year of Emissions									
	Particulate Matter (PM10)[(b)]		Carbon Monoxide (CO)		Nitrogen Oxides (NO_X)		Sulfur Dioxide (SO_2)		Volatile Organic Compounds (VOCs)	
Facility	**Actual**	**PTE[(c)]**	**Actual**	**PTE**	**Actual**	**PTE**	**Actual**	**PTE**	**Actual**	**PTE**
Construction Equipment										
Wet Aggregate Plant	0.53	2.94	NA[(d)]	NA	NA	NA	NA	NA	NA	NA
Concrete Batch Plant	0.06	2.33	NA	NA	NA	NA	NA	NA	NA	NA
Cementing Services Equipment	0.02	14.86	NA	NA	NA	NA	NA	NA	NA	NA
Fuel Burning/Storage										
Diesel Fired Generators	0.35	2.86	1.39	9.31	6.30	42.94	0.29	2.59	0.39	3.20
Gasoline Fired Generators	0.00	0.12	0.00	1.17	0.00	1.85	0.00	0.10	0.00	2.52
Propane Generators	0.00	0.02	0.01	0.95	0.01	1.44	0.000	0.001	0.00	0.20
Boilers	0.11	0.38	0.28	0.94	1.11	3.77	0.02	0.08	0.07	0.25
Bulk Gasoline Storage Tank	NA	NA	NA	NA	NA	NA	NA	NA	0.98	1.45
Bulk Diesel Fuel Storage Tank	NA	NA	NA	NA	NA	NA	NA	NA	0.01	0.02
Chemical Releases										
NPTEC	0	1.50	0	1.50	0	1.50	0	1.50	0	10.00
Detonations										
Port Gaston	0.03	0.21	0.13	1.49	0.051	0.085	0.00	0.01	0.00	0.01
NPTEC	0.00	0.21	0.00	1.485	0.00	0.085	0.00	0.010	0.00	0.01
BEEF	0.00	1.8	0.00	1.99	0.00	0.50	0.00	0.04	0.00	0.03
Total by Pollutant	1.10	27.23	1.81	18.84	7.47	52.16	0.31	4.33	1.45	17.68
Total Emissions	**Actual: 12.14 PTE: 120.25**									

(a) For metric tons (mtons), multiply tons by 0.9072
(b) Particulate matter equal to or less than 10 microns in diameter
(c) PTE's include only those facilities that were operational in 2016.
(d) Not applicable: the facility does not emit the specified pollutant(s); therefore, there is no emission limit established in the air permit

Table 4-13. Criteria air pollutants and HAPs released on the NNSS over the past 10 years

	Total Emissions (tons/yr)[(a)]									
Pollutant	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Particulate Matter (PM10)[(b)]	0.54	0.22	0.49	1.09	2.40	6.51	0.45	0.43	0.52	1.10
Carbon Monoxide (CO)	0.51	0.94	0.55	1.33	3.70	2.38	1.54	1.44	1.74	1.81
Nitrogen Oxides (NO_X)	1.21	3.36	2.45	6.09	16.15	10.51	6.38	6.12	7.43	7.47
Sulfur Dioxide (SO_2)	0.01	0.06	0.10	0.36	1.20	1.14	0.23	0.19	0.39	0.31
Volatile Organic Compounds (VOCs)	1.14	0.60	0.71	0.33	1.68	1.08	1.69	1.35	1.69	1.45
Hazardous Air Pollutants (HAPs)[(c)]	0.02	0.09	0.30	0.02	0.04	0.03	0.23	0.03	0.03	0.02

(a) For mtons, multiply tons by 0.9072
(b) Particulate matter equal to or less than 10 microns in diameter
(c) The site-wide PTE for HAPs is 8 tons per individual HAP and 23.3 tons for all HAPs combined

4.2.4 Performance Emission Testing and State Inspection

The current NNSS air permit requires performance emission testing of equipment that vents emissions through stacks (called "point sources"). The tests must be conducted once during the 5-year life of the NNSS air permit for each specified source. Once a source accumulates 100 hours of operation (since issuance of the permit in June 2002), it must be tested within 90 days. Testing is conducted by inserting a probe into the stack while the equipment is operating. Visible emissions readings must also be conducted by a certified evaluator during the tests. No performance emission tests were conducted in 2016. It is anticipated that once the renewed NNSS air permit is issued (see Section 4.2.2), none of the equipment will require performance testing. One state air inspection was conducted in 2016. There were no findings. Following the inspection, copies of generator logbook records were submitted to the state as per their request.

4.2.5 Opacity Readings

Visual opacity readings are conducted in accordance with permit and regulatory requirements. Personnel that take opacity readings are certified semiannually. In 2016, seven employees on the NNSS were certified. Readings were taken for the following NNSS facilities regulated under the NAAQS opacity limit of 20%: Area 1 Concrete Batch Plant, Area 1 Wet Aggregate Plant, Area 6 Storage Silos, and one diesel generator located in Area 23. None of the readings exceeded the 20% limit.

4.2.6 Chemical Releases and Detonations Reporting

The NNSS air permit regulates the release of chemicals at specific locations under three separate "systems": NPTEC in Area 5 (System 29), Site-Wide Releases throughout the NNSS (System 81), and Port Gaston in Area 26 (System 95). The types and amounts of chemicals that may be released vary depending on the system. In 2016, the Chemours chemical test series was conducted at NPTEC. Sixteen small chemical releases were conducted over a 2-day period. The chemicals released were non-regulated; thus, no permit limits were exceeded.

Near-surface explosives detonations can take place at nine locations on the NNSS (BEEF in Area 4; EODU in Area 11; NPTEC in Area 5; Port Gaston in Area 26; HEST in Area 14; Test Cell C, Calico Hills, and ARL in Area 25; and Baker in Area 27). BEEF is permitted to detonate large quantities of explosives (up to 41.5 tons per detonation with a limit of 50.0 tons per 12-month period), while the other locations are limited to much smaller quantities (1 ton per detonation with a limit of 10 tons per 12-month period). Permitted limits exist also for the amounts of criteria air pollutant and HAP emissions generated by the detonations. In 2016, explosives were detonated at BEEF and Port Gaston, and no permit limits were exceeded (see Table 4-12). One unpermitted series of detonations, the Forensics Surface Shots, took place in Area 15. Approval to conduct the detonations was received in advance from the state. Quantities of explosives detonated were small, and emissions were within the limits imposed for the non-BEEF detonation locations.

PM10 monitoring was conducted for each chemical release test and detonation at NPTEC, Port Gaston and the Forensics Surface Shots in 2016. Monitoring was conducted in accordance with the permit and met calibration and performance audit requirements.

In addition to annual reporting, the NNSS air quality operating permit requires the submittal of test plans and final analysis reports to the state for chemical releases or release series and for detonations. For BEEF and for the detonation facilities, quarterly test plans and final reports must be submitted for the types and weights of explosives used and estimated emissions that may be released. Completion reports are submitted at the end of each calendar quarter for all chemical releases and detonations. In 2016, all of the required quarterly reports were submitted prior to the reporting deadline, and to streamline reporting, they were included in the quarterly HAPs reports to NDEP (see Section 4.2.3).

4.2.7 ODS Recordkeeping

At the NNSS, refrigerants containing ODS are mainly used in air conditioning units in vehicles, buildings, refrigerators, drinking water fountains, vending machines, and laboratory equipment. Halon 1211 and 1301, classified as ODS, have been used in the past in fire extinguishers and deluge systems, but all known occurrences of these halons have been removed from the NNSS. ODS recordkeeping requirements applicable to NNSS operations include maintaining evidence of technician certification at all times and for 3 years, recycling/recovery equipment approval, servicing records for appliances containing 22.7 kilograms (50 pounds) or more of refrigerant, and the amount and type of refrigerant sent offsite for reclamation.

4.2.8 Asbestos Abatement

A Notification of Demolition and Renovation Form is submitted to the EPA at least 10 working days prior to the start of a demolition or renovation project if the quantities of asbestos-containing material (ACM) to be removed are estimated to equal or exceed 260 linear feet, 160 square feet, or 35 ft^3. Small asbestos abatement projects are conducted throughout the year consisting of the removal of lesser quantities of ACM within a single facility per project, and a Notification of Demolition and Renovation Form is not required for these projects.

Five Notification of Demolition and Renovation Forms were submitted during 2016. These were for demolition of five trailers in Area 12. Three of the demolition projects were not completed and will be reassessed when funding becomes available. The remaining asbestos abatement activities throughout the NNSS complex were minor in scope, involving the removal of quantities of ACM less than the reporting threshold per facility. ACM was buried in the Area 10 or Area 23 solid waste disposal site as per each project's work plan. Friable materials are segregated in a defined section of the landfill. Asbestos abatement records continued to be maintained as required.

The recordkeeping requirements for asbestos abatement activities include maintaining air and bulk sampling data records, abatement plans, and operations and maintenance activity records for up to 75 years; and maintaining location-specific records of ACM for a minimum of 75 years. Compliance is verified through periodic internal management assessments.

4.2.9 Fugitive Dust Control

The NNSS Class II Air Quality Operating Permit states that the best practical methods should be used to prevent particulate matter from becoming airborne prior to the construction, repair, demolition, or use of unpaved or untreated areas. At the NNSS, the main method of dust control is the use of water sprays. In 2016, field personnel observed operations throughout the NNSS for the occurrence of excessive fugitive dust, and water sprays were used to control dust at sites where trenching and digging activities occurred in Areas 1, 12, and 23.

Off the NNSS, all NNSA/NFO surface-disturbing activities that cover 5 or more acres are regulated by stand-alone Class II Surface Area Disturbance (SAD) permits issued by the state. Current SADs exist for the operation of three Underground Test Area (UGTA) wells on the Nevada Test and Training Range: ER-EC-13, ER-EC-14, and ER-EC-15. No activities occurred at these wells during 2016, and all reporting requirements of the SADs were met.

4.2.10 Environmental Impact

During 2016, NNSS activities produced a total of 12.14 tons of criteria air pollutants and 0.02 tons of HAPs. These small quantities had little, if any, impact on air quality on or around the NNSS. NNSS air pollutant emissions are very low compared to the estimated daily releases from point sources in Clark County, Nevada. For example, the average annual projected emissions of NO_X in Clark County for base year 2002 through projected year 2018 is 37,549 tons per year (Pollack 2007), whereas the estimated annual release from the NNSS in 2016 of 7.47 tons of NO_X represents 0.02% of Clark County's projected annual emissions of this criteria pollutant.

Impacts of the chemical release tests at the NNSS are minimized by controlling the amount and duration of each release. Biological monitoring at NPTEC is performed if there is a risk of significant exposure to downwind plants and animals from the planned tests. To date, chemical releases at NPTEC and other locations have used such small quantities (when dispersed into the air) that downwind test-specific monitoring has not been necessary. No measurable impacts to downwind plants or animals have been observed.

4.3 References

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Chapter 5: Water Monitoring

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This chapter presents the recent results of water monitoring conducted by the U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO) on and adjacent to the Nevada National Security Site (NNSS). NNSA/NFO monitors groundwater to ensure that drinking water for NNSS workers and visitors is safe, that NNSS groundwater is protected from contamination from current activities, and to take corrective actions to protect the public and the environment from areas of known underground radiological contamination resulting from historical nuclear testing. Monitoring is conducted to comply with all applicable state and federal water quality and water protection regulations, U.S. Department of Energy (DOE) directives, and the Federal Facility Agreement and Consent Order (FFACO) between the U.S. Department of Energy, the U.S. Department of Defense, and the State of Nevada (see Table 2-1).

The Nevada State Health Division's Bureau of Health Care Quality and Compliance is allowed access to the NNSS to independently sample onsite water supply wells at its discretion. Monitoring results from the state's independent sampling and analysis are also presented in this chapter, if the state performed sampling during the reporting year.

The Community Environmental Monitoring Program (CEMP), established by NNSA/NFO; and the Nye County Tritium Groundwater Monitoring program, funded through a grant from DOE Environmental Management, perform annual, independent radiological monitoring of water supply systems in communities surrounding the NNSS and emphasize community involvement. The reader is directed to Chapter 7, Sections 7.2 and 7.3 for the presentation of CEMP's and Nye County's groundwater monitoring activities in 2016.

5.1 Radiological Monitoring

Radionuclides (see Glossary, Appendix B) have been detected in the groundwater in some areas of the NNSS as a result of historical underground nuclear tests (UGTs). Between 1951 and 1992, 828 of these tests were conducted, and approximately one-third were detonated near or in the ***saturated zone*** (see Glossary, Appendix B) (NNSA/NFO 2015). The FFACO (as amended) established underground test area (UGTA) corrective action units (CAUs) that geographically group the underground nuclear tests on the NNSS (Figure 5-1). A thorough description of the complex hydrogeological environment in which underground nuclear testing was conducted is presented in *Attachment A: Site Description*, which is included on the compact disc of this report and on the NNSA/NFO web site at http://www.nnss.gov/pages/resources/library/NNSSER.html.

NNSA/NFO is tasked, under the FFACO, with developing UGTA CAU-specific models of groundwater flow and radionuclide transport. These models are used to develop contaminant boundaries within which radiological contaminants are forecasted to exceed the Safe Drinking Water Act (SDWA) limits at any time within a 1,000-year period. The current status of the CAU-specific models of groundwater flow and contaminant transport is discussed in Section 11.1.2 of Chapter 11 of this report. Groundwater sampling and analyses support the development and evaluation of these models and demonstrate that there is no impact to public water sources as a result of underground nuclear testing. Other NNSS wells and surface waters are monitored by NNSA/NFO to demonstrate compliance with state-issued water discharge permits; with DOE Order DOE O 458.1, "Radiation Protection of the Public and the Environment"; with protection of groundwater from ongoing radiological waste disposal activities; and to demonstrate that the onsite drinking water supply is below SDWA radionuclide limits.

The design of the NNSS Integrated Groundwater Sampling Plan (NNSA/NFO 2014), referred to hereafter as the Plan, is presented in the sub-sections below. It is a comprehensive, integrated approach for collecting and analyzing groundwater samples to meet NNSA/NFO's radiological water monitoring objectives associated with underground nuclear testing (see green text box on page 5-3). This chapter presents the most recent tritium analysis results for monitored wells and other water analysis results related to meeting NNSA/NFO's radiological water monitoring objectives.

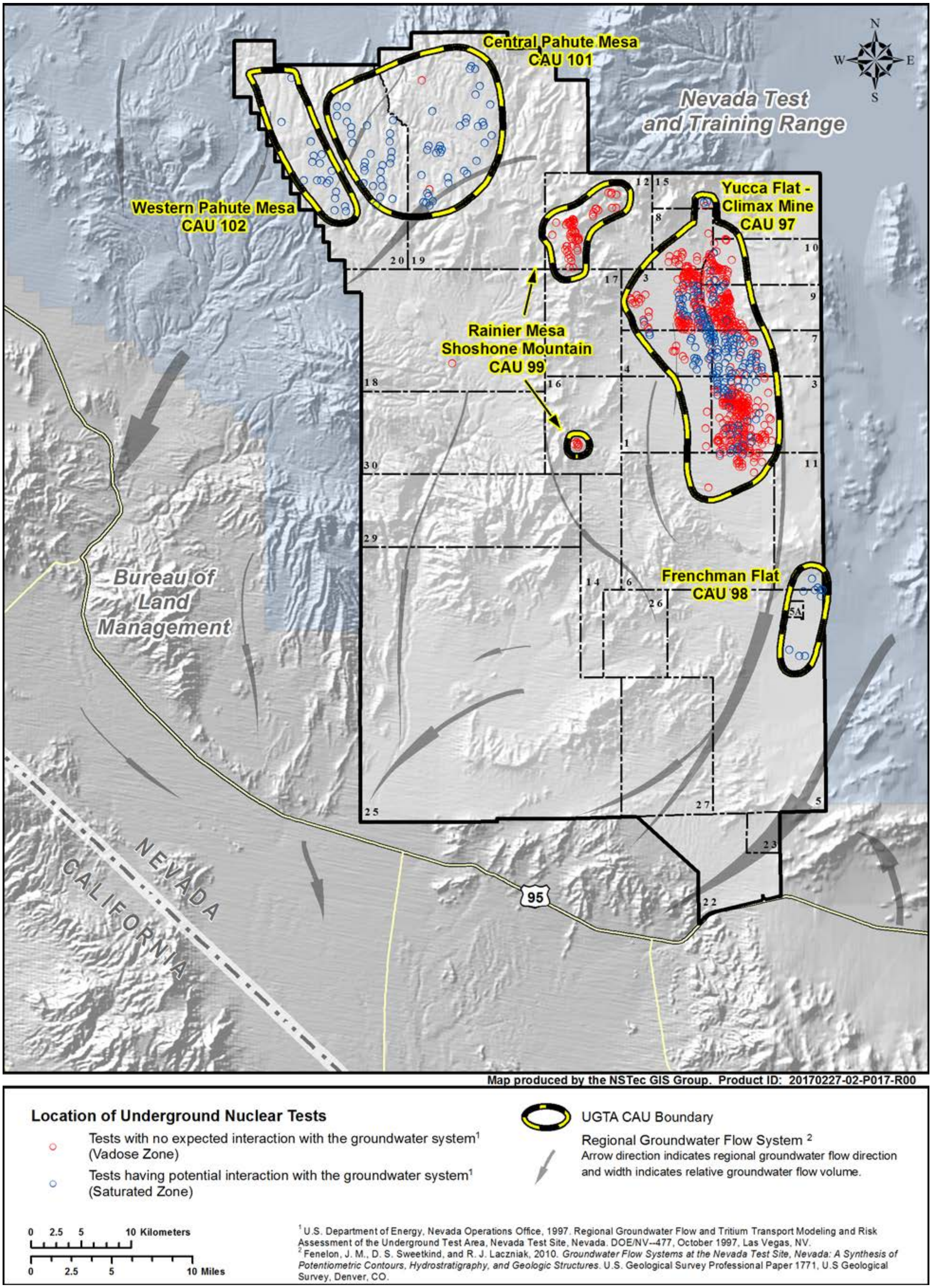

Figure 5-1. Locations of underground nuclear tests and UGTA CAUs on the NNSS

Radiological Water Monitoring Objectives
Provide data to complete corrective actions prescribed under the FFACO to protect the public from groundwater contaminated by historical underground nuclear testing.
Identify and evaluate trends in radionuclide concentrations in water supply wells on the NNSS (referred to as onsite wells).
Determine compliance with the dose limits to the general public set by DOE O 458.1 via the water pathway (see Chapter 9 for estimates of public dose).
Determine compliance with wastewater discharge permit limits for radionuclides at permitted NNSS facilities.
Monitor wells downgradient of an NNSS radioactive waste disposal unit in accordance with a Resource Conservation and Recovery Act (RCRA) permit to ensure wastes do not impact groundwater.

5.1.1 NNSA/NFO Groundwater Sampling Design

The radiological water sampling network consists of 84 sample locations, categorized into seven different well types. Table 5-1 defines each sample source type and the monitoring objectives, analytes, and sample frequency associated with each. Some locations are sampled to meet multiple objectives. The sampling network is shown in Figure 5-2.

The Plan focuses on evaluating the extent and movement of contaminants resulting from underground nuclear testing. Baseline data are established at downgradient locations (see the Regional Groundwater Flow System arrows in Figure 5-2 depicting groundwater flow direction and volume) so that the presence of radioisotopes is known with a high level of certainty well before they reach SDWA limits. Wells upgradient from the UGTA CAUs are not included in the sampling network. Also, no NNSS springs are included in the network. Ten NNSS springs have been monitored periodically and reported in past annual environmental reports. They include Cane, Captain Jack, Cottonwood, Gold Meadows, John’s, Tipipah, Topopah, Tub, Twin, and Whiterock springs; see Figure A-4 of *Attachment A: Site Description* included on the compact disc of this report for the location of NNSS springs and seeps. The groundwater that feeds these onsite springs is locally derived and is not hydrologically connected to the ***aquifers*** (see Glossary, Appendix B) that may be impacted by underground nuclear tests. Detectable man-made radionuclides in onsite springs are from historical atmospheric testing activities, including global radioactive fallout (U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office [NNSA/NSO] 2008).

Table 5-1. Type definitions and objectives for NNSA/NFO radiological water sample locations

Sample Source Type	Definition	Objective	Analytes	Frequency
Characterization	Used for system characterization or model evaluation	• Support development and/or evaluation of flow and transport models • Identify groundwater flow paths • Establish the presence or absence of groundwater contaminants of concern (COCs) and contaminants of potential concern (COPCs) • Estimate travel time of contaminants • To be reclassified and sampled according to its new type when above objectives are met	Specific to UGTA Strategy stage (FFACO, as amended) for each UGTA CAU (may include general chemistry, metals, gamma emitters, age and migration parameters, gross alpha, gross beta, and other radioisotopes)	2–3 years, as needed
Source/Plume	Located within the plume from an underground nuclear test (i.e., test-related contamination present)	• Support development and/or evaluation of flow and transport models • Identify COCs for downgradient wells • Monitor contaminant migration • Monitor natural attenuation of radiological contaminants	Radiological COCs and CAU-specific COPCs (see Table 5-2)	4 years

Table 5-1. Type definitions and objectives for NNSA/NFO radiological water sampling locations (continued)

Sample Source Type	Definition	Objective	Analytes	Frequency[(a)]
Early Detection	Located downgradient of an underground test and no radioisotopes detected above the minimum detection level for standard analysis	• Support development and/or evaluation of flow and transport models • Detect and monitor plume edge	Tritium (^{3}H) (low-level analysis)	2–5 years
Distal	Downgradient of the Early Detection area	• Monitor COC (^{3}H) below SDWA 1,000 pCi/L detection limit • Support development and/or evaluation of flow and transport models	^{3}H (standard analysis)	5 years
Community	Located on Bureau of Land Management (BLM) or private land; used as a water supply source or is near one	• Monitor COC (^{3}H) below SDWA 1,000 pCi/L detection limit	^{3}H (standard analysis)	5 years
NNSS PWS	Permitted water supply well that is part of a state-designated noncommunity public water system (PWS) on the NNSS	• Monitor to demonstrate safety of NNSS drinking water (radiological monitoring is not required by the state for noncommunity PWSs)	^{3}H (standard analysis), gross alpha, gross beta	Quarterly
Compliance	Sampled to comply with specific federal/state regulations or permits	• Determine if radiological COCs are within permit limits	As specified by permit	As specified by permit

(a) The sampling frequency can be as long as every 2–5 years because of known low groundwater velocity and the resulting slow change over time in radionuclide concentrations expected within certain wells.

5.1.1.1 Analytes

An inventory of 43 radionuclides produced by NNSS underground nuclear tests is presented in Finnegan et al. (2016). Many of these radionuclides are relatively immobile because they are bound within the melt glass produced during nuclear detonation or have chemical properties that cause them to bind strongly to the aquifer rock materials. Those radionuclides that are most mobile in groundwater and are produced in high abundance from nuclear testing have the greatest potential for impacting groundwater quality.

A single contaminant of concern (COC) and, at some locations, additional contaminants of potential concern (COPCs) were identified based on the Finnegan et al. (2016) inventory, an understanding of the radionuclide's relative mobility, previous sampling and analysis data, and modeling results (Table 5-2). ***Tritium*** (see Glossary, Appendix B) has been identified as the single COC for all sample locations based on extensive groundwater characterization data from wells throughout each CAU. The Plan therefore prescribes tritium analysis for all sampling locations at frequencies that range from every 2 to 5 years (Table 5-1). NNSS public water system (PWS) wells are sampled quarterly, and Compliance well sampling is consistent with the applicable permit requirements.

Tritium is a radioactive form of hydrogen with a half-life of 12.3 years. The Safe Drinking Water Act (SDWA) limit for tritium in drinking water is 20,000 pCi/L. If an individual were to drink water with this amount of contamination for an entire year, it would produce approximately the same dose of radiation one would get during a single commercial flight between Los Angeles and New York City.

pCi/L [picocurie per liter] is a unit of measure used to express the amount of radioactivity in one liter of a gas or a liquid. A picocurie is one-trillionth of a Curie, and 1 pCi/L is the amount of radioactive material in 1 liter of a gas or liquid that will produce 0.037 disintegrations per second. In the case of tritium, a disintegration is the emission of a beta particle.

For all CAUs except Rainier Mesa/Shoshone Mountain, tritium is the only radionuclide included in the inventory that is known to have exceeded its SDWA maximum contaminant level (MCL) of 20,000 picocuries per liter (pCi/L) in sampling locations away from the nuclear test cavity (NNSA/NFO 2014). Although plutonium (Pu) has been reported above its SDWA MCL of 15 pCi/L in T Tunnel, located in Rainier Mesa (Zavarin 2009), it has not been detected in downgradient wells at concentrations above 10% of its SDWA MCL. Pu has therefore been identified as a COPC for the Rainier Mesa/Shoshone Mountain CAU and is analyzed for in all Characterization and Source/ Plume well samples in that CAU. Similarly, the other CAU-specific COPCs (Table 5-2) may have exceeded their SDWA MCLs in samples collected from the test cavity, but have generally not exceeded 10% of their MCLs in downgradient locations.

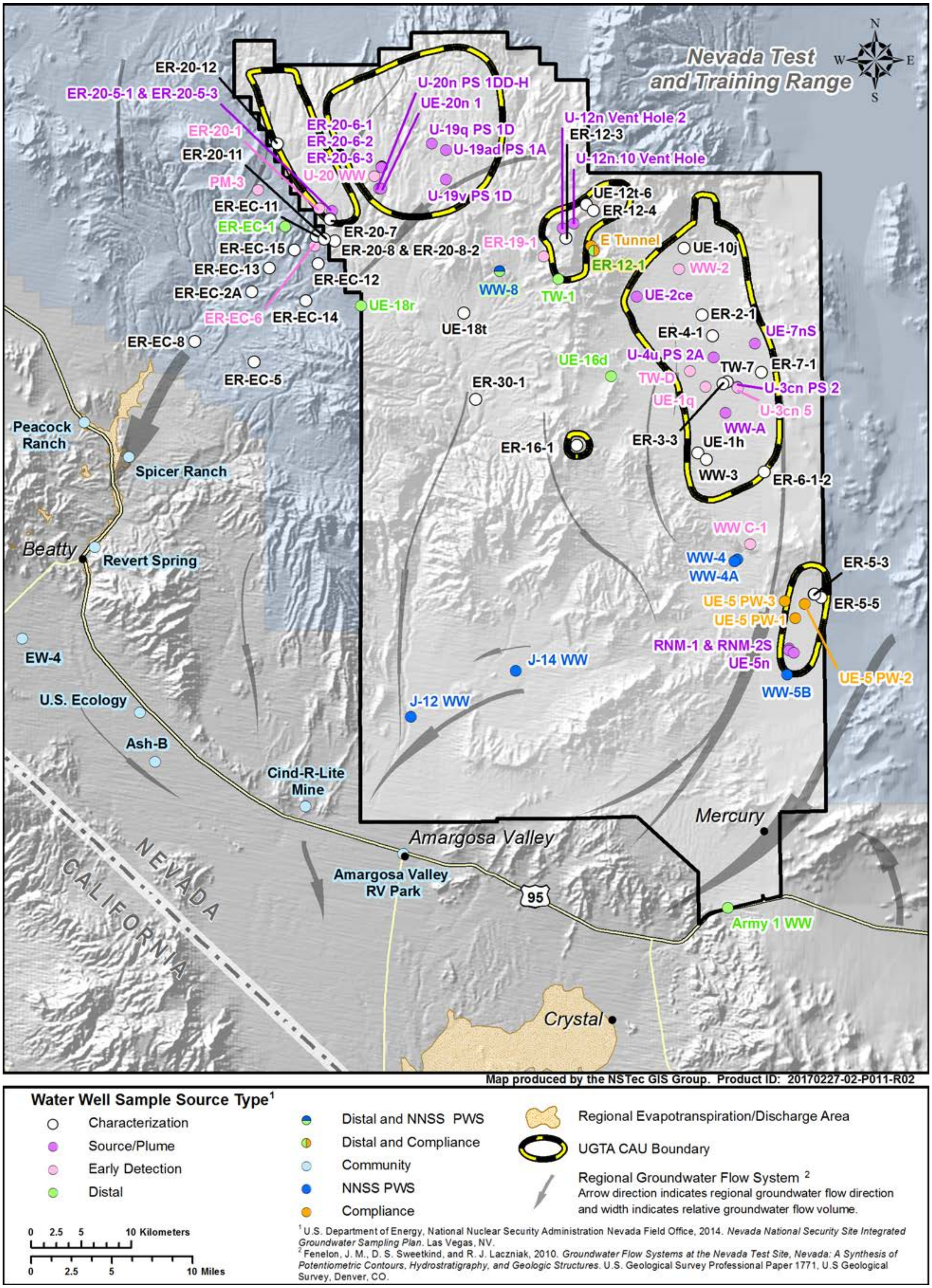

Figure 5-2. NNSA/NFO water sampling network

Table 5-2. CAU-specific COCs and COPCs

CAU	COC(a)	COPC(b)
Frenchman Flat	^{3}H	^{14}C, ^{36}Cl, ^{99}Tc, and ^{129}I
Pahute Mesa	^{3}H	^{14}C, ^{36}Cl, ^{99}Tc, and ^{129}I
Rainier Mesa/Shoshone Mountain	^{3}H	^{14}C, ^{36}Cl, ^{90}Sr, ^{99}Tc, ^{129}I, and Pu
Yucca Flat/Climax Mine	^{3}H	^{14}C, ^{36}Cl, ^{99}Tc, and ^{129}I (and ^{90}Sr and ^{137}Cs in the lower carbonate aquifer samples)

Note: See Table 1-5 of Chapter 1 for a listing of full names and half-lives of radionuclide abbreviations listed.

(a) A radionuclide that has exceeded its SDWA MCL in sampling locations downgradient from a nuclear test cavity.

(b) A radionuclide that has the potential to become a COC based either on historical analytical data and/or on model results. COPCs may have exceeded SDWA MCLs in samples from a nuclear test cavity, but have generally not exceeded 10% of their MCLs in sampling locations downgradient from a test cavity.

Groundwater characterization data have shown that COPCs, if present, are at insignificant levels (i.e., < 0.1% of their MCL) unless tritium is present at concentrations that greatly exceed its 20,000 pCi/L MCL. Therefore, COPCs are only analyzed in Source/Plume wells, where tritium exceeds the detection limit for standard tritium analysis (300 pCi/L). Instrumentation capable of detecting COPCs at levels well below their MCLs are used for their analysis in Source/Plume and Characterization well samples. This ensures that a baseline for COPC levels is established and that they will be detected early. Trends in the COPC data will be evaluated to determine whether a COPC should be reclassified as a COC and monitored in Early Detection wells. Samples collected from Characterization wells are analyzed for many of the immobile radionuclides listed in Finnegan et al. (2016). These radionuclides have not been found near their SDWA MCL in any of the samples, including those collected from underground nuclear test cavities. While not analyzed routinely as part of the Plan, the suite of radionuclides will be periodically expanded for some Source/Plume wells to confirm that they are not present near their MCLs in groundwater in, or downgradient of, the underground nuclear test cavities.

Gross alpha (α) and gross beta (β) radioactivity and gamma spectroscopy analyses have been conducted for some groundwater samples in the past according to a prescribed sampling schedule (see Table 5-1 of National Security Technologies, LLC [NSTec], 2012). During development of the Plan, a decision was made to analyze for gross alpha and gross beta radioactivity and gamma emitters at Characterization wells to establish a baseline. Gross alpha and gross beta radioactivity continue to be monitored for NNSS PWS wells and for certain Compliance water sampling locations, as required. In 2016, water samples from the NNSS PWS wells were also sampled for uranium to establish a baseline.

5.1.1.2 Sample Collection Methods

Water sampling methods are based, in part, on the characteristics and configurations of sample locations. For example, wells with dedicated pumps may be sampled from the associated plumbing (e.g., spigots) at the wellhead, while wells without pumps may be sampled using a wireline bailer or a portable pumping system. The majority of wells sampled are single-zone completion wells where samples are collected from one depth interval. Some wells, however, are multiple-completion wells that are sampled at multiple depths (e.g.,Wells ER-EC-11, -12, -13, -14, and -15). Water samples are generally collected in a manner that ensures they represent ambient formation water following the sampling methods described in standard operating procedures. This may involve purging the well until the stability of certain water quality parameters (e.g., pH, temperature, and electrical conductivity) is achieved. Stabilization of these water quality parameters indicates that formation water is being sampled instead of stagnant water from within and surrounding the wellbore. In some cases, samples are collected using a depth-discrete bailer. While these samples may not be as representative of ambient formation water as samples collected using a pump, they are considered to be adequate for certain sampling objectives (e.g., sufficient to demonstrate early detection of tritium at levels well below the 20,000 pCi/L MCL). Water sampling methods also depend on the suite of analytes and the hydrogeologic system being sampled. Determination of cost-effective groundwater monitoring technologies is an active area of study for UGTA. These studies include identifying mobile sampling technologies capable of sampling the deep (up to 4,100 ft) wells included in the Plan.

5.1.1.3 Detection Limits

Samples collected from all Early Detection wells and from some Characterization wells, are enriched before being analyzed for tritium. These wells are expected to have tritium levels less than 300 pCi/L, which is the approximate ***minimum detectable concentration (MDC)*** (see Glossary, Appendix B) using a standard (or un-enriched) analysis method. The enrichment process (DOE 1997), referred to throughout this report as low-level tritium analysis, concentrates tritium in a sample to provide lower MDCs, which range from approximately 2 to 40 pCi/L depending on the laboratory performing the enrichment process. For samples with expected levels of tritium above the laboratory's standard detection capability, tritium enrichment is not performed. The MDCs for standard tritium analyses (approximately 300 pCi/L) are well below the U.S. Environmental Protection Agency (EPA) SDWA-required detection limit of 1,000 pCi/L for tritium. Standard methods are used for analysis of COPCs and are performed by State of Nevada certified commercial laboratories. The MDCs must be at or below the SDWA MCL. The MDCs for gross alpha and beta radioactivity are 2 and 4 pCi/L, respectively, and satisfy their EPA SDWA required detection limits of 3 and 4 pCi/L, respectively.

> The standard tritium analysis method can detect tritium at levels ≥ 300 pCi/L.
>
> The low-level tritium analysis method, which concentrates tritium in a sample through an enrichment process, can detect tritium at levels of 2–40 pCi/L.
>
> Groundwater samples collected at all Early Detection wells are analyzed using the low-level tritium analysis method.

Highly sensitive instrumentation is used by Lawrence Livermore National Laboratory (LLNL) to analyze tritium concentrations in many Characterization and Early Detection wells when standard methods are not sufficient (i.e., tritium is expected to be at levels less than the 300 pCi/L MDC for the standard method). LLNL's instrumentation is capable of detecting tritium at concentrations less than 1 pCi/L. Similarly, LLNL uses highly sensitive methods for COPC analyses for samples from Source/Plume and Characterization wells. These methods are capable of measuring natural levels of some COPCs (^{14}C and ^{36}Cl) in the groundwater.

Analytical methods routinely include quality control samples such as duplicates, blanks, and spikes. Chapter 14 discusses in more detail the quality assurance and control procedures used for sampling and analyzing groundwater.

5.1.2 Presentation of Water Sampling Data

The maximum tritium concentration that has been measured in each well in the Plan's sampling network is used to classify each well into one of four concentration levels relative to its percentage of the 20,000 pCi/L SDWA MCL (Table 5-3). Figure 5-3 depicts spatially the levels of tritium among all sampling locations using color codes for these four categories of tritium concentration levels. The lowest concentration category, less than 5% of the SDWA MCL, is coded blue on Figure 5-3 and includes wells in which tritium has not been detected at all, such as the Community sampling locations. The nineteen wells that currently exceed the SDWA MCL (coded red on Figure 5-3) are all located on the NNSS and are either Source/Plume or Characterization wells.

Table 5-3. Tritium concentration categories

Tritium Concentration (X) in pCi/L	Percent of SDWA MCL
X < 1,000	< 5[(a)]
1,000 < X < 10,000	5–50
10,000 < X < 20,000	50–100
X > 20,000	> 100 (Exceeds SDWA MCL)

(a) includes samples in which tritium is undetectable

Table 5-4 presents the maximum tritium concentration data used to create the color-coded categories shown in Figure 5-3. Table 5-4 groups the sampling location data by CAU and then by sample location type. When tritium was not detected, the value is reported as less than the sample's MDC (i.e., <1.5 or <270 when the sample's MDC is either 1.5 or 270 pCi/L, respectively). For wells at which multiple samples were collected and analyzed during a single year, Table 5-4 presents the result for the sample that had the highest tritium concentration. Similarly, for wells that are sampled at multiple depths during a single year, Table 5-4 presents the result for the depth sample that had the highest tritium. The results of analyses for those radionuclides identified as COPCs (Table 5-2) are not

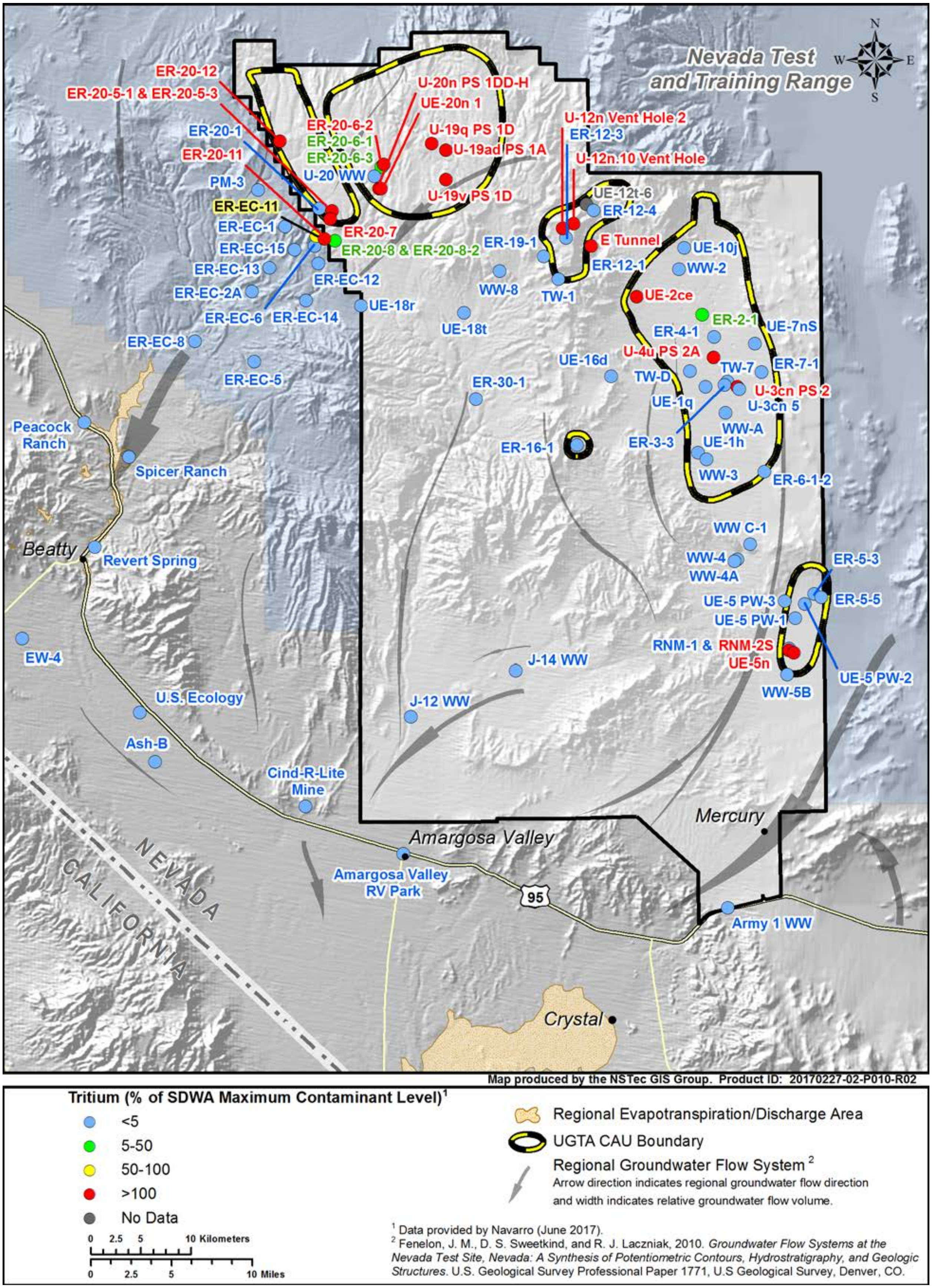

Figure 5-3. Current (2016) classification of tritium concentrations at NNSA/NFO sampling locations

tabulated in this report but can be acquired upon request from NNSA/NFO. The tritium, gross alpha, and gross beta levels for water samples collected and analyzed in 2016 for the NNSS PWS and Compliance sampling locations are presented in Table 5-5. Not shown in Table 5-5 are the uranium analysis results for each quarterly water sample of the NNSS PWS wells. Uranium was detected at concentrations that ranged from 0.38 to 6.9 µg/L.

Table 5-4. Tritium concentrations for the most recent sampling events at wells in the NNSA/NFO sampling network. For multiple samples within the same year, the higher value is presented.

Sampling Locations	Land Management or NNSS Operations Area	Sample Year	Maximum Tritium Concentration (pCi/L)[a]
Yellow shaded entries indicate tritium levels that exceed the SDWA MCL of 20,000 pCi/L			
	Frenchman Flat		
Characterization Wells			
ER-5-3[b]	Area 5	2016	<3.73
ER-5-3-2[b]	Area 5	2016	<3.71
ER-5-5[b]	Area 5	2016	<3.65
Source/Plume Wells			
RNM-1	Area 5	2014	620
RNM-2S[b]	Area 5	2016	76,000
UE-5n[b]	Area 5	2016	135,000
Inactive Wells			
ER-11-2[b]	Area 5	2016	<2.99[c]
	Pahute Mesa (Central and Western)		
Characterization Wells			
ER-20-7	Area 20	2014	15,600,000
ER-20-8	Area 20	2015	4,600
ER-20-8-2	Area 20	2014	2,670
ER-20-11	Area 20	2013	191,000
ER-20-12	Area 20	2016	39,200
ER-EC-2A	NTTR	2016	< 2.90
ER-EC-5	NTTR	2003	< 320[d]
ER-EC-8	NTTR	2016	< 4.52[e]
ER-EC-11	NTTR	2014	16,100
ER-EC-12	NTTR	2016	<2.99[f]
ER-EC-13	NTTR	2013	< 3.0
ER-EC-14	NTTR	2014	< 2.2
ER-EC-15	NTTR	2014	< 2.1
Source/Plume Wells			
ER-20-5-1	Area 20	2015	24,800,000
ER-20-5-3	Area 20	2015	84,000
ER-20-6-1	Area 20	1998	3,200
ER-20-6-2	Area 20	1997	71,000
ER-20-6-3	Area 20	1998	1,110
U-19ad PS 1A	Area 19	2008	12,900,000
U-19q PS 1D	Area 19	2003	11,000,000
U-19v PS 1D	Area 19	2009	84,900,000
U-20n PS 1DD-H	Area 20	2005	33,300,000
UE-20n 1	Area 20	2012	55,500,000
Early Detection Wells			
ER-20-1	Area 20	2015	< 2.2
PM-3	NTTR	2016	194
ER-EC-6	NTTR	2015	5.2
U-20 WW	Area 20	1999	< 29
Distal Wells/Locations			
ER-EC-1	NTTR	2016	< 2.87
UE-18r	Area 18	2007	< 22
Community Wells/Springs			
Amargosa Valley RV Park	BLM	2012	< 24
Ash B, Piezometer 1	BLM	2014	< 183
Ash B, Piezometer 2	BLM	2014	< 177

Table 5-4 (continued). Tritium concentrations for the most recent sampling events at wells in the NNSA/NFO sampling network. For multiple samples within the same year, the higher value is presented.

Sampling Location	Land Management or NNSS Operations Area	Sample Year	Maximum Tritium Concentration (pCi/L)
Yellow shaded entries indicate tritium levels that exceed the SDWA MCL of 20,000 pCi/L			
Community Wells/Springs (continued)			
Cind-R-Lite Mine	BLM	2012	< 24
EW-4	Private land	2011	< 30
Peacock Ranch	Private land	2012	< 21
Revert Spring	Private land	2012	< 22
Spicer Ranch	Private land	2012	< 21
U.S. Ecology	BLM	2012	< 22
Inactive Wells			
U-20AA PS1D	Area 20	2016	29,100,000
Rainier Mesa/Shoshone Mountain			
Characterization Wells			
ER-12-3	Area 12	2016	27.3
ER-12-4	Area 12	2016	7.62
ER-16-1	Area 16	2008	< 340[d]
ER-30-1	Area 30	1996	< 215[d]
UE-12t-6	Area 12	Not yet sampled	NA[g]
UE-18t	Area 18	2016	<3.07
Source/Plume Wells			
U-12n.10 Vent Hole	Area 12	2008	6,260,000
U-12n Vent Hole 2	Area 12	2011	1,030,000
Early Detection Wells			
ER-19-1	Area 19	2016	3.31[h]
Distal Wells			
ER-12-1[i]	Area 12	2013	< 366
TW-1	Area 17	2013	< 22
UE-16d	Area 16	2016	< 180
WW-8[j]	Area 18	2016	< 236
Inactive Sampling Locations			
E Tunnel discharge	Area 12	2016	313,000
Yucca Flat/Climax Mine			
Characterization Wells			
ER-2-1	Area 2	2015	1,010
ER-3-3	Area 3	2016	<300
ER-4-1	Area 4	2016	<2.16[k]
ER-6-1-2	Area 6	2004	< 370[d]
ER-7-1	Area 7	2014	< 3.8
TW-7	Area 7	2015	< 2.5
UE-1h	Area 1	2014	< 2.0
UE-10j	Area 8	1997	< 210[d]
WW-3	Area 3	2015	6.3
Source/Plume Wells			
U-3cn PS 2	Area 3	2007	7,680,000
U-4u PS 2A	Area 4	2008	24,100,000
UE-2ce	Area 2	2016	144,000
UE-7nS	Area 7	2015	53
WW-A	Area 3	2012	355
Early Detection Wells			
TW-D	Area 4	2013	< 27
U-3cn 5	Area 3	2011	< 6.5
UE-1q	Area 1	2013	< 26
WW C-1	Area 6	2012	< 27
WW-2	Area 2	2015	< 2.2

Table 5-4 (continued). Tritium concentrations for the most recent sampling events at wells in the NNSA/NFO sampling network. For multiple samples within the same year, the higher value is presented.

Sampling Location	Land Management or NNSS Operations Area	Sample Year	Maximum Tritium Concentration (pCi/L)
Yellow shaded entries indicate tritium levels that exceed the SDWA MCL of 20,000 pCi/L			
Yucca Flat/Climax Mine (continued)			
Distal Wells			
Army 1 WW	Area 22	2015	< 229
Inactive Wells			
ER-2-2	Area 2	2016	13.3[l]

(a) Concentrations presented as less than (<) a number, indicate that tritium levels are less than its sample-specific MDC shown. When the results of multiple samples are below the MDC, the lowest MDC is reported.
(b) Well included in the Frenchman Flat Post-Closure Monitoring Network (see Section 11.1.2 of Chapter 11)
(c) Reported value (< 2.99 pCi/L) is for a second sample collected. The original ER-11-2 sample result (17.48 pCi/L) was reported as anomalous due to suspected contamination during collection, handling, or analysis.
(d) The standard tritium analysis method was used (see Section 5.1.1.3). Prior to 2013, the low-level tritium analysis method, resulting in lower MDCs, was not routinely used for analyses of all Characterization well samples.
(e) The reported value (< 4.52 pCi/L) is for the regular field sample. In the ER-EC-8 duplicate sample, tritium was detected at 10.8 pCi/L, but it is expected to be a false positive resulting from contamination during collection, handling, or analysis. The laboratory is reanalyzing the samples.
(f) This 2016 result (< 2.99 pCi/L) is associated with the shallow sampling interval for ER-EC-12. In 2012, samples collected from a deep interval of this well had a detectable tritium level of 4.2 pCi/L.
(g) NA = not applicable.
(h) The reported value (3.31 pCi/L) is only slightly greater than the analytical detection limit (3.01 pCi/L) and is considered highly uncertain (measurement error is 1.98 pCi/L). It is likely that no tritium is present in well ER-19-1.
(i) ER-12-1 is also a Compliance well (see Table 5-5).
(j) WW-8 is also a NNSS PWS well (see Table 5-5).
(k) The reported value (<2.16 pCi/L) is for a sample collected from the regional carbonate aquifer (see discussion in Section 5.1.3.1).
(l) Reported by the commercial analytical laboratory as an estimate; for sample collected from the regional carbonate aquifer (see discussion in Section 5.1.3.8).

Table 5-5. Sample analysis results from NNSS PWS wells and Compliance wells/surface waters

Sampling Location	NNSS Operations Area	Date Sampled	Concentration (pCi/L)[a]		
			^3H	α	β
NNSS PWS Wells					
J-12 WW	Area 25	1/26/16	<177	<1.5	<1.4
		4/18/16	<111	1.9	4.8
		7/26/16	<186	2.5	3.9
		10/25/16	<268	<1.8	3.3
J-14 WW	Area 25	1/26/16	<180	3.8	10.6
		4/19/16	<107	<3.0	7.9
		4/19/16 FD	<107	3.1	7.8
		7/26/16	<192	5.1	7.1
		10/25/16	<267	5.5	6.1
WW-4	Area 6	1/26/16	<180	7.6	6.8
		4/19/16	<109	9.7	4.5
		7/26/16	<197	8.6	5.1
		7/26/16 FD	<194	7.6	4.8
		10/25/16	<236	7.4	5.9
WW-4A	Area 6	1/26/16	<179	13.1	7.0
		4/19/16	<108	7.9	3.9
		7/26/16	<194	10.0	3.6
		10/25/16	<235	9.5	5.1

Table 5-5. Sample analysis results from NNSS PWS wells and Compliance wells/surface waters (continued)

Sampling Location	NNSS Operations Area	Date Sampled	Concentration (pCi/L)[(a)] ^3H	α	β
WW-5B	Area 5	1/26/16	<186	6.1	11.8
		1/26/16 FD	<178	4.0	11.4
		4/19/16	<106	5.1	8.9
		7/26/16	<192	5.8	8.0
		10/25/16	<236	3.3	7.4
WW-8	Area 18	1/26/16	<177	<2.0	2.2
		4/19/16	<110	<1.4	1.5
		7/25/16	<196	1.2	2.4
		10/25/16	<235	1.7	2.1
		10/25/16 FD	<236	<1.8	2.2
Compliance Wells/Surface Waters					
UE-5 PW-1	Area 5	3/15/16	<253	NA	NA
		3/15/16 FD	<248	NA	NA
		3/15/16 FD	<255	NA	NA
		8/16/16	<251	NA	NA
		8/16/16 FD	<223	NA	NA
		8/16/16 FD	<224	NA	NA
UE-5 PW-2	Area 5	3/15/16	<253	NA	NA
		3/15/16 FD	<250	NA	NA
		3/15/16 FD	<253	NA	NA
		8/17/16	<252	NA	NA
		8/17/16 FD	<221	NA	NA
		8/17/16 FD	<216	NA	NA
UE-5 PW-3	Area 5	3/15/16	<251	NA	NA
		3/15/16 FD	<248	NA	NA
		3/15/16 FD	<253	NA	NA
		8/16/16	<254	NA	NA
		8/16/16 FD	<221	NA	NA
		8/16/16 FD	<218	NA	NA
ER-12-1[(d)]	Area 12	4/15/15	<348	13.9	6.9
		4/15/15 FD	<348	14.4	7.1
E Tunnel Waste Water Disposal System	Area 12	10/18/16	331,000	8.8	18.7
		10/18/16 FD	329,000	11.7	11.9

(a) Concentrations presented as less than (<) a number, indicate that tritium levels are less than its sample-specific MDC shown.
(b) FD = field duplicate sample.
(c) NA = not applicable, analysis was not performed.
(d) ER-12-1 is sampled every 24 months; it was not sampled in 2016.

5.1.3 Discussion of 2016 Sample Results

The following subsections discuss the analytical results for the seven well types that comprise the radiological water sampling network in the Plan. In addition, results are presented for samples collected from wells and/or tunnel discharges that are of interest to UGTA, but which are not in the Plan (i.e., Inactive Wells/Sampling Locations; see Section 5.1.3.8). As illustrated in Figure 5-2, all Characterization, Source/Plume, Early Detection, Distal, NNSS PWS, and Compliance wells are located on government-owned property. All Community wells or springs are located on BLM or private land. As reflected in Table 5-4 and presented in the sections below, no test-related radionuclides have been detected in the Distal or Community wells. Consistent with the definition of Early Detection wells (tritium levels are less than 300 pCi/L), low concentrations of tritium at a few locations have been detected in these wells. Sampling results from PWS wells located on the NNSS indicate that water sources used by NNSS personnel are not affected by underground nuclear tests. In addition, all regulatory requirements associated with the Compliance well samples were satisfied.

5.1.3.1 Characterization Wells

Thirty-one Characterization wells are currently included in the sampling network including one new well in the Western Pahute Mesa CAU and two new wells in the Yucca Flat/Climax Mine CAU. Characterization wells are either new wells, or wells that require additional radionuclide data to establish a baseline and/or to ensure that the current list of COCs and COPCs (Table 5-2) is accurate for the CAU. Once a baseline has been developed, each Characterization well will be reclassified and sampled according to its new type (Source/Plume, Early Detection, Distal, or Community). In 2016, NNSA/NFO sampled a total of six Characterization wells.

Frenchman Flat CAU - Three Characterization wells are present in this CAU and all were sampled as part of post-closure monitoring (see Section 11.1.2 of Chapter 11) in 2016. No tritium was detected in any of the samples (Table 5-4). ER-5-3 is located near five UGTs in northern Frenchman Flat. ER-5-3-2 is located in Frenchman Flat but was initially selected to monitor potential radionuclide transport out of the Yucca Flat basin through the regional lower carbonate aquifer. It is now used as a monitoring well for the lower carbonate aquifer in this CAU. The third Characterization well in this CAU, ER-5-5, was drilled in 2012 to evaluate the Phase II flow and contaminant transport models. Although low-level tritium was detected in ER-5-5 in 2013 (1.1 pCi/L) as forecasted by the models (Navarro Nevada Environmental Services, LLC, 2010), no tritium was detected in 2016 at the slightly greater detection limits (Table 5-4).

Pahute Mesa CAUs - Thirteen Characterization wells are associated with the Central and Western Pahute Mesa CAUs. One new well, ER-20-12, was drilled in 2015 and 2016. Four Characterization wells were sampled in 2016 (ER-20-12, ER-EC-2A, ER-EC-8, and ER-EC-12; Table 5-4). To date, tritium has been detected in a total of seven Characterization wells in this CAU (ER-20-7, ER-20-8, ER-20-8-2, ER-20-11, ER-20-12, ER-EC-11, and ER-EC-12 [see footnote f of Table 5-4]).

> Tritium was detected in Well ER-EC-11, a Characterization well in the Pahute Mesa CAUs, in 2009 at 10,600 pCi/L. This was the first time that a radionuclide from NNSS UGTs had been detected in groundwater beyond NNSS boundaries. In 2014, it was detected at 16,100 pCi/L. This concentration is below the allowable drinking water limit of 20,000 pCi/L set by the EPA.

The highest tritium concentration among the Characterization wells is at Well ER-20-7, sampled in 2014 (15,600,000 pCi/L; Table 5-4). This well is located 960 meters (m) (3,150 feet [ft]) and 2,100 m (6,890 ft) from the detonation points for the Tybo and Benham UGTs, respectively. The tritium concentration in ER-20-7 decreased from 19,100,000 pCi/L, as measured in 2010. This decrease is primarily a result of tritium decay over the 4-year time period but also indicates some tritium movement away from the well. Tritium in ER-20-7, ER-20-11, ER-EC-11, ER-20-8, and ER-20-8-2 (Table 5-4) is believed to represent a downgradient extension of the Benham-Tybo contaminant plume (see Section 11.1.1.2). For wells ER-20-8 and ER-20-8-2, tritium concentrations increased from their earlier reported values: from 3,020 pCi/L in 2011 to 4,590 pCi/L in 2015 for ER-20-8 and from 1,280 pCi/L in 2009 to 2,670 pCi/L in 2014 for ER-20-8-2.

ER-20-12, in the far northwestern portion of the NNSS, was drilled to a total depth of 1,385 m (4,543 ft) below ground surface (bgs) to evaluate the source of tritium observed at PM-3. ER-20-12 is located approximately 2.3 kilometers (km) (1.4 miles [mi]) south–southwest of the Handley UGT and approximately 5.1 km (3.2 mi) north–northeast of PM-3. It consists of the main borehole, which accesses a deep aquifer, along with four ***piezometers*** (see Glossary, Appendix B) that access four additional depth intervals. Four aquifers can be accessed from this well (two piezometers access the same aquifer). In 2016, samples were collected from all piezometers using a depth-discrete bailer and from the main completion borehole using a depth-discrete bailer and a pump. The deepest piezometer (988 to 1,135 m [3,243 to 3,725 ft] bgs) was also sampled in 2016 using a pump. The tritium concentrations were higher in the bailed sample (19,800 pCi/L) than in the pumped samples (18,600 and 18,900 pCi/L) from this piezometer. The maximum tritium concentration, 39,200 pCi/L (Table 5-4), was measured in a sample collected using a wireline bailer at a depth of 890 m (2,920 feet) bgs. The maximum tritium concentration observed in pumped samples was 34,000 pCi/L. This sample was collected from the main well at a depth interval of 1,194 to 1,385 m (3,916 to 4,543 ft) bgs. The depth of the Handley UGT detonation point was 1,209 m (3,967 ft) bgs.

The shallow interval of well ER-EC-12 was sampled in 2016 and no tritium was detected above the 2.99 pCi/L detection limit (Table 5-4). This is consistent with the 2011 sample from this interval. In 2012, a deeper interval was sampled and had a very low reported concentration of tritium (4.2 pCi/L; footnote f of Table 5-4). Additional sampling and analyses are needed to confirm this marginally measureable amount of tritium in ER-EC-12. Sampling of the deeper interval is planned for 2018.

Well ER-EC-2A was sampled in 2016, and no tritium was observed above the 2.9 pCi/L detection limit (Table 5-4). This well has been sampled four times (in 2000, 2003, 2010, and 2016), and sufficient data are available to recategorize it as an Early Detection well.

ER-EC-8 was sampled in 2016, and tritium was reported by the commercial laboratory in the duplicate sample (10.9 pCi/L) but not in the regular field sample (<4.52 pCi/L). No tritium was detected in the ER-EC-8 sample analyzed by LLNL (<0.4 pCi/L), which indicates that the tritium detected in the field duplicate sample is not likely accurate. These samples are presently being reanalyzed by the commercial laboratory. The Characterization wells within the Pahute Mesa CAUs in which tritium has not been detected will be categorized as Early Detection or Distal wells depending on their proximity to the UGTs and Source/Plume wells after characterization is complete.

Rainier Mesa/Shoshone Mountain CAU - Six Characterization wells are located within this CAU (Table 5-4) and three (ER-12-3, ER-12-4, and UE-18t) were sampled in 2016. Tritium was detected at 27.3 pCi/L and 7.62 pCi/L in the 2016 ER-12-3 and ER-12-4 samples, respectively (Table 5-4). In 2015, ER-12-3 and ER-12-4 main boreholes were sampled, and in 2016 the piezometers were sampled for the first time. The ER-12-3 and ER-12-4 piezometers monitor tritium migration in the perched water system near N and T Tunnels, respectively. The main completions, on the other hand, monitor potential tritium migration in the deeper carbonate aquifer.

While tritium at UE-18t had been reported at 144 pCi/L in 1999, no tritium was detected above the 3.07 pCi/L detection limit in 2016 samples. The most recent tritium concentrations for ER-16-1 and ER-30-1 from 2008 and 1996, respectively, are below sample-specific MDCs using the standard tritium analysis method (Table 5-4). These locations are planned for sampling in 2017 (ER-30-1) and 2018 (ER-16-1). Sampling priorities were placed on locations closer to UGTs, those not previously sampled, and those with anomalous tritium results (i.e., UE-18t). UE-12t-6 has yet to be sampled under the Plan. This well requires significant road construction before sampling can take place. The Characterization wells will likely be re-categorized as Early Detection or Distal wells depending on their levels of tritium and relative proximity to UGTs after characterization is complete.

Yucca Flat/Climax Mine CAU - Nine Characterization wells are located within this CAU, including two recently drilled wells, ER-3-3 and ER-4-1. Only the new wells were sampled in 2016 (Table 5 4). ER-3-3 was drilled to investigate contaminant migration near the Wagtail UGT, which was detonated at a depth of 750 m (2,459 ft), and ER-4-1 was drilled to investigate contaminant migration near the Strait UGT, which was detonated at a depth of 782 m (2,567 ft) (NNSA/NFO 2015). The primary purpose for these wells is to evaluate and monitor radionuclide contamination in the regional carbonate aquifer near UGT cavities that potentially reached this aquifer. The regional carbonate aquifer is deeper than 850 m (2,800 ft) bgs at these well locations. ER-3-3 accesses two depths that sample separate aquifers: a shallow volcanic rock aquifer and the deeper regional carbonate aquifer. No tritium was detected in samples collected from either depth. Samples from ER-4-1 in 2016 were collected from the open borehole before well casing and piezometers were installed. No tritium was observed above the 2.16 pCi/L detection limit in a sample collected from the regional carbonate aquifer (Table 5-4). The maximum tritium level reported was 59,600 pCi/L in samples collected from the shallow volcanic rock aquifer at a depth of 539 m (1,768 ft). This high concentration is anticipated because of its close proximity to the UGT cavity. The tritium sample associated with the regional carbonate aquifer is reported in Table 5-4 because this is the aquifer that will be routinely sampled by ER-4-1 in the future in support of the Plan.

The tritium concentration was reported as 1,010 pCi/L at ER-2-1 in 2015, which is an increase from the reported 228 pCi/L value reported in 2003. This well is located within 1 mile of 62 nuclear tests, 19 of which are near or below the ***water table*** (see Glossary, Appendix B). Five of the tests that were below the water table are within 457 m (1,500 ft) of ER-2-1 (Elliott and Fenelon 2010). The low concentration of tritium (6.3 pCi/L) detected in WW-3 in 2015 is thought to result from seepage from an adjacent surface-water pond rather than from an underground nuclear test. All other Characterization wells in this CAU have undetectable tritium, some using standard analysis and some using low-level (Table 5-4). The low-level tritium analysis method will be used in the future for all Characterization wells in this CAU to verify the presence or absence of tritium at the lower MDC.

ER-6-1-2 and UE-10j are scheduled for sampling in fiscal year 2017. The Characterization wells will likely be re-categorized as Source/Plume, Early Detection, or Distal wells depending on the presence/absence of tritium and their relative proximity to the UGTs after characterization is complete.

5.1.3.2 Source/Plume Wells

Twenty Source/Plume wells are included in the sampling network. They have detectable radionuclides from NNSS underground nuclear testing and vary in location from within a test cavity where radionuclide concentrations are high, to downgradient of the detonation, where radionuclide concentrations can be relatively low in comparison to SDWA MCLs. With the exception of Source/Plume wells sampled in Frenchman Flat as part of post-closure monitoring, samples are collected every 4 years (three samples per one tritium half-life). All Frenchman Flat post-closure monitoring wells will be sampled annually over the next 5 years. All Source/Plume wells are analyzed for tritium and CAU-specific COPCs (Table 5-2). Two Source/Plume wells in the Frenchman Flat CAU and one in the Yucca Flat/Climax Mine CAU were sampled in 2016.

Frenchman Flat CAU - Three Source/Plume wells are located in this CAU, and two were sampled in 2016 as part of post-closure monitoring (see Section 11.1.2 of Chapter 11). Both wells exceeded the 20,000 pCi/L SDWA MCL for tritium (Table 5-4; Figure 5-3). The tritium concentrations in the 2016 samples were lower than the 2014 values of 77,000 and 153,000 pCi/L for RNM-2S and UE-5n, respectively. None of the COPCs were detected in the 2016 water samples. RNM-1 accesses the explosion region of the Cambric UGT (Stoller-Navarro Joint Venture [SNJV] 2005). As a result of extensive pumping of RNM-2S from 1975 to 1991, the tritium in RNM-1 groundwater no longer exceeds SDWA MCLs; therefore, this well is not included in the network of Frenchman Flat post-closure monitoring wells.

Pahute Mesa CAUs - Ten Source/Plume wells, associated with six different UGTs, are located within the Central and Western Pahute Mesa CAUs (Table 5-4). None of these wells were sampled in 2016. The groundwater in all but two wells (ER-20-6-1 and ER-20-6-3) exceed the tritium MCL (Table 5-4; Figure 5-3). A few radionuclides (^{90}Sr, ^{129}I, ^{137}Cs, and Pu) exceed their SDWA MCLs (8, 200, 1, and 15 pCi/L, respectively) in samples from wells drilled directly into a test cavity (U-19ad PS 1A, U-19v PS 1D, and U-20n PS 1DD-H). They have not, however, exceeded their MCLs in wells located away from the test cavity, even where the wells are within 300 m of the cavity (U-19q PS 1D and UE-20n 1) and when high levels of tritium were detected (Table 5-4). In samples from U-19q PS 1D and UE-20n 1, only ^{14}C was found at levels ≥10% of its SDWA MCL of 2,000 pCi/L. The maximum tritium concentration in well ER-20-5-3 decreased from 96,200 pCi/L in 2011 to 84,000 pCi/L in 2015. This decrease in tritium concentration is primarily a result of decay. The maximum tritium concentration in Well ER-20-5-1 decreased from 30,100,000 pCi/L in 2011 to 24,800,000 pCi/L in 2015. The ^{129}I activity (0.195 pCi/L) is ≥10% of its SDWA MCL for well ER-20-5-1; the ^{129}I activity has remained nearly constant (within measurement uncertainty) from 0.192 pCi/L in 2004 to 0.193 pCi/L in 2011 to 0.195 pCi/L in 2015. No other radionuclide exceeded ≥10% of its SDWA MCL in the ER-20-5-1 and ER-20-5-3 samples collected in 2015.

Rainier Mesa/Shoshone Mountain CAU - Two Source/Plume locations are monitored within the Rainier Mesa/Shoshone Mountain CAU, but were not sampled in 2016 (Table 5-4). They are two historical N Tunnel vent holes. The N Tunnel complex was sealed in 1994 and became flooded with groundwater, which is sampled through the vent holes to monitor radionuclides within the tunnel complex. While tritium was observed above the MCL in these vent holes (Table 5-4), no other radionuclides were observed above their MCLs. In the U-12n.10 Vent Hole, ^{36}Cl, ^{129}I, and Pu are within 10% of their SDWA MCLs. The N Tunnel vent holes are scheduled for sampling in 2017.

Yucca Flat/Climax Mine CAU - Five Source/Plume wells are located within the Yucca Flat/Climax Mine CAU (Table 5-4). One Source/Plume well (UE-2ce) was sampled in 2016 and the tritium concentration was reported as 144,000 pCi/L, which was a decrease from the 267,000 pCi/L concentration reported in 2008. This decrease in tritium concentration is primarily a result of decay. UE-2ce is located within 200 m (655 ft) from the Nash detonation cavity. While tritium exceeded the 20,000 pCi/L SDWA MCL in the 2016 samples, no COPCs were detected by the commercial laboratory. Two of the Source/Plume wells are drilled directly into a test cavity (U-3cn PS 2 and U-4u PS 2A); groundwater from these wells exceed the 20,000 pCi/L MCL for tritium. Well WW-A is located approximately 520 m (1,705 ft) from a test cavity. Tritium was detected in WW-A in the late

1980s, peaked at ~700 pCi/L in 1999, and declined to 355 pCi/L by 2012 (Table 5-4). The combined presence of four radionuclides (^{14}C, ^{90}Sr, ^{129}I, and ^{137}Cs) in well U-4u PS 2A exceeds the SDWA MCL for beta- and photon-emitting radionuclides allowed in drinking water, which is the combined concentration of such emitters that would result in an exposure of 4 mrem/yr. No other radionuclides in samples from Source/Plume wells in this CAU exceed the SDWA MCL. No radionuclides are present at levels ≥10% of their SDWA MCLs in wells located away from a test cavity within the Yucca Flat/Climax Mine CAU.

5.1.3.3 Early Detection Wells

Ten Early Detection wells are included in the sampling network: four within the Pahute Mesa CAUs, one within the Rainier Mesa/Shoshone Mountain CAU, and five within the Yucca Flat/Climax Mine CAU; there are no Early Detection wells currently associated with the Frenchman Flat CAU (Table 5-4). They are the next wells down-gradient of a UGT or Source/Plume well and have expected tritium levels less than the MDCs for standard tritium analyses (i.e., < 300 pCi/L). In the absence of tritium, no other test-related radionuclides are present in historically sampled groundwater; therefore, Early Detection wells are monitored solely for low levels of tritium using the low-level tritium method. Early Detection wells associated with the Central and Western Pahute Mesa CAUs are sampled every 2 years to ensure that the plume front is detected in a reasonable time frame and that a time trend for tritium is established early. For the other CAUs, the sampling frequency is once every 5 years because of the low groundwater velocities and the resulting slow change in radionuclide concentration with time. Two Early Detection wells (PM-3 and ER-19-1) were sampled in 2016.

Pahute Mesa CAUs - Well PM-3 is located in Western Pahute Mesa, and the presence of tritium has been reported in this Early Detection well since 2010 (Navarro-Intera 2015). In 2016, samples were collected from this well's two piezometers using a depth discrete bailer (at 475 and 607 m [1,560 and 1,990 ft]) in the same manner as in 2014. The maximum tritium concentration reported for PM-3 in 2016 was lower (194 pCi/L) than that in 2014 (237 pCi/L). In 2013, pumped samples were collected and the maximum tritium concentration was reported as 249 pCi/L. This well will continue to be monitored every 2 years as an Early Detection well. Once tritium levels reach 300 pCi/L, PM-3 (and any other Early Detection well) will be re-categorized as a Source/Plume well and will be sampled for tritium and COPCs.

Rainier Mesa/Shoshone Mountain CAU – Well ER-19-1 was sampled in 2016 from two piezometers using a depth-discrete bailer. While the tritium reported for the regular field sample from the deeper piezometer (777 to 835 m [2550 to 2738 ft]) was a "nondetect" (<2.87 pCi/L), the tritium in the duplicate sample was reported as 3.31 pCi/L (the value presented in Table 5-4), which is only slightly greater than the analytical detection limit (3.01 pCi/L). This value is considered highly uncertain and it is likely that no tritium is present in this well.

5.1.3.4 Distal Wells

Seven Distal wells are included in the sampling network: two for the Pahute Mesa CAUs, four for the Rainier Mesa/ Shoshone Mountain CAU, and one for the Yucca Flat/Climax Mine CAU; there are no Distal wells currently associated with the Frenchman Flat CAU (Table 5-4). Distal wells are analyzed for tritium using the standard EPA method. Samples are collected at a 5-year frequency. The sampling objective for these wells is to demonstrate that tritium is not present downgradient of UGTs at levels above the SDWA-required minimum detection limit of 1,000 pCi/L. These wells also support the development and evaluation of the flow and contaminant transport models. Two Distal wells (UE-16d and WW-8) within the Rainier Mesa/Shoshone Mountain CAU and one Distal well (ER-EC-1) within the Pahute Mesa CAUs were sampled in 2016. No tritium was detected (Tables 5-4 and 5-5). WW-8 is also an NNSS PWS well (see Section 5.1.3.6).

5.1.3.5 Community Wells/Springs

Eight Community sampling locations occur within the sampling network, all associated with the Pahute Mesa CAUs (Table 5-4). None were sampled in 2016. These wells and springs are either used as private, business, or community water supply sources or are near such sources, and they are sampled for tritium every 5 years. Sampling at a 5-year frequency is sufficient because of the long flow paths to these locations, the low groundwater velocities, and the monitoring of Early Detection wells upgradient from the Community wells and springs. Early Detection well samples will detect the arrival of a contaminant plume at very low concentrations (i.e., measuring tritium at 0.01% of its MCL) long before such a plume could be detected in these private, business, or community water supply sources. Samples are analyzed using a standard EPA method. The objective is to demonstrate that tritium is not present at levels above the SDWA-required minimum detection limit of 1,000 pCi/L. Well Ash B was last sampled in 2014, Well EW-4 was last sampled in 2011, and the other six Community sampling locations were last sampled in 2012. No tritium has been detected at any of these locations (Table 5-4).

5.1.3.6 NNSS PWS Wells

Results from the NNSS PWS water wells sampled quarterly in 2016 continue to indicate that historical underground nuclear testing has not impacted the NNSS water supply network. No tritium measurements were above their MDCs using the EPA standard analysis method (Table 5-5). Gross alpha and gross beta radioactivity were found at concentrations slightly greater than their MDCs in most 2016 samples and are believed to represent the presence of naturally occurring radionuclides. However, no water supply samples had gross alpha measurements that exceeded the EPA MCL (15 pCi/L) or gross beta measurements that exceeded the EPA level of concern (50 pCi/L). Detectable uranium was found at very low concentrations (0.38 to 6.9 µg/L) and is believed to be naturally occurring. Uranium levels were 1.2 to 23% of the EPA MCL of 30 µg/L in drinking water.

5.1.3.7 Compliance Wells/Groundwater Discharges

5.1.3.7.1 RCRA Permitted Wells for the Area 5 Mixed Waste Disposal Unit

Wells UE-5 PW-1, UE-5 PW-2, and UE-5 PW-3 are sampled semi-annually for tritium. They are monitored for tritium and nonradiological parameters (see Section 10.1.7 of Chapter 10) to verify the performance of the Area 5 Mixed Waste Disposal Unit (Cell 18), which is operated under a RCRA permit. In 2016, standard tritium analyses of the wells' water samples were performed; all samples had non-detectable levels of tritium (Table 5-5), and their MDCs were well below the permit established investigation level (IL) of 2,000 pCi/L. Further groundwater analysis is required if the IL is exceeded. Results continue to indicate that Cell 18 radioactive wastes have not contaminated local groundwater. Table 10-3 in Chapter 10, Section 10.1.7 presents the 2016 sampling results for four additional indicators of groundwater contamination, and all 2016 sample analysis results for these three wells are presented in NSTec (2017).

5.1.3.7.2 NDEP Permitted E Tunnel Waste Water Disposal System (ETDS)

NNSA/NFO manages and operates the ETDS in Area 12 under a water pollution control permit (NEV 96021) issued by the Nevada Division of Environmental Protection (NDEP) Bureau of Federal Facilities. The permit governs the management of radionuclide-contaminated wastewater that drains from the E Tunnel portal into a series of holding ponds. The permit requires Well ER-12-1 groundwater to be monitored once every 24 months and E Tunnel discharge waters (retained in the E Tunnel Ponds) to be monitored once every 12 months for tritium, gross alpha, and gross beta as well as for numerous nonradiological parameters (see Section 5.2.4, Table 5-9).

On October 18, 2016, annual sampling for radiological analyses of ETDS discharge water was performed. No sampling of Well ER-12-1 was performed in 2016; its next scheduled sampling is in April 2017. The permissible limits for tritium, gross alpha, and gross beta in the tunnel discharge waters are 1,000,000, 35.1, and 101 pCi/L, respectively. The permissible limits for Well ER-12-1 are identical to the EPA SDWA limits of 20,000, 15, and 50 pCi/L, respectively. When last sampled in 2015, no tritium measurements for ER-12-1 were above their MDCs using an EPA-approved standard analysis method (Table 5-5) (Navarro 2016). Gross alpha and gross beta radioactivity were found at concentrations slightly greater than their MDCs and are believed to represent the presence of naturally occurring radionuclides. All 2016 samples for E Tunnel Ponds and 2015 samples for Well ER-12-1 were below their permit limits (Table 5-5).

5.1.3.7.3 UGTA Well Discharged Groundwater and Fluids

UGTA wells are regulated by the state through an agreement between NNSA/NFO and NDEP called the UGTA Fluid Management Plan (Attachment 1 of NNSA/NSO [2009]) in lieu of having separate State-issued water pollution control permits for each well. The plan prescribes the methods of disposing groundwater and fluids pumped from UGTA wells during drilling, development, and testing based on the levels of radiological contamination. Discharge water and drilling fluids having ≥400,000 pCi/L of tritium are required to be diverted to lined sumps to evaporate; otherwise they may be diverted to unlined sumps to evaporate. Samples of the discharge water from the wellhead are analyzed for gross alpha, gross beta, tritium, and RCRA-regulated metals to ensure discharged water is below the established fluid management criteria for these parameters. When the tritium level in discharge water and drilling fluids is ≥400,000 pCi/L, lead is monitored in the field to ensure that the RCRA limit for lead of 5 milligrams per liter (mg/L) is not exceeded; exceeding this level may result in the generation of a hazardous or mixed waste in a sump, which could cause the suspension of drilling operations.

Three new wells (ER-2-2, ER-3-3, and ER-4-1; see Section 11.1.1.4 of Chapter 11) were drilled in Yucca Flat in 2016. Groundwater discharged during drilling was directed to a lined sump and monitored in accordance with the fluid management plan. The maximum tritium concentration in samples collected using a bailer were reported as 23,400,000 pCi/L and 59,600 pCi/L for ER-2-2 and ER-4-1, respectively. No tritium was detected in samples bailed from ER-3-3. Groundwater purged from all other sampled wells was directed to either lined or unlined sumps. Grab samples from all sumps were below the fluid management criteria limits for all analyzed parameters. There is no discharge from samples collected using a bailer.

5.1.3.8 UGTA Inactive Wells/Sampling Locations

Wells or groundwater discharges that have not been assigned to one of the seven previously discussed water sample location types are called Inactive Wells or Inactive Sampling Locations; they are not included in the NNSA/NFO water sampling network depicted in Figures 5-2 and 5-3. Three inactive wells (ER-2-2, ER-11-2, and U-20AA PS1D) and one Inactive Sampling Location (E Tunnel discharges) were sampled in 2016.

ER-2-2, located in the Yucca Flat/Climax Mine CAU, was drilled near the Callabash UGT in 2016. This well was drilled to a total depth of 1,053 m (3,457 ft) to access the regional carbonate aquifer, but was plugged below a depth of 836 m (2,743 ft) bgs because of unstable borehole conditions. A single sample was collected from the carbonate aquifer prior to plugging the well. The tritium concentration, 13.3 pCi/L, was reported as an estimate by the laboratory (Table 5-4). The maximum tritium concentration for ER-2-2 samples collected in 2016 from the shallower volcanic units closer to the Callabash detonation point was much greater (23,400,000 pCi/L), indicating little hydrologic communication between the volcanic rock aquifers and the regional carbonate aquifer.

ER-11-2 is included in the Frenchman Flat post-closure monitoring network, but is considered an Inactive Well with respect to the Plan. ER-11-2 was sampled in 2016, and no tritium was detected.

U-20AA PS1D, located at Pahute Mesa, is a post-shot hole drilled in 1976 to evaluate the environment near the Colby UGT in support of Pahute Mesa source term characterization. The maximum tritium concentration observed in U-20AA PS1D samples collected in 2016 using a bailer was 29,100,000 pCi/L (Table 5-4). This high concentration is expected because the sample was collected near the Colby detonation point. An evaluation of these data is in progress.

Additional sampling of the E Tunnel discharges (located in the Rainier Mesa/Shoshone Mountain CAU) was performed in 2016 to support the UGTA Activity. Discharge samples, including field duplicate samples, were collected for the full characterization suite. The maximum tritium concentration was reported as 313,000 pCi/L (Table 5-4). While none of the COPCs were present at concentrations near their MCL, the following radioisotopes were detected: ^{238}Pu (0.30 and 0.20 pCi/L), $^{239/240}$Pu (1.85 and 1.77 pCi/L), and ^{137}Cs (18.5 and 18.6 pCi/L).

5.2 Nonradiological Drinking Water and Wastewater Monitoring

The quality of drinking water and wastewater on the NNSS is regulated by federal and state laws. The design, construction, operation, and maintenance of many of the drinking water and wastewater systems are regulated under state permits. NNSA/NFO ensures that such systems meet the applicable water quality standards and permit requirements. The NNSS nonradiological water monitoring goals are shown below. They are met by conducting field water sampling and analyses, performing assessments, and maintaining documentation. This section describes the results of 2016 activities. Information about radiological monitoring of drinking water on and off the NNSS and of wastewater on the NNSS is presented in Sections 5.1.3.5, 5.1.3.6, and 5.1.3.7.

Nonradiological Water Monitoring Goals
Ensure that the operation of NNSS ***public water systems (PWSs)*** and ***private water systems*** (see Glossary, Appendix B) provides high-quality drinking water to workers and visitors of the NNSS.
Determine if NNSS PWSs are operated in accordance with the requirements in Nevada Administrative Code NAC 445A, "Water Controls," under permits issued by the state.
Determine if the operation of commercial septic systems that process domestic wastewater on the NNSS meets operational standards in accordance with the requirements NAC 445A under permits issued by the state.
Determine if the operation of industrial wastewater systems on the NNSS meets operational standards of federal and state regulations as prescribed under the GNEV93001 state permit.

5.2.1 Drinking Water Monitoring

Six wells on the NNSS are permitted to supply the potable water needs of NNSS operations. These are grouped into three PWSs (Figure 5-4). The largest system (Areas 23 and 6) is classified under its permit as a non-transient, non-community PWS and serves the main work areas of the NNSS. The other two systems (Area 12 and Area 25) are classified as transient non-community PWSs. The PWSs are designed, operated, and maintained in accordance with the requirements in NAC 445A under permits issued by the NDEP Bureau of Safe Drinking Water (BSDW). PWS permits are renewed annually.

The three PWSs must meet National Primary Drinking Water Standards and Secondary Standards (set by Nevada) for water quality. They are sampled according to a 9-year monitoring cycle, which identifies the specific classes of contaminants to monitor for each drinking water source and the frequency of their monitoring (Table 5-6). At all building locations, the sampling point for coliform bacteria is a sink within the building. Samples for the chemical contaminants are collected at the points of entry to the PWSs. Although not required by regulation or by any permit, additional samples are collected inside service connections for coliform bacteria to ensure safe drinking water.

For work locations at the NNSS that are not connected to a PWS, NNSA/NFO hauls potable water in two water tanker trucks. Three work locations (the Device Assembly Facility in Area 6, the Joint Actinide Shock Physics Experimental Research facility in Area 27, and the Area 5 Radioactive Waste Management Site) are designated as service connections of the Area 23 and 6 PWS. The trucks are permitted by the BSDW, and the water they carry is subject to water quality standards for coliform bacteria (Table 5-6). Normal use of these trucks involves hauling to remote service connections and to hand-washing stations at construction sites, activities not subject to permitting. NNSA/NFO renews the permits for these trucks annually.

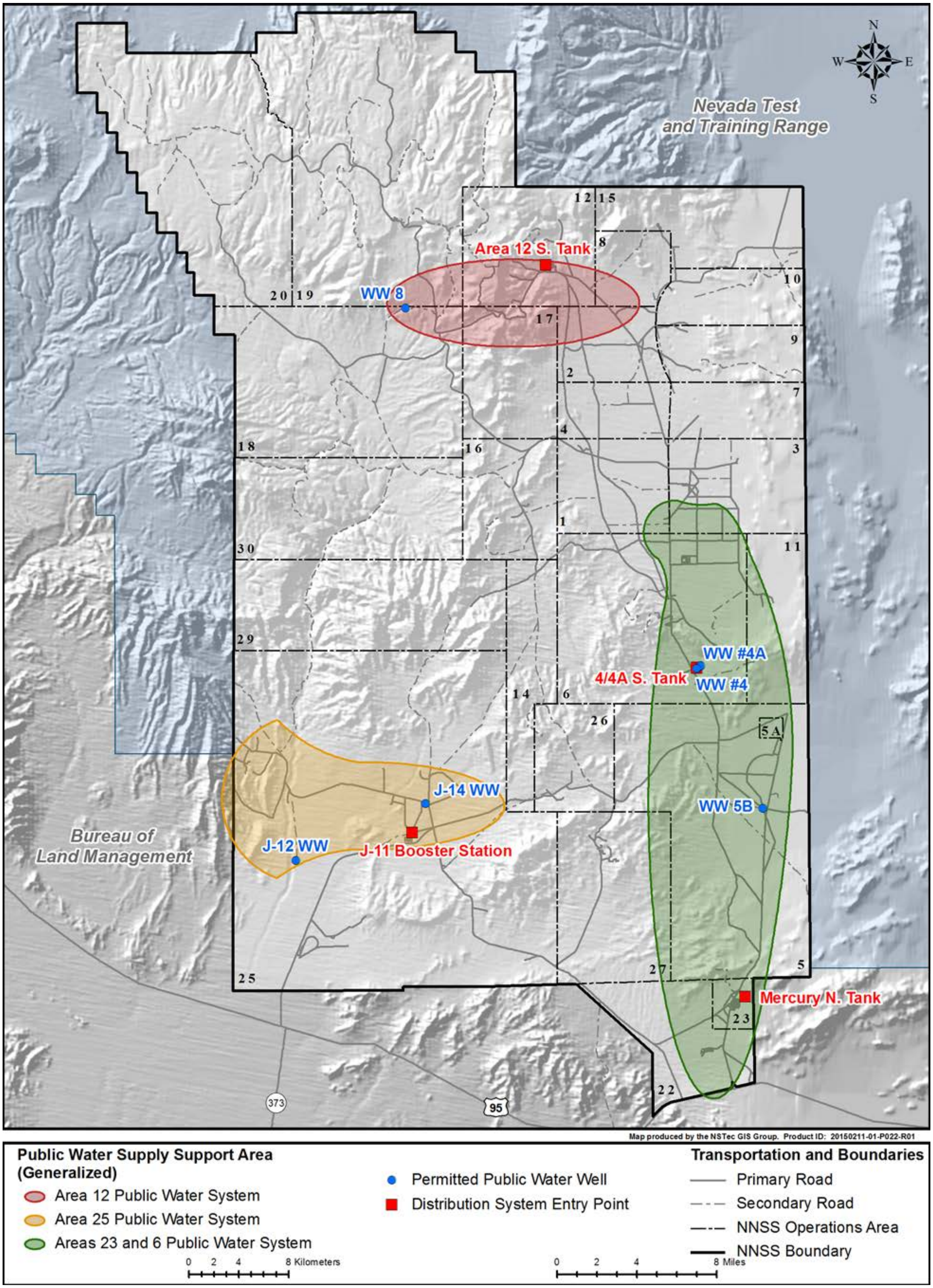

Figure 5-4. Water supply wells and drinking water systems on the NNSS

Table 5-6. Current sampling requirements for permitted NNSS PWSs and water-hauling trucks

System/ Truck	Contaminant or Contaminant Category	Sample Location	Sampling Cycle	Number of Samples
Area 23 and 6	**National Primary Standards**			
	Coliform	WDP-23/6[(a)]	monthly	2
	Disinfectant residual	WDP-23/6	monthly	2
	Asbestos	WDP-23/6	9 year	1
	Disinfection by-products	WDP-23/6	1 year	1
	Lead and copper	WDP-23/6	3 year	10
	Arsenic	POE-23/6[(b)]	3 year	1
	IOCs[(c)] - Phase 2 and 5[(d)]	POE-23/6	9 year	1
	Nitrate	POE-23/6	1 year	1
	Nitrite	POE-23/6	3 year	1
	SOCs[(e)] - Phase 2 and 5	POE-23/6	6 year	1
	VOCs[(f)] - Phase 2 and 5	POE-23/6	3 year	1
	Secondary Standards			
	Secondary IOCs	POE-23/6	3 year	1
Area 12 and Area 25	**National Primary Standards**			
	Coliform	WDP-12/25[(g)]	quarterly	1
	Nitrate	POE-12/25[(h)]	1 year	1
	Nitrite	POE-12/25	3 year	1
	Secondary Standards			
	Secondary IOCs	POE-12/25	3 year	1
Water-Hauling Trucks				
Trucks 84846 and 84847	Coliform Bacteria	Truck valve	monthly	1

(a) WDP–23/6 = Water delivery points for the Area 23 and 6 PWS: taps within Buildings 5-7, 6-609, 6-900, 22-1, 23-180, 23-701, 23-777, 23-1103, and the U1H restroom

(b) POE–23/6 = Points of entry for the Area 23 and 6 PWS: Mercury N. Tank and 4/4A S. Tank (Figure 5-4)

(c) IOCs = Inorganic chemicals

(d) Refers to sets of chemical contaminants in drinking water for which the EPA established maximum contaminant levels (MCLs) through a series of rules known as the Chemical Phase Rules issued from1987 (Phase 1) through 1992 (Phase 5); see http://water.epa.gov/lawsregs/rulesregs/sdwa/chemicalcontaminantrules/basicinformation.cfm.

(e) SOCs = Synthetic organic chemicals

(f) VOCs = Volatile organic compounds

(g) WDP-12/25 = Water delivery points for the Area 12 and Area 25 PWSs: Buildings 12-909 and 25-3123 or 25-4222

(h) POE-12/25 = Points of entry for the Area 12 and Area 25 PWSs: Area 12 S. Tank, J-11 Booster Station, and J-14 WW (Figure 5-4)

5.2.1.1 2016 Results of PWS and Water-Hauling Truck Monitoring

All 2016 water samples were collected in accordance with accepted practices, and the analyses were performed by state-approved laboratories. The laboratories used approved analytical methods listed in NAC 445A and Title 40 Code of Federal Regulations (CFR) Part 141, "National Primary Drinking Water Standards." The 2016 monitoring results indicated that all of the PWSs complied with applicable National Primary Drinking Water Quality Standards (Table 5-7). All water samples from the water-hauling trucks were negative for coliform bacteria in 2016.

5.2.1.2 State Inspections

Periodically, NDEP conducts a sanitary survey of the permitted NNSS PWSs. It consists of an inspection of the wells, tanks, and other visible portions of each PWS to ensure that they are maintained in a sanitary configuration. As non-community water systems, the minimum survey frequency is once every 5 years. No sanitary surveys were conducted in 2016. NDEP inspects the two water-hauling trucks annually at the time of permit renewal to make sure they still meet the requirements of NAC 445A. Inspections were performed in September 2016, and permits were renewed.

Table 5-7. Water quality analysis results for NNSS PWSs

Contaminant	Maximum Contaminant Level (mg/L)*	2016 Results (mg/L)*		
		Area 23 and 6 PWS	Area 12 PWS	Area 25 PWS
Coliform Bacteria	Absent in all samples	Absent in all samples	Absent in all samples	Absent in all samples
Inorganic Chemicals				
Antimony	0.006	0.001 U[(a)] and 0.001 U	NA[(b)]	NA
Asbestos	< 0.2	< 0.2 and < 0.2	NA	NA
Barium	2.0	0.00335 B[(c)] and 0.00279 U	NA	NA
Beryllium	0.004	0.001 U and 0.001 U	NA	NA
Cadmium	0.005	0.001 U and 0.001 U	NA	NA
Chromium	0.1	0.00269 B and 0.0154	NA	NA
Cyanide	0.2	ND[(d)] and ND	NA	NA
Mercury	0.002	0.0006 and 0.0006	NA	NA
Nickel	0.1	0.0015 U and 0.0015 U	NA	NA
Nitrate	10 (as nitrogen)	4.00 and 2.74	1.09	1.87
Selenium	0.5	0.00161 B and 0.00163 B	NA	NA
Thallium	0.002	0.00045 U and 0.00045	NA	NA
Secondary Standards				
Aluminum	0.2	0.068 U and 0.068 U	NA	0.068 U
Chloride	400	11.5 and 21.6	NA	7.29
Color	15 color units	0 and 0 color units	NA	0 color units
Copper	1.3	0.003 U and 0.003 U	NA	0.003 U
Fluoride	2	0.675 and 0.707	NA	1.77
Foaming Agents	0.5	ND and ND	NA	ND
Iron	0.6	0.03 U and 0.03 U	NA	0.0596 B
Magnesium	150	7.75 and 2.26	NA	1.23
Manganese	0.1	0.002 U and 0.002 U	NA	0.002 U
Odor	3	0 and 0	NA	0
pH	6.5–8.5 S.U.[(e)]	8.12 and 8.5 S.U.	NA	8.29 S.U.
Silver	0.1	0.001 U and 0.001 U	NA	0.001 U
Sulfate	500	40.9 and 55.8	NA	22.0
Total Dissolved Solids	1,000	250 and 290	NA	170
Zinc	5	0.0033 U and 0.0033 U	NA	0.00411 B
Volatile Organic Chemicals				
1, 1, 1-Trichloroethane	0.2	<0.0005	NA	NA
1,1,2-Trichloroethane	0.005	<0.0005	NA	NA
1, 1-Dichloroethylene	0.007	<0.0005	NA	NA
1,2,4-Trichlorobenzene	0.7	<0.0005	NA	NA
1, 2-Dichloroethane	0.005	<0.0005	NA	NA
1, 2-Dichloropropane	0.005	<0.0005	NA	NA
Benzene	0.005	<0.0005	NA	NA
Carbon tetrachloride	0.005	<0.0005	NA	NA
Chlorobenzene	0.1	<0.0005	NA	NA
cis-1, 2-Dichloroethylene	0.07	<0.0005	NA	NA
Ethylbenzene	0.7	<0.0005	NA	NA
Methylene chloride	0.005	<0.0005	NA	NA
o-Dichlorobenzene	0.6	<0.0005	NA	NA
p-Dichlorobenzene	0.075	<0.0005	NA	NA
Styrene	0.1	<0.0005	NA	NA
Tetrachloroethylene	0.005	<0.0005	NA	NA
Toluene	1	<0.0005	NA	NA
trans-1, 2-Dichloroethylene	0.1	<0.0005	NA	NA
Trichloroethylene	0.005	<0.0005	NA	NA
Vinyl chloride	0.002	<0.0005	NA	NA
Xylenes (total)	10	<0.0005	NA	NA

* Unless otherwise stated
(a) U = Flagged by the analytical laboratory as below detection limits
(b) NA = Not applicable, no requirement to sample for this contaminant in this PWS in 2016.
(c) B = Flagged by the analytical laboratory as contaminant detected in the blank
(d) ND = Not detected
(e) S.U. = Standard units of pH

5.2.2 Domestic Wastewater Monitoring

A total of 17 active permitted septic systems for domestic wastewater are being used on the NNSS (Figure 5-5). These septic systems are permitted to handle up to 5,000 gallons of wastewater per day. The permitted septic systems are inspected periodically for sediment loading and are pumped as required. The NNSS Management and Operations contractor maintains a septic pumping contractor permit issued by the state. The state conducts onsite inspections of pumper trucks and pumping contractor operations. NNSS personnel perform management assessments of the permitted systems and services to determine and document adherence to permit conditions. The assessments are performed according to existing directives and procedures.

In May 2016, the state conducted one inspection of the NNSS septic pumper trucks, and NNSS personnel conducted one management assessment of the domestic wastewater systems. No compliance issues were identified relating to domestic wastewater on the NNSS.

A septic tank pumping contractor permit (NY-17-03318), four septic tank pump truck permits (NY-17-03313, NY-17-03315, NY-17-03317, NY-17-06838), and a septic tanker permit (NY-17-06839) were approved by the state and renewed in July 2016.

5.2.3 Industrial Wastewater Monitoring

Industrial discharges on the NNSS are limited to three operating sewage lagoon systems: Area 6 Yucca Lake, Area 6 DAF, and Area 23 Mercury (these lagoon systems also receive domestic wastewater) (Figure 5-5). The Area 6 Yucca Lake system consists of two primary lagoons and two secondary lagoons. The DAF system consists of one primary and one secondary lagoon, which were reactivated in 2014 after it was determined that the permitted DAF septic system could not adequately manage the wastewater. The Area 6 Yucca Lake and DAF lagoons are all lined with compacted native soils that meet the State of Nevada requirements for transmissivity (10^{-7} centimeters per second). The Area 23 Mercury system consists of one primary lagoon, a secondary lagoon, and an infiltration basin. The primary and secondary lagoons have a geosynthetic clay liner and a high-density polyethylene liner. The lining of the ponds allows these systems to operate as fully contained, evaporative, non-discharging systems.

The three sewage systems are operated in compliance with Water Pollution Control General Permit GNEV93001. The permit was renewed in 2016 and issued by NDEP on February 25, 2016 as Revision XI.

5.2.3.1 Quarterly and Annual Influent Monitoring

Sewage systems are monitored quarterly for influent quality. Composite samples from each system are collected over a period of 8 hours and in accordance with accepted practices. The analyses are performed by state-approved laboratories. The laboratories use approved analytical methods listed in NAC 445A and 40 CFR 141. The composite samples are analyzed for three parameters: 5-day ***biological oxygen demand*** (BOD_5) (see Glossary, Appendix B), total suspended solids (TSS), and pH. In 2016, all results for BOD_5, TSS, and pH for sewage system influent waters were within permitted limits (Table 5-8). The quarterly average flow rate for two of the systems were also within permitted limits, while the flow rate for the Area 6 DAF system, as in previous years, exceeded its limit (Table 5-8). NDEP issued a waiver in August 2015 regarding the DAF system's flow limit which was set based on a standard water balance calculation when no metering device was in place and was set too low. This waiver applies to the 2016 Revision XI Permit and allows exceedance of the permitted flow rate for the DAF system.

Toxicity monitoring of influent waters of the lagoons was not conducted in 2016. The permit requires that the lagoons be sampled and analyzed for the 29 contaminants shown in Table 4-10 of the *Nevada Test Site Environmental Report 2008* (NSTec 2009) only in the event of specific or accidental discharges of potential contaminants. There were no such discharges that warranted sampling in 2016.

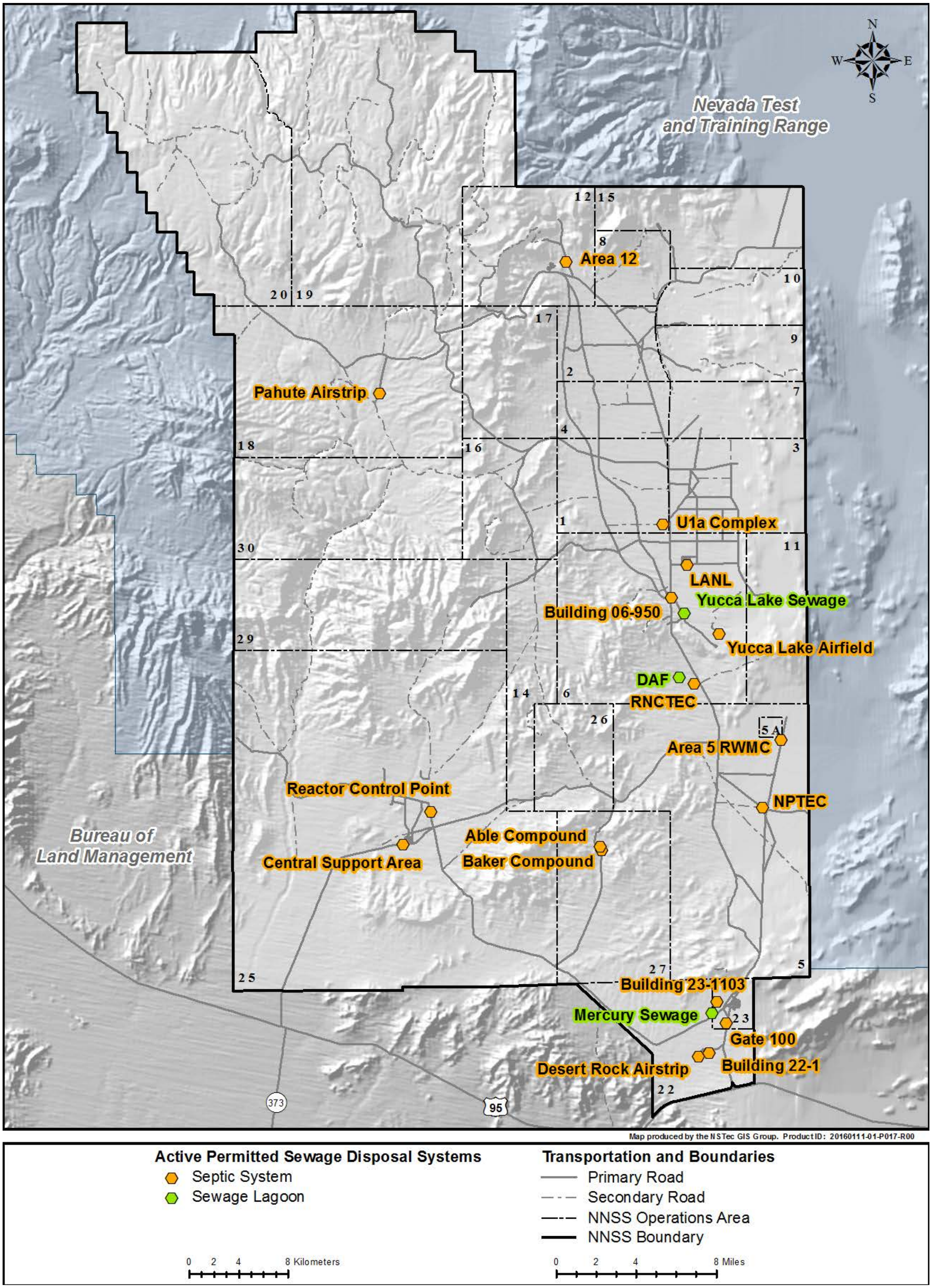

Figure 5-5. Active permitted sewage disposal systems on the NNSS

Table 5-8. Water quality analysis and flow monitoring results for NNSS sewage lagoon influent waters in 2016

		Minimum and Maximum Values from Quarterly Samples		
Parameter	**Units**	**Area 6 Yucca Lake**	**Area 23 Mercury**	**Area 6 DAF**
BOD_5	mg/L	95–403	96–210	52–296
Permit Limit		None	None	None
BOD_5 Mean Daily Load[(a)]	kg/d	0.43–7.41	5.57–22.23	0.44–10.23
Permit Limit		34.43	124.31	15.29
TSS	mg/L	105–193	110–218	12–30.4
Permit Limit		None	None	None
pH	S.U.[(b)]	7.75–8.69	7.87–8.71	8.42–8.55
Permit Limit		6.0–9.0	6.0–9.0	6.0–9.0
Quarterly Average Flow Rate	GPD[(c)]	918–5,595	23,768–9,326	4,911–10,572
Permit Limit		10,850	73,407	3,080[(d)]

(a) BOD_5 Mean Daily Load in kilograms per day (kg/d) = (mg/L BOD × liters per day (L/d) average flow × 3.785)/10^6
(b) Standard units of pH
(c) Gallons per day
(d) Waiver granted by NDEP for flow rate limit in August 2015

5.2.3.2 *Sewage System Inspections*

NNSS personnel inspect active systems weekly and inactive lagoon systems quarterly. NDEP inspects both active and inactive NNSS lagoon systems annually. NNSS personnel inspect for abnormal conditions, weeds, algae blooms, pond color, abnormal odors, dike erosion, burrowing animals, discharge from ponds or lagoons, depth of staff gauge, crest level, excess insect population, maintenance/repairs needed, and general conditions. NNSS personnel conducted weekly and quarterly inspections throughout 2016. They cover field maintenance programs, lagoons, sites, and access roads functional to operations. There were no notable findings from the onsite inspections. NDEP did not perform an annual inspection in 2016 of the NNSS sewage lagoons.

5.2.4 *ETDS Monitoring*

NNSA/NFO manages and operates the ETDS in Area 12 under a separate water pollution control permit (NEV 96021) issued by the NDEP Bureau of Federal Facilities. The permit governs the management of radionuclide-contaminated wastewater that drains from the E Tunnel portal into a series of holding ponds. The permit requires ETDS discharge waters to be monitored every 12 months for radiological parameters (see Table 5-5 and Section 5.1.3.7.2) and for the nonradiological parameters listed in Table 5-9. It also requires nearby Well ER-12-1 to be sampled for the same parameters but at a frequency of once every 24 months. The ETDS is also monitored monthly for flow rate, pH, temperature, and specific conductance (SC) of the discharge water and the total volume and structural integrity of the holding ponds. Monitoring data are reported to the NDEP Bureau of Federal Facilities in annual and quarterly reports.

On October 18, 2016, monitoring personnel sampled the ETDS discharge water. Well ER-12-1 was not scheduled for sampling in 2016. All nonradiological parameters were within the threshold limits specified by the permit (Table 5-9).

Table 5-9. Nonradiological results for Well ER-12-1 groundwater and ETDS discharge samples

	ETDS Discharge Water Sampled Every 12 Months (October 2016)		Well ER-12-1 Groundwater Sampled Every 24 Months (from April 2015)	
Nonradiological Parameter	**Threshold (mg/L)**	**Measured Value (mg/L)**	**Threshold (mg/L)**	**Measured Value (mg/L)**
Cadmium	0.045	0.005[(e)]	0.005	0.00018
Chloride	360	9.8	250	17
Chromium	0.09	0.01[(e)]	0.09	0.0006
Copper	1.2	0.01[(e)]	1.2	0.003

Table 5-9. Nonradiological results for Well ER-12-1 groundwater and ETDS discharge samples (continued)

	ETDS Discharge Water Sampled Every 12 Months (October 2016)		Well ER-12-1 Groundwater Sampled Every 24 Months (from April 2015)	
Nonradiological Parameter	**Threshold (mg/L)**	**Measured Value (mg/L)**	**Threshold (mg/L)**	**Measured Value (mg/L)**
Fluoride	3.6	0.14	3.6	0.26
Iron	5.0	1.6	5.0	4.4
Lead	0.014	0.004[e]	0.014	0.00013
Magnesium	135	0.92	135	61
Manganese	0.25	0.018	0.25	0.14
Mercury	0.0018	0.0002[e]	0.0018	0.00006
Nitrate nitrogen	9	0.24	9	0.2
Selenium	0.045	0.005[e]	0.045	0.002
Sulfate	450	17.0	450	350
Zinc	4.5	0.025	4.5	0.018
Flow Rate (liters/minute)	MR[a]	28.2[d]	NA	NA
pH (S.U.)[b]	6.0–9.0	6.9[d]	6.5–8.5	7.62
Specific conductance (µS/cm)[c]	<1,500	380[d]	<1,500	1,002

(a) Permit requires NNSA/NFO to monitor and report; there are no threshold limits
(b) S.U. = standard unit(s) (for measuring pH)
(c) µS/cm = microsiemens per centimeter
(d) Average of 12 monthly measures

5.3 Water Level and Usage Monitoring

The U.S. Geological Survey (USGS) Nevada Water Science Center collects, compiles, stores, and reports hydrologic data used in determining the local and regional hydrogeologic conditions in and around the NNSS. Hydrologic data are collected quarterly or semi-annually from wells on and off the NNSS. The USGS also maintains and develops the Death Valley Regional Groundwater Flow System Model (Belcher and Sweetkind 2010, Belcher et al. 2017) and manages the NNSS well hydrologic and geologic information database.

During 2016, the USGS monitored water levels in 216 wells, which included 119 on the NNSS and 97 off the NNSS. Water levels are monitored to identify where water occurs in the subsurface, changes in the quantity of water in aquifers, the direction of groundwater movement, and groundwater velocity (derived from knowledge of groundwater movement and rock properties). Along with radiological groundwater data presented in Section 5.1, water level data are used to develop UGTA CAU-specific models of groundwater flow and radionuclide transport (see Section 11.1.1 of Chapter 11). A map showing the location of monitored wells and all water-level data are posted on the USGS/U.S. Department of Energy Cooperative Studies in Nevada web page at https://nevada.usgs.gov/doe_nv/.

Groundwater-use data are collected from water supply wells on the NNSS using flow meters, and are reported monthly. The principal NNSS water supply wells monitored during 2016 included J-12 WW, J-14 WW, UE-16d WW, WW #4, WW #4A, WW 5B, and WW 8 (see Figure 5-2). The USGS compiles the annual water-use data and reports annual withdrawals in millions of gallons. Discharge data from these wells for 2016 have been compiled, processed, and entered onto the USGS/DOE Cooperative Studies in Nevada website at https://nevada.usgs.gov/doe_nv/water_withdrawals.html. Discharge from these wells during 2016 was approximately 149 million gallons (Figure 5-6).

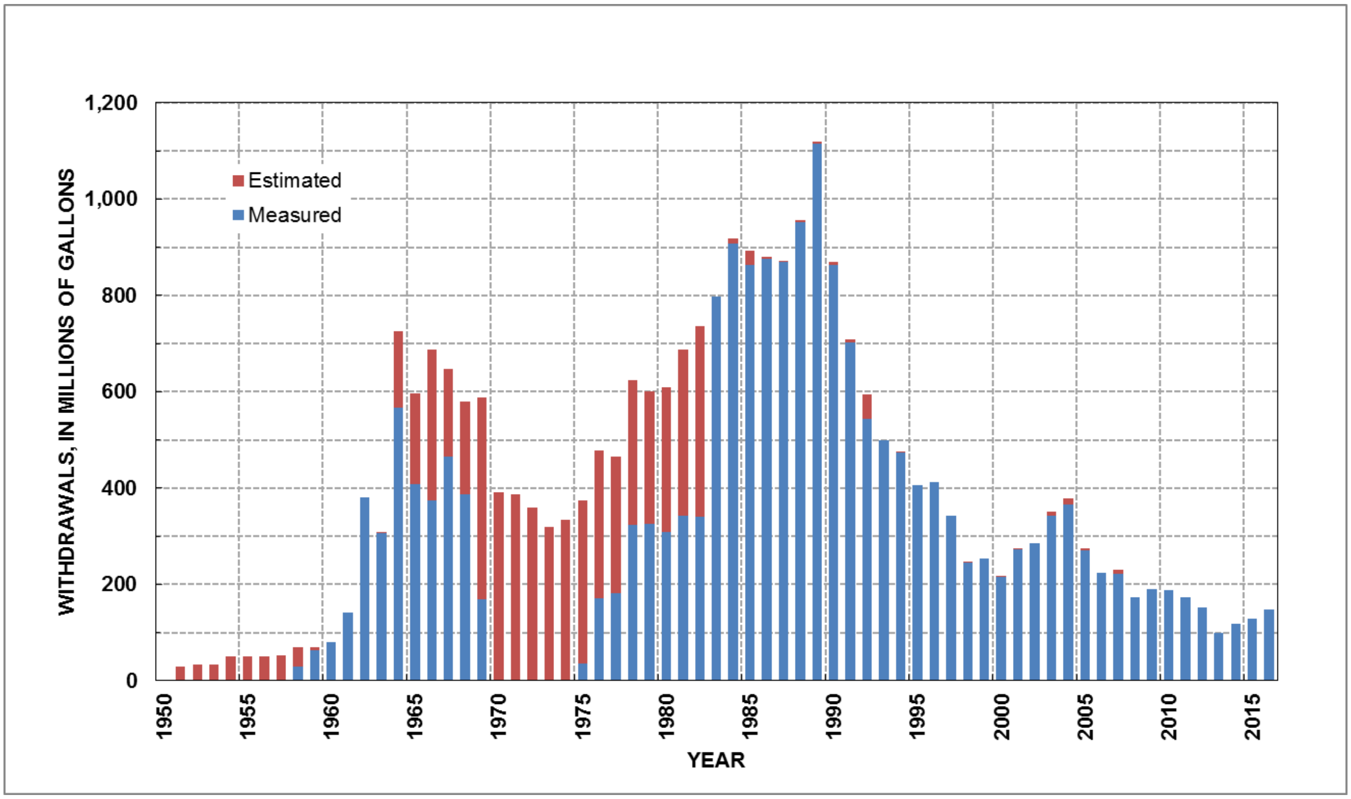

Figure 5-6. Annual withdrawals from the NNSS, 1951 to 2016

5.4 Water Monitoring Conclusions

The potential radiological impact to water resources from past activities on the NNSS is the migration of radionuclides in the groundwater downgradient from the UGTA CAUs. Currently, sampling and analysis data indicate that underground nuclear testing only within the Pahute Mesa CAUs has impacted groundwater off the NNSS; tritium has been detected above the tritium standard analysis method MDC of 300 pCi/L in one UGTA well on NTTR (ER-EC-11). Current data indicate, however, that the distance over which radionuclides have migrated from underground nuclear testing in the Pahute Mesa CAUs is not significant relative to the distance to offsite public water supply wells. Six Characterization wells within the Pahute Mesa CAUs intercept a contaminant plume of tritium believed to originate from the Tybo and Benham UGTs. These six wells are within 900 ft to 17,000 ft (3.2 miles) of these two UGTs. Well sampling to date has not detected the presence of man-made radionuclides downgradient of Pahute Mesa in nine other UGTA wells on the NTTR. As presented in previous annual reports, samples from offsite monitoring wells in Oasis Valley, farther downgradient of Pahute Mesa, also contain no detectable man-made radionuclides. These sampling results are consistent with UGTA's Phase I Pahute Mesa flow and transport model (SNJV 2009), which forecasts migration of tritium off the NNSS within 50 years of the first nuclear detonation (1965) from the Central and Western Pahute Mesa CAUs (see Figure 11-4 of Chapter 11).

Currently, groundwater contaminated by historical UGTs does not impact the public or NNSS workers who drink water from wells located off or on the NNSS. However, NNSS wildlife can be exposed to tritium in their drinking water or aquatic habitats available as a result of the NDEP-approved method of containing contaminated waters in the E Tunnel ponds and in constructed sumps that may be used to contain groundwater pumped from UGTA wells. The potential dose to NNSS biota from these water sources is routinely assessed and reported annually in Chapter 9, Section 9.2 of this report. Each year, the results have demonstrated that the doses to biota are below the limits set to protect plant and animal populations.

Potential nonradiological contaminants in drinking water and wastewater monitored on the NNSS in 2015 were all less than permit limits, with the following exceptions: Area 25 PWS exceeded the Nevada Secondary Standards for aluminum and iron, and the DAF sewage lagoon exceeded the daily flow limit. The Area 25 exceedances were determined to have been due to natural causes or the condition of the water distribution systems themselves; they have not been the result of the release of contaminants into the groundwater from site operations. The DAF sewage lagoon flow exceedance had no impact, as there was no loss of containment. If present, nonradiological contamination of groundwater from NNSS operations would likely be co-located with the radiological contamination that has occurred from historical underground nuclear testing within UGTA CAUs. It is expected to be minor, however, in comparison to the radiological contamination. For nuclear tests above the water table, potential nonradiological contaminants are not likely to reach groundwater because of their negligible advective and dispersive transport rates through the thick vadose zone. Water samples from UGTA investigation wells, which include highly contaminated wells, have not had elevated levels of nonradiological man-made contaminants.

Well drilling, waste burial, chemical storage, and wastewater management are the only current NNSS activities that have the potential to contaminate groundwater with nonradiological contaminants. This potential is very low, however, due to engineered and operational deterrents and natural environmental factors. Current drilling operations procedures include the containment of drilling muds and well effluents in sumps (see Section 5.1.3.7.3). Well effluents are monitored for nonradiological contaminants (predominantly lead) to ensure that lined sumps are used when necessary. The Area 3 and Area 5 Radioactive Waste Management Sites and the solid waste landfills are designed and monitored to ensure that contaminants do not reach groundwater (see Chapter 10). In addition, the potential for mobilization of contaminants from all these sources to groundwater is negligible due to the arid climate, the great depth to groundwater (thickness of the vadose zone), and the proven behavior of liquid and vapor fluxes in the vadose zone (primarily upward liquid movement towards the ground surface due to evapotranspiration).

The Environmental Restoration program for the Soils and Industrial Sites conducts cleanup and closures of historical surface and shallow subsurface contamination sites, some of which have nonradiological contaminants such as metals, petroleum hydrocarbons, hazardous organic and inorganic chemicals, and unexploded ordnance (see Sections 11.2 and 11.3). The potential for mobilization of these contaminants to groundwater is negligible due to the same regional climatic, soil, and hydrogeologic factors mentioned above.

Water level monitoring continues be used to develop and refine CAU-specific models of groundwater flow and contaminant transport. The reader is directed to Section 11.1.1 of Chapter 11 of this report for a description of the status of these models.

Current water usage, monitored annually, has dropped to levels that have not been seen since the early 1960s, due mainly to changes in site operations, and to some extent, recent conservation actions. Within the past several years, NNSA/NFO has taken actions to conserve groundwater by addressing DOE's water efficiency and water management goals, which include reducing both potable and non-potable water use (see Table 3-2 of Chapter 3).

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Chapter 6: Direct Radiation Monitoring

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U.S. Department of Energy (DOE) Orders DOE O 458.1, "Radiation Protection of the Public and the Environment," and DOE O 435.1, "Radioactive Waste Management," have requirements to protect the public and environment from exposure to radiation; see descriptions of these orders in Table 2-1 of Chapter 2. Energy absorbed from radioactive materials outside of the body results in an external dose. On the Nevada National Security Site (NNSS), external dose comes from direct ***ionizing radiation*** (see Glossary, Appendix B) including natural radioactivity from cosmic and terrestrial sources as well as man-made radioactive sources. This chapter presents the data obtained to assess external dose during 2016. Chapters 4, 5, and 8 present the monitoring results of radioactivity from NNSS activities in air, water, and biota, respectively. Those results are used to estimate potential internal radiation dose to the public via inhalation and ingestion. The total estimated dose, both internal and external, from NNSS activities is presented in Chapter 9.

Direct radiation monitoring is conducted to assess the external radiation environment, detect changes in that environment, respond to releases from U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO) activities, and measure gamma radiation levels near potential exposure sites. In addition, DOE O 458.1 states that "it is also an objective that potential exposures to members of the public be as low as is reasonably achievable (ALARA)."

Direct Radiation Monitoring Program Goals
Assess the proportion of external dose that comes from ***background*** (see Glossary, Appendix B) radiation versus NNSS operations.
Measure external radiation in order to assess the potential external dose to a member of the public from NNSA/NFO operations at the NNSS (see Chapter 9 for estimates of public dose).
Measure external radiation in order to assess the potential external dose to a member of the public from operations at the Area 3 and Area 5 Radioactive Waste Management Sites (RWMSs) (see Chapter 9 for estimates of public dose).
Monitor operational activities involving radioactive material, radiation-generating devices, and accidental releases of radioactive material to ensure exposure to members of the public are kept ALARA as stated in DOE O 458.1.
Measure external radiation in order to assess the potential external and absorbed radiation doses to NNSS plants and animals; see Chapter 9, Section 9.2 for biota dose assessments.
Determine the patterns of exposure rates through time at various soil contamination areas in order to characterize releases in the environment.

An offsite monitoring program has been established by NNSA/NFO to monitor direct radiation in communities adjacent to the NNSS. The Desert Research Institute (DRI) conducts this monitoring as part of its Community Environmental Monitoring Program (CEMP). DRI's 2016 direct radiation monitoring results are presented in Chapter 7, Sections 7.1.4 and 7.1.5; the DRI ***thermoluminescent dosimeter (TLD)*** (see Glossary, Appendix B) data are compared with on-site TLD data in this chapter (see Figures 6-2 and 6-3).

6.1 Measurement of Direct Radiation

Direct (or external) radiation exposure can occur when alpha particles, beta particles, or electromagnetic (gamma and X-ray) radiation interact with living tissue. Electromagnetic radiation can travel long distances through air and penetrate living tissue, causing ionization within the body tissues. For this reason, electromagnetic radiation is one of the greater concerns of direct radiation exposure. By contrast, alpha and beta particles do not travel far in air (a few centimeters for alpha, and about 10 meters [m] or 33 feet [ft] for beta particles). Alpha particles deposit only negligible energy to living tissue as they rarely penetrate the outer dead layer of skin and cannot penetrate thin plastic. Beta particles are generally absorbed in the layers of skin immediately below the outer layer.

Direct radiation exposure is usually reported in the unit milliroentgen (mR), which is a measure of exposure in terms of numbers of ionizations in air. The dose in human tissue resulting from an exposure from one of the most common radionuclides (cesium-137) is approximated by equating a 1 mR exposure with a 1 millirem (mrem) (or 0.01 millisievert [mSv]) dose.

6.2 Thermoluminescent Dosimetry Surveillance Network Design

A surveillance network of TLD sampling locations (Figure 6-1) has been established on the NNSS to monitor those NNSS areas that have elevated radiation levels resulting from historical nuclear weapons testing, current and past radioactive waste management activities, and/or current operations involving radioactive material or radiation-generating devices. The objectives and design of the network are described in detail in the *Routine Radiological Environmental Monitoring Plan* (RREMP) (Bechtel Nevada 2003).

TLDs have the capability to measure exposure from all sources of ionizing radiation, but with normal use, the TLD will detect only electromagnetic radiation, high-energy beta particles, and in some special cases, neutrons. This is due to the penetrative abilities of the radiation. The TLD currently used for environmental sampling is the Panasonic UD-814AS, which has three calcium sulfate elements housed in an air-tight, water-tight, ultra-violet light-protected case. Measurements from the three calcium sulfate elements are averaged to assess penetrating gamma radiation.

A pair of TLDs is placed at 1.0 ± 0.3 m (28 to 51 inches [in.]) above the ground at each monitoring location. These are exchanged quarterly for analysis. Analysis of TLDs is performed using automated TLD readers calibrated and maintained by the Radiological Control Department. Reference TLDs are exposed to a 100 mR cesium-137 source under tightly controlled conditions. These are read along with TLDs collected from the network to calibrate their responses.

There were 103 active environmental TLD locations on the NNSS during 2016 (Figure 6-1) along with six control locations. They include the following:

- Background (B) – 10 locations where radiation effects from NNSS operations are negligible.
- Environmental 1 (E1) – 41 locations where there is no measurable radioactivity from past operations, but are locations of interest due to the presence of people in the area and/or the potential for increased radiation exposure from a current operation.
- Environmental 2 (E2) – 35 locations where there is or has been measurable added radioactivity from past operations; these locations are of interest for monitoring direct radiation trends in the area. Some locations fitting this description are grouped with the Waste Operations category below.
- Waste Operations (WO) – 17 locations in and around the Area 3 and Area 5 RWMSs.
- Control (C) – 5 locations in Building 652 and 1 location in Building 650 (both in Area 23). Control TLDs are kept in stable environments. Those in Building 652 are shielded inside a lead cabinet, and those in Building 650 are shielded by just the building itself. These TLDs are used as a quality check on the TLDs and the analysis process.

This network of TLD stations, along with the analysis of their data, serve to monitor operational activities throughout the NNSS to identify changes in external radiation measures over time and any accidental releases of radioactive material. TLD data are reviewed annually to identify any patterns of exposure rates through time at various soil contamination areas.

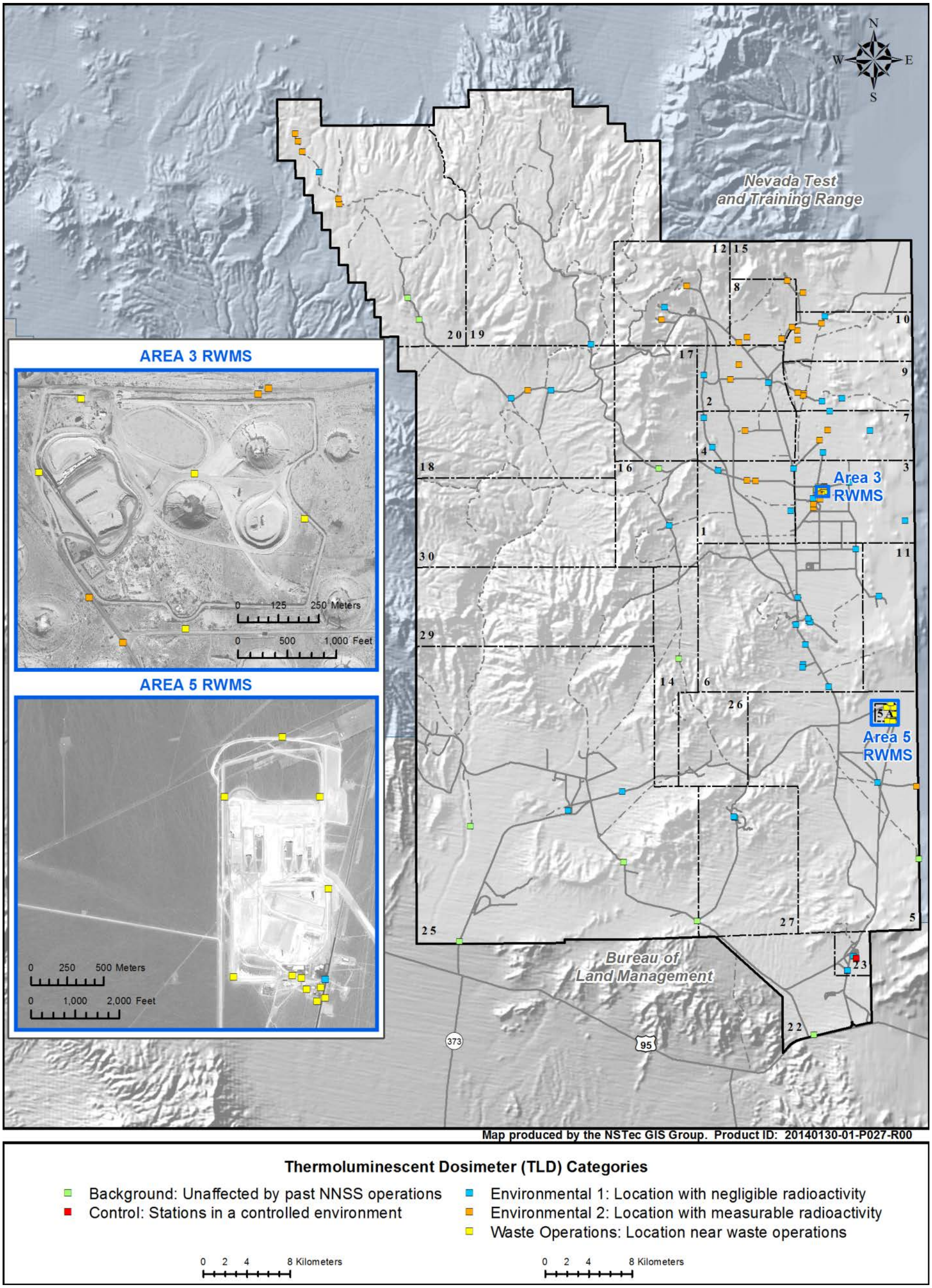

Figure 6-1. Locations of TLDs on the NNSS

6.2.1 Data Quality

Quality assurance (QA) procedures for direct radiation monitoring involve: 1) comparing the readings among the three TLD elements in individual TLDs, 2) comparing data from the paired TLDs at each location to estimate the measurement and its precision, 3) comparing current and past data measurements at each TLD location, and 4) reviewing data from the TLDs in the control locations. The TLDs in control locations allow the detection and estimation of any systematic variations that might be introduced by the measurement process itself.

As directed by the RREMP, QA and quality control (QC) protocols (including Data Quality Objectives) have been developed and are maintained as essential elements of direct radiation monitoring. The QA/QC requirements established for the monitoring program include the use of sample packages to thoroughly document each sampling event, rigorous management of databases, and completion of essential training (see Chapter 14). The Radiological Control Department maintains certification through the U.S. Department of Energy Laboratory Accreditation Program for dosimetry.

There are four steps in the monitoring process for each environmental TLD: the TLD is (1) annealed (i.e., heated and then cooled) to reset it to its original unexposed condition, then stored in a shielded location; (2) deployed to the field at the beginning of the quarter; (3) collected from the field at the end of the quarter; and (4) again stored in a shielded location until it is read. In the past, perturbations have been noticed in the data related to variation in the amount of time TLDs were held in shielded locations prior to deployment and following collection. An adjustment procedure was developed and implemented in 2014 to control for the variability in this additional dose. This procedure involves estimating the additional dose based on the holding time and the shielded control location measurements and subtracting that estimate from the measured quarterly dose before computing annual exposure estimates. This adjustment has been applied retroactively to data from 2003 on. This adjustment resulted in a decrease in estimated dose of between 0.2% and 4.4%, averaging 1.4%, in 2016.

6.2.2 Data Reporting

Direct radiation is recorded as exposure per unit time in milliroentgens per day (mR/d), calculated by dividing the measured exposure per quarter for each TLD by the number of days the TLD was exposed at its measurement location. These are multiplied by 365.25 to obtain annualized values. The estimated annual exposure is the average of the quarterly annualized values; this is the metric used to determine compliance with federal annual dose limits.

6.3 Results

Estimated annual exposures for all TLD locations are given in Table 6-1. Summary statistics for the five location types are given in Table 6-2 and Figure 6-2. Data were successfully obtained from nearly all of the TLDs during all quarters of 2016; two measurements were rejected due to inadequate inter-element agreement, one TLD was damaged and unreadable, and one pair was missing. Otherwise, agreement between the results provided by the paired TLDs was quite good, with an average relative percent difference between measurements of 3.1%. The quarter-to-quarter coefficient of variation (CV) (i.e., the relative standard deviation) ranged from 1.4% to 10.3% (median = 4.8%) over all locations excluding Gate 100 Truck Parking 1 (see the discussion in Section 6.3.2).

6.3.1 Background Exposure

During 2016, the average of the estimated annual exposures among the 10 background locations was 120 mR, ranging from 79 to 168 mR (Table 6-2). A 95% prediction interval (PI) for annual exposures based on the 2016 estimated mean annual exposures at the background locations (denoted “95% PI from B” in the plots) is 44.9 to 194.4 mR. This interval predicts mean annual background exposures at locations where radiation effects from NNSS operations are negligible.

For comparison, the CEMP’s estimated annual exposure in Las Vegas, Nevada (at 617 m [2,025 ft] elevation), was 100 mR in 2016 (see Chapter 7, Table 7-3). Estimated annual exposures at CEMP locations ranged from 85 mR at Pahrump, Nevada (716 m [2,400 ft] elevation), to 145 mR at Beatty, Nevada (930 m [3,216 ft] elevation) and Milford, Utah (1,417 m [4,900 ft] elevation). There is a general increasing relationship between natural background exposure and elevation (Figure 6-3), generally due to cosmic radiation. The NNSS background locations with lowest and highest exposures are at elevations 1,064 m (3,490 ft) at Old Indian Springs Road in Area 5 and 1,737 m (5,700 ft) at Stake A-112 in Area 20, respectively.

Exposure estimates at all locations include contributions from natural sources of radiation (i.e., cosmic), legacy sources (i.e., contaminated soils from NNSS historical nuclear testing), and current NNSS operational sources. It is important to note that all DOE dose limits to the public are for dose over and above what may be received from natural sources.

Table 6-1. Annual direct radiation exposures measured at TLD locations on the NNSS in 2016

NNSS Area	Station	Location Type[b]	Number of Quarters	Estimated Annual Exposure (mR)[a]		
				Mean[c]	Minimum[c]	Maximum[c]
5	Old Indian Springs Road	B	4	79	77	81
14	Mid-Valley	B	4	143	136	151
16	Stake P-3	B	4	122	116	133
20	Stake A-112	B	4	168	155	194
20	Stake A-118	B	4	160	147	174
22	Army #1 Water Well	B	4	85	81	92
25	Gate 25-4-P	B	4	129	126	135
25	Gate 510	B	4	125	121	131
25	Jackass Flats & A-27 Roads	B	4	79	76	82
25	Skull Mtn Pass	B	4	107	101	113
23	Building 650 Dosimetry	C	4	57	55	58
23	Lead Cabinet, 1	C	4	25	24	25
23	Lead Cabinet, 2	C	4	25	25	26
23	Lead Cabinet, 3	C	4	25	25	26
23	Lead Cabinet, 4	C	4	25	25	26
23	Lead Cabinet, 5	C	4	25	24	26
1	BJY	E1	4	118	115	122
1	Sandbag Storage Hut	E1	4	112	109	113
1	Stake C-2	E1	4	122	114	132
2	Stake M-140	E1	4	134	127	141
2	Stake TH-58	E1	4	95	89	103
3	LANL Trailers	E1	4	124	122	126
3	Stake OB-20	E1	4	91	86	99
3	Well ER 3-1	E1	4	128	117	140
4	Stake TH-41	E1	4	109	107	114
4	Stake TH-48	E1	4	116	108	126
5	Water Well 5B	E1	4	112	106	118
6	CP-6	E1	4	68	66	70
6	DAF East	E1	4	96	92	100
6	DAF North	E1	4	101	96	108
6	DAF South	E1	4	135	128	143
6	DAF West	E1	4	84	80	86
6	Decon Facility NW	E1	4	126	116	133
6	Decon Facility SE	E1	4	131	124	138
6	Stake OB-11.5	E1	4	132	122	149
6	Yucca Compliance	E1	4	92	86	96
6	Yucca Oil Storage	E1	4	99	96	100
7	Reitmann Seep	E1	3	127	121	132
7	Stake H-8	E1	4	130	126	135
9	Papoose Lake Road	E1	4	87	86	90
9	U-9CW South	E1	4	106	103	109
9	V & G Road Junction	E1	4	118	109	130

Table 6-1. Annual direct radiation exposures measured at TLD locations on the NNSS in 2016 (continued)

NNSS Area	Station	Location Type[b]	Number of Quarters	Estimated Annual Exposure (mR)[a] Mean[c]	Minimum[c]	Maximum[c]
10	Gate 700 South	E1	4	130	121	141
11	Stake A-21	E1	4	131	127	135
12	Upper N Pond	E1	4	133	122	141
16	3545 Substation	E1	4	139	134	149
18	Stake A-83	E1	4	153	142	171
18	Stake F-11	E1	4	150	139	161
19	Stake P-41	E1	4	164	153	171
20	Stake J-41	E1	4	146	135	164
23	Gate 100 Truck Parking 1	E1	4	103	75	148
23	Gate 100 Truck Parking 2	E1	4	64	60	70
23	Mercury Fitness Track	E1	4	58	57	59
25	HENRE	E1	4	122	119	129
25	NRDS Warehouse	E1	4	127	119	142
27	Cafeteria	E1	4	112	108	117
27	JASPER-1	E1	4	116	109	132
1	Bunker 1-300	E2	4	111	107	116
1	T1	E2	4	221	207	246
2	Stake L-9	E2	4	166	154	184
2	Stake N-8	E2	4	397	368	434
3	Stake A-6.5	E2	4	137	132	143
3	T3	E2	4	293	273	329
3	T3 West	E2	4	269	259	281
3	T3A	E2	4	303	287	318
3	T3B	E2	4	408	395	418
3	U-3co North	E2	4	173	165	182
3	U-3co South	E2	4	141	138	146
4	Stake A-9	E2	4	394	384	405
5	Frenchman Lake	E2	4	247	229	265
7	Bunker 7-300	E2	4	200	190	208
7	T7	E2	4	120	113	129
8	BANEBERRY 1	E2	4	320	299	333
8	Road 8-02	E2	4	125	119	135
8	Stake K-25	E2	4	96	91	104
8	Stake M-152	E2	4	161	156	167
9	B9A	E2	4	125	117	136
9	Bunker 9-300	E2	4	125	116	136
9	T9B	E2	4	425	409	455
10	Circle & L Roads	E2	4	119	111	129
10	Sedan East Visitor Box	E2	4	131	125	146
10	Sedan West	E2	4	208	193	218
10	T10	E2	4	231	208	260
12	T-Tunnel #2 Pond	E2	4	227	206	245
12	Upper Haines Lake	E2	4	108	101	118
15	EPA Farm	E2	4	114	106	126
18	JOHNNIE BOY North	E2	4	150	139	166
20	PALANQUIN	E2	4	210	200	232
20	SCHOONER-1	E2	4	498	440	552
20	SCHOONER-2	E2	4	229	210	258
20	SCHOONER-3	E2	4	145	135	152
20	Stake J-31	E2	4	155	145	166

Table 6-1. Annual direct radiation exposures measured at TLD locations on the NNSS in 2016 (continued)

NNSS Area	Station	Location Type[b]	Number of Quarters	Estimated Annual Exposure (mR)[a] Mean[c]	Minimum[c]	Maximum[c]
3	A3 RWMS Center	WO	4	139	132	148
3	A3 RWMS East	WO	4	134	132	135
3	A3 RWMS North	WO	4	128	122	132
3	A3 RWMS South	WO	4	282	266	289
3	A3 RWMS West	WO	4	126	122	129
5	A5 RWMS East Gate	WO	4	98	95	103
5	A5 RWMS Expansion NE	WO	4	145	133	160
5	A5 RWMS Expansion NW	WO	4	146	140	150
5	A5 RWMS NE Corner	WO	4	124	118	131
5	A5 RWMS North	WO	4	141	135	153
5	A5 RWMS South Gate	WO	4	108	104	110
5	A5 RWMS SW Corner	WO	4	122	117	130
5	Building 5-31	WO	4	103	99	106
5	WEF East	WO	4	125	119	130
5	WEF North	WO	4	114	112	118
5	WEF South	WO	4	124	121	130
5	WEF West	WO	4	120	117	125

(a) To obtain estimated daily exposure rates, divide annual exposure estimates by 365.25

(b) Location types: B = Background locations; C = Control locations; E1 = Environmental locations with exposure rates near background, but monitored for potential for increased exposures due to NNSS operations; E2 = Environmental locations with measurable radioactivity from past operations, excluding those designated WO; WO = Locations in or near waste operations.

(c) Mean, minimum, and maximum values from adjusted quarterly estimates. Each quarterly estimate is the average of two TLD readings per location in all but three instances where one of the paired TLDs could not be read due to loss or damage.

Table 6-2. Summary statistics for 2016 mean annual direct radiation exposures by TLD location type

Location Type	Number of Locations	Estimated Annual Exposure (mR) Mean	Minimum	Maximum
Background (B)	10	120	79	168
Environmental 1 (E1)	41	116	58	164
Environmental 2 (E2)	35	214	96	498
Waste Operations (WO)	17	134	98	282
Control, Shielded (C)	5	25	25	25
Control, Unshielded (C)	1	57	--	--

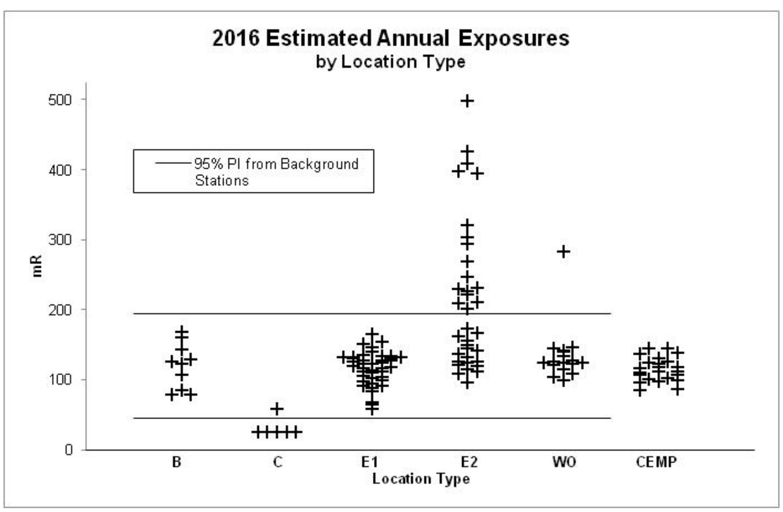

Figure 6-2. 2016 annual exposures on the NNSS, by location type, and off the NNSS at CEMP stations

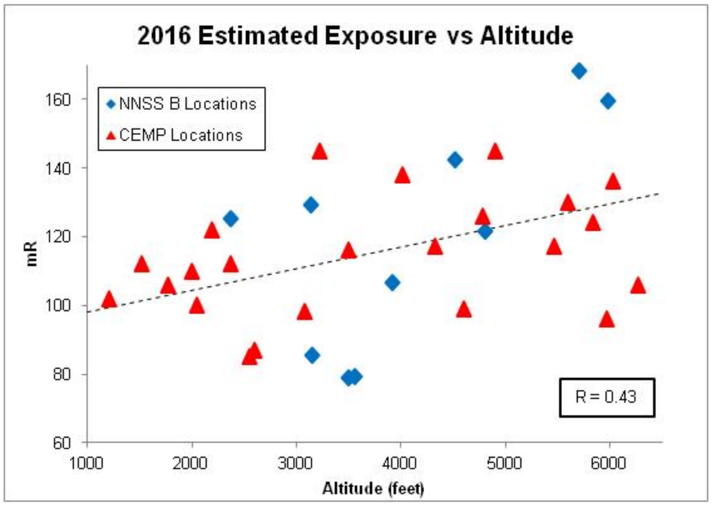

Figure 6-3. Correlation between 2016 annual exposures at NNSS Background and CEMP TLD locations and altitude

6.3.2 Potential Exposure to the Public along the NNSS Boundary

Most of the NNSS is not accessible to the public; the public has limited access only at the southern portion of the NNSS. Gate 100 is the primary entrance point to the NNSS. The outer parking areas are accessible to the public. Trucks hauling radioactive materials, primarily low-level waste (LLW) destined for disposal in the RWMSs, often park outside Gate 100 while waiting to enter the NNSS. Two TLD locations were established in October 2003 to monitor this truck parking area.

The TLDs at the north end of the parking area (Gate 100 Truck Parking 2) had an estimated annual exposure of 64 mR during 2016, with quarterly estimates of 62, 60, 70, and 63 mR. The TLD location about 64 m (210 ft) away, on the west side of the parking area (Gate 100 Truck Parking 1), has had elevated exposure levels at various times in its history, likely from waste shipments. Its average value for 2016 was 103 mR, with quarterly estimates of 148, 90, 75, and 101 mR. All results for both locations are within the range of background variation; however, all quarterly exposure estimates are higher than those at the nearby Mercury Fitness Track station.

While the public has limited access to the NNSS at Gate 100 along its southern border, others may have access to other boundaries of the NNSS. Most of the NNSS is bounded by the Nevada Test and Training Range (NTTR). Military or other personnel on the NTTR who are not classified as radiation workers would also be subject to the DOE public dose limit of 100 mrem/yr (1 mSv/yr). Nuclear tests on the NTTR (Double Tracks and Project 57) consisted of experiments (called safety experiments) where weapons were exploded conventionally without going critical (i.e., starting a nuclear chain reaction). These areas, therefore, have primarily alpha-emitting radionuclides that do not contribute significantly to external dose. Historical nuclear testing activities also occurred on the Tonopah Test Range (TTR) (Clean Slate I, II, and III) located in the northwest portion of the NTTR. Radiation exposure rates are measured on and around the TTR, and the results are reported by Sandia National Laboratories in the TTR annual environmental report posted at http://www.sandia.gov/news/publications/environmental/index.html.

A radioactive material area boundary extends beyond the NNSS in the Frenchman Lake region of Area 5 along the southeast boundary of the NNSS. This region was a location of atmospheric weapons testing in the 1950s and is inaccessible to the public. A TLD location was established there in July 2003 to characterize direct radiation levels from this legacy soil contaminated area and to assess the external dose to personnel not classified as radiation workers who may visit the area. The estimated annual exposure to a hypothetical person at the Frenchman Lake TLD location during 2016 was 247 mR. This has been consistently declining over time, down from 420 mR in 2003. The estimated above-background dose during 2016 would be approximately 79 to 168 mrem, depending on which background value is subtracted. This may exceed the 100 mrem dose limit to a person residing full time, year-round, at this location, but there are no living quarters or full-time non-radiation workers in this vicinity. Workers specially trained and classified as radiation workers, although they do not work in the vicinity, have a higher allowable dose limit of 5,000 mrem per year, which would not be exceeded in the vicinity of the Frenchman Lake TLD.

Based on these results, the potential external dose to a member of the public due to past or present operations at the NNSS does not exceed 100 mrem/yr (1 mSv/yr) and exposures are kept ALARA, as required by DOE O 458.1.

6.3.3 Exposures from NNSS Operational Activities

Forty-one TLDs are in locations where either workers and/or the public, have the potential to receive radiation exposure from current operations (E1 locations). E1 locations have negligible radioactivity from past operations. The mean estimated annual exposure at these locations was 116 mR during 2016, a little lower than the mean estimated annual exposure at background locations (see Table 6-2). Overall, annual exposures were not different between B and E1 locations (Figure 6-2); the estimated annual exposures at all E1 locations are well within the 95% PI of B locations. E1 location exposures were also comparable with the offsite exposures reported by the CEMP stations, as shown in Figure 6-2.

6.3.4 Exposures from RWMSs

DOE M 435.1-1, "Radioactive Waste Management Manual," states that LLW disposal facilities shall be operated, maintained, and closed so that a reasonable expectation exists that the annual dose to members of the public shall not exceed 25 mrem from all exposure pathways combined. The RWMSs are located well within the NNSS boundaries, which are patrolled by security personnel; no member of the public can access these areas for significant periods of time. TLDs placed at the RWMSs show the potential dose from external radiation to a hypothetical person residing year-round at each RWMS.

Between 1952 and 1972, 60 nuclear weapons tests were conducted in Yucca Flat within 400 m (1,312 ft) of the current Area 3 RWMS boundary. Fourteen of these tests were atmospheric tests that left radionuclide-contaminated surface soil and, therefore, elevated radiation exposures across the area. Waste pits in the Area 3 RWMS are subsidence craters from seven subsurface tests, which have been filled with LLW and then covered with clean soil. As a result, exposures inside the Area 3 RWMS are low when compared with those at or outside the fence line.

Annual exposures measured inside the Area 3 RWMS and at three of four locations at the boundary were within the range of NNSS background exposures in 2016 (Figure 6-4). The boundary location A3 RWMS South has an estimated exposure above the range of NNSS background; it is 160 m (525 ft) from the site of two atmospheric nuclear weapons tests. The three E2 TLD locations outside the RWMS that are also above the range of NNSS background (Figure 6-4) are a similar distance from the same atmospheric tests, but on the other side, farther from the RWMS boundary. Based on these measurements, it does not appear that waste buried at the Area 3 RWMS would have contributed external exposure to a hypothetical person residing at its boundary during 2016.

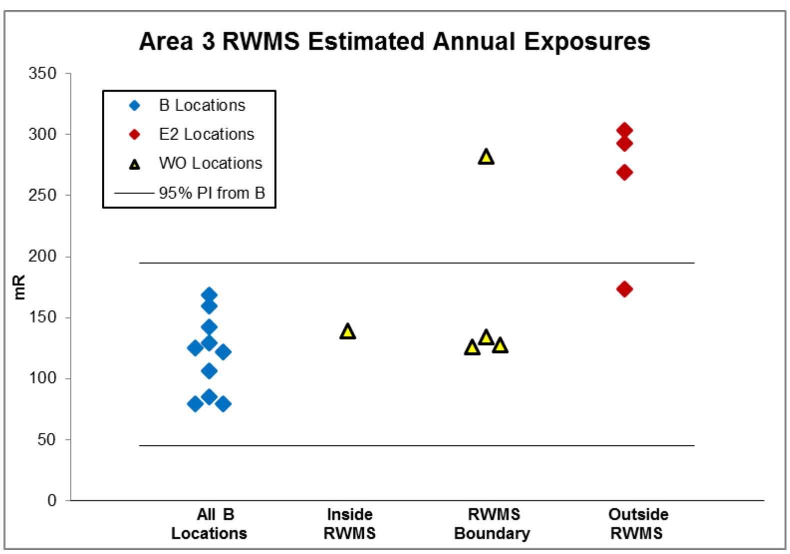

Figure 6-4. 2016 annual exposures in and around the Area 3 RWMS and at background locations

The Area 5 RWMS is located in the northern portion of Frenchman Flat. Between 1951 and 1971, 25 nuclear weapons tests were conducted within 6.3 kilometers (km) (3.9 miles [mi]) of the Area 5 RWMS. Fifteen of these were atmospheric tests and, of the remaining ten, nine released radioactivity to the surface, which contributes to exposures in the area. No nuclear weapons testing occurred within the boundaries of the Area 5 RWMS.

During 2016, estimated annual exposures at Area 5 RWMS TLD locations were within the range of exposures measured at NNSS background locations (Figure 6-5). The one location outside the Area 5 RWMS that has an estimated exposure above background levels (the Frenchman Lake TLD station) is within 0.5 km (0.3 mi) of six atmospheric tests in the Frenchman Lake Playa.

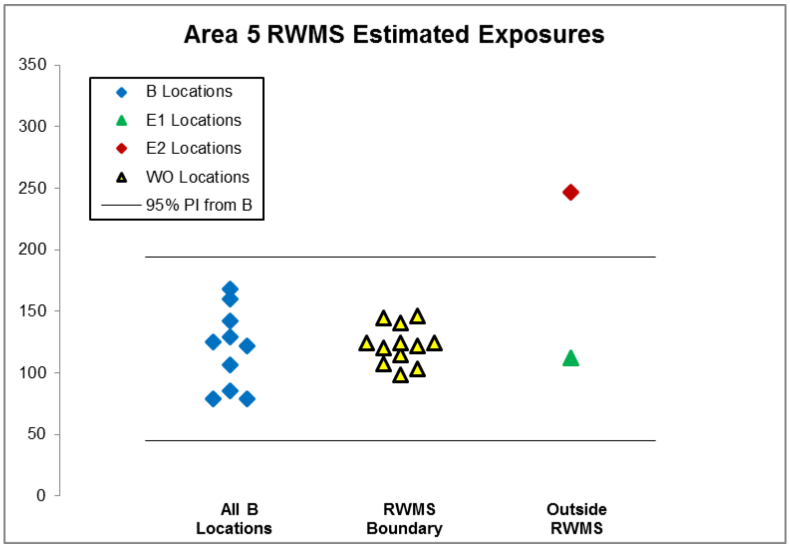

Figure 6-5. 2016 annual exposures around the Area 5 RWMS and at background locations

Based on these results, the potential external dose to a member of the public from operations at the Area 3 and Area 5 RWMSs does not exceed the 25 mrem/yr (0.25 mSv/yr) dose limit to members of the public, specified in DOE M 435.1-1. See Section 9.1.2 of this report for a summary of the potential dose to the public from the RWMSs from all exposure pathways.

6.3.5 Exposures to NNSS Plants and Animals

The highest exposure rate measured at any TLD location during 2016 was 552 mR/yr (1.51 mR/d) at the Schooner-1 location during the third quarter (Table 6-1). Given such a large area source, there is very little difference between the exposure measured at a height of 1 m (3.3 ft) and that measured near the ground (e.g., 3 cm [1.2 in.]) where small plants and animals reside. The daily exposure rate near the ground surface would be less than 2% of the total dose rate limit to terrestrial animals and less than 1% of the limit to terrestrial plants (see Chapter 9, Section 9.2). Hence, doses to plants and animals from external radiation exposure at NNSS monitoring locations are much lower than the dose limits. Dose to biota from both internal and external radionuclides is presented in Section 9.2 of Chapter 9.

6.3.6 Exposure Patterns in the Environment over Time

Direct radiation monitoring is conducted to help characterize releases from NNSA/NFO activities. Continued monitoring of exposures at locations of past releases on the NNSS helps to accomplish this. Small quarter-to-quarter changes are normally seen in exposure rates from all locations. During 2016, the median CV for measurements between quarters was 4.8%. Gate 100 Truck Parking 1 showed the highest variation with a CV of 30.2%. Only one other station had a CV over 10% (Stake A-112 in Area 20, 10.3%). In the past 5 years the median CV has ranged from 2.8% (2012 and 2014) to 3.8% (2013); so the quarter-to-quarter variability in 2016 is a bit higher, on average, than in the past 5 years.

Long-term trends are displayed in Figure 6-6 by location type for locations that have been monitored for at least 10 years. The average decay rates by location group are 0.15% (B), 0.34% (C), 0.32% (E1), 1.93% (E2), and 0.73% (WO). Annual exposures decreased 3.12% per year on average at those locations with significant added man-made radiation, those being the E2 and WO locations with 2016 estimated exposures higher than the 95% PI calculated from B locations. These average rates of decay are very similar to those measured from 2008 through 2015. The observed decreases are due to a combination of natural radioactive decay, dispersal, and dilution in the environment.

The stations with the five highest exposures in 2016 are Schooner-1 (Area 20), T9B (Area 9), T3B (Area 3), Stake N-8 (Area 2), and Stake A-9 (Area 4). Their annual exposures have been decreasing at an estimated rate of 50% every 14, 24, 40, 15, and 16 years respectively.

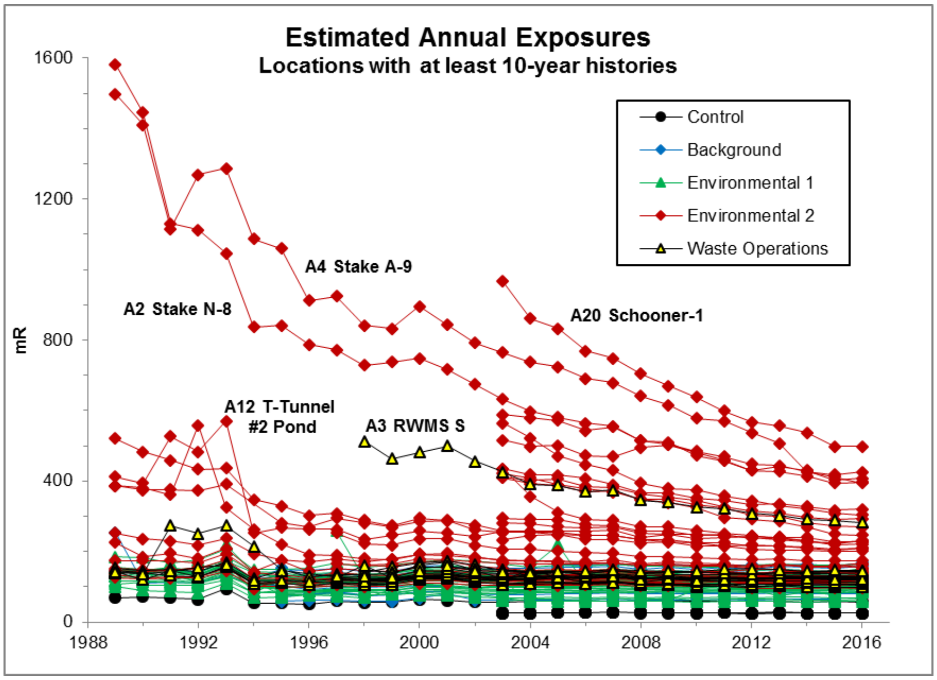

Figure 6-6. Trends in direct radiation exposure measured at TLD locations

6.4 Environmental Impact

Direct radiation exposure to the public from NNSS operations during 2016 was negligible. Radionuclides historically released to the environment on the NNSS have resulted in localized elevated exposures. The areas of elevated exposure are not open to the public, nor do personnel work in these areas full-time. Overall exposures at the RWMSs appear to be generally lower inside and at the boundary than those outside the RWMSs. This is due to the presence of radionuclides released from historical testing distributed throughout the area around the RWMSs compared with the clean soil used inside the RWMSs to cover the waste. The external dose to plants and animals at the location with the highest measured exposure was a small fraction of the dose limit to biota; hence, no detrimental effects to biota from external radiation exposure are expected at the NNSS.

6.5 References

Bechtel Nevada, 2003. *Routine Radiological Environmental Monitoring Plan*. DOE/NV/11718--804, Las Vegas, NV, prepared for U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office.

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Chapter 7: Community-Based Offsite Monitoring

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Two community-based radiological monitoring programs are conducted off the Nevada National Security Site (NNSS). They provide independent results for the presence of man-made radionuclides in air and groundwater samples from communities surrounding the NNSS.

The Community Environmental Monitoring Program (CEMP) was initiated in 1981 and is conducted by the Desert Research Institute (DRI) of the Nevada System of Higher Education. CEMP's mission is to provide data to the public regarding the presence of man-made radionuclides in air and groundwater off of the NNSS that could be the result of current operations or past nuclear testing on the NNSS. Initially, the CEMP network functioned as a first line of offsite detection of potential radiation releases from underground nuclear tests at the NNSS. It currently exists as a non-regulatory public informational and outreach program. Monitored and collected data include, but are not necessarily limited to, ***background*** (see Glossary, Appendix B) and airborne radiation data, meteorological data, and tritium concentrations in downgradient community drinking water. Network air monitoring stations, located in Nevada, Utah, and California, are managed by local citizens, many of them high school science teachers, whose routine tasks are to ensure equipment is operating normally and to collect air filters and route them to the DRI for analysis. These Community Environmental Monitors (CEMs) are also available to discuss the monitoring results with the public and to speak to community and school groups. DRI's responsibilities include maintaining the physical monitoring network through monthly visitations by environmental radiation monitoring specialists, who also participate in training and interfacing with CEMs and interacting with other local community members and organizations to provide information related to the monitoring data. DRI also provides public access to the monitoring data through maintenance of a project website at http://www.cemp.dri.edu/. A detailed informational background narrative about the CEMP can be found at http://www.cemp.dri.edu/cemp/moreinfo.html along with more detailed descriptions of the various types of sensors found at the stations and on outreach activities conducted by the CEMP.

The Nye County Tritium Sampling and Monitoring Program (TSaMP) was initiated in 2015 when the U.S. Department of Energy (DOE) Environmental Management (EM) office issued a 5-year grant to Nye County to monitor tritium in wells downgradient from the NNSS. The grant supports annual sampling of 10 wells in the first year and up to 20 wells every year thereafter. It also supports Nye County's involvement in technical reviews of the Underground Test Area (UGTA) corrective action program (see Chapter 11). Nye County coordinates with DRI, CEMs, and Nye County citizens to determine the sample well locations. Due to CEMP's success at involving and educating local communities, the DOE EM grant requests that data administration and communication to the public of Nye County's monitoring program be conducted through the CEMP. DRI provides a link to Nye County's TSaMP data from the CEMP website at http://www.cemp.dri.edu/.

Sections 7.1 and 7.2 of this chapter present the 2016 CEMP air and water monitoring results. Section 7.3 presents the 2016 accomplishments and monitoring results of the Nye County TSaMP. The radiological monitoring of air, groundwater, direct radiation, and biota conducted on the NNSS and the Nevada Test and Training Range (NTTR) by the U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO) are presented in Chapters 4, 5, 6, and 8.

7.1 CEMP Air Monitoring

In 2016, DRI managed 24 CEMP stations, which compose the Air Surveillance Network (ASN) (Figure 7-1). The ASN stations include various types of equipment used to monitor airborne radiation and meteorological conditions, as described in Section 7.1.1. More detailed descriptions of the various types of sensors located at the stations can be found at http://www.cemp.dri.edu/cemp/moreinfo.html. The CEMP station in Tonopah, Nevada, which has all of the air monitoring equipment described in Section 7.1.1, is shown in Figure 7-2.

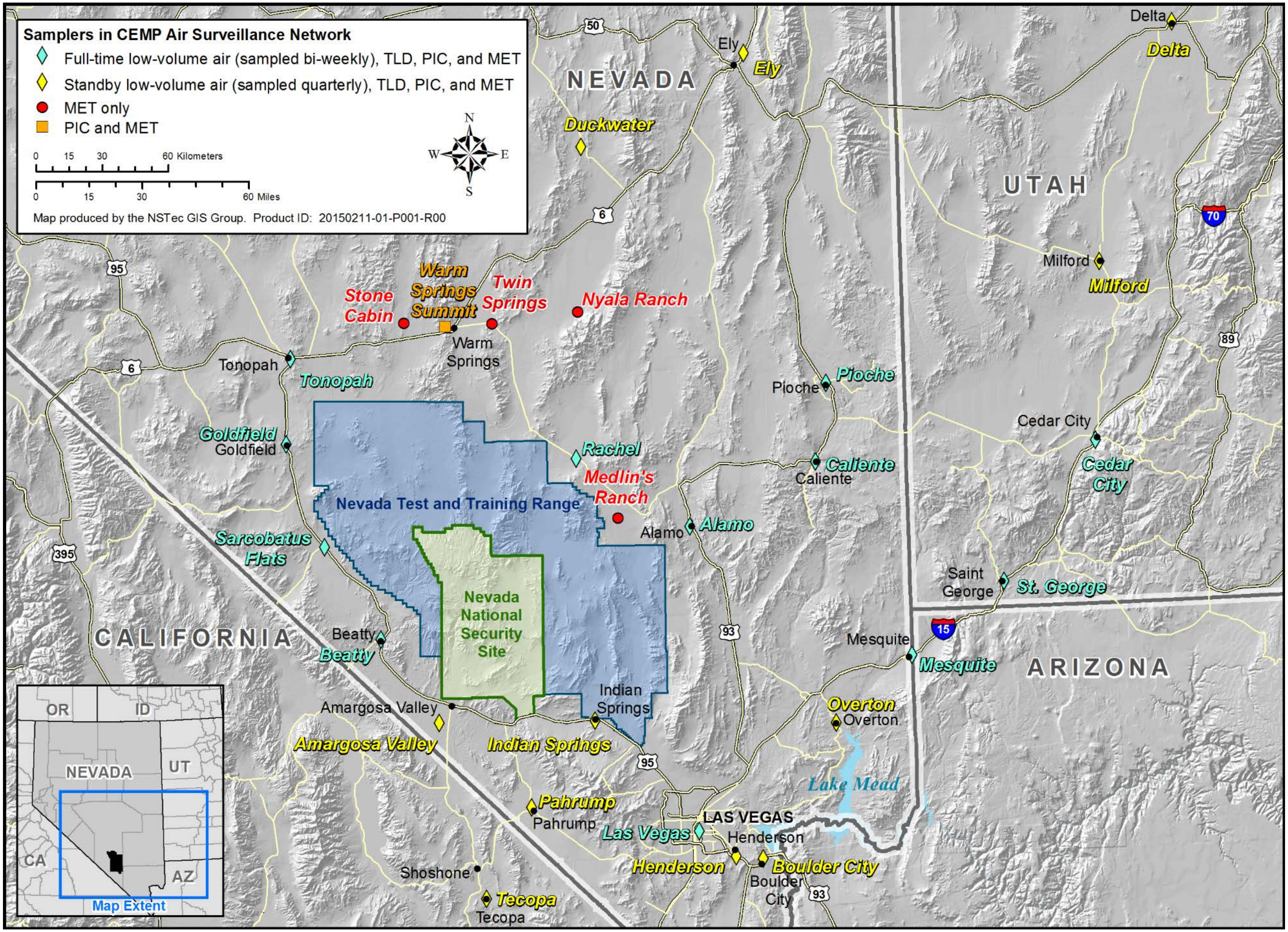

Figure 7-1. 2016 CEMP Air Surveillance Network

CEMP Goals
Provide independent monitoring at offsite locations and communicate environmental data relevant to past and continuing activities at the NNSS
Engage the public hands-on in monitoring environmental conditions in their communities relative to activities at the NNSS
Communicate environmental monitoring data to the public in a transparent and accessible manner
Provide an educated, trusted, local resource for public inquiries and concerns regarding past and present activities at the NNSS

7.1.1 Air Monitoring Equipment

CEMP Low-Volume Air Sampler Network – During 2016, the CEMP ASN included continuously operating low-volume particulate air samplers at 12 "full-time" stations that are either near to, or typically downwind from, the NNSS (Figure 7-1). The ASN in 2016 also included low-volume air samplers at 11 "standby" stations that are either farthest from the NNSS or most frequently upwind from the NNSS; these samplers collected 2-week air samples once each quarter (see Figure 7-1). Warm Springs Summit, Nevada, is the only ASN station where a low-volume air sampler is not located. Duplicate continuously operating air samplers are operated at two randomly selected full-time stations for 3 months (one calendar quarter) before being moved to a new location. Glass-fiber filters from the low-volume particulate samplers are collected by the CEMs and mailed to DRI, where they are prepared and forwarded to an independent laboratory to be analyzed for gross ***alpha*** and ***beta radioactivity*** (see Glossary, Appendix B). Samples are held for a minimum of 7 days after collection to allow for the decay of naturally occurring radon progeny. Upon completion of the gross alpha/beta analyses, the filters are returned to DRI to be composited on a quarterly basis for gamma spectroscopy analysis.

Figure 7-2. CEMP Station in Tonopah, Nevada

CEMP Thermoluminescent Dosimetry Network – Thermoluminescent dosimetry is used to measure both individual and population external exposure to ambient radiation from natural and artificial sources. In 2016, this network consisted of fixed environmental thermoluminescent dosimeters (TLDs) at 23 of the 24 CEMP stations (see Figure 7-1). A TLD is not currently deployed at Warm Springs Summit due to limited access during the winter months. The TLD used is a Panasonic UD-814AS. Within the TLD, a slightly shielded lithium borate element is used to check low-energy radiation levels, and three calcium sulfate elements are used to measure penetrating ***gamma radiation*** (see Glossary, Appendix B). For quality assurance (QA) purposes, duplicate TLDs are deployed at three randomly selected stations. An average daily exposure rate was calculated for each quarterly exposure period. The average of the quarterly values was multiplied by 365.25 days to obtain the total annual exposure for each station.

CEMP Pressurized Ion Chamber (PIC) Network – The PIC detector measures gamma radiation exposure rates and, because of its sensitivity, may detect low-level exposures that go undetected by other monitoring methods. PICs are in place at all 24 stations in the CEMP ASN (see Figure 7-1). The primary function of the PIC network is to detect changes in ambient gamma radiation due to human activities. In the absence of such activities, ambient gamma radiation rates vary naturally among locations, reflecting differences in altitude (cosmic radiation), radioactivity in the soil (terrestrial radiation), and slight variations at a single location due to weather patterns. Because a full suite of meteorological data is recorded at each CEMP station, variations in PIC readings caused by weather events such as precipitation or changes in barometric pressure are more readily identified. Variations can be easily viewed by selecting a station location on the Graph link from the CEMP home page, http://www.cemp.dri.edu/, then selecting the desired variables.

CEMP Meteorological (MET) Network – Changing weather conditions can have an effect on measurable levels of background radiation; therefore, meteorological instrumentation is in place at each of the 24 CEMP stations and at the four ranch MET stations that do not monitor airborne radiation: Stone Cabin, Twin Springs, Nyala Ranch, and Medlin's Ranch (see Figure 7-1).The MET network includes sensors that measure air temperature, humidity, wind speed and direction, solar radiation, barometric pressure, precipitation, and soil temperature and moisture data. All of these data can be observed real-time at the onsite station display, and archived data are available by accessing the CEMP home page at http://www.cemp.dri.edu/.

7.1.2 Air Sampling Methods

Samples of airborne particulates from CEMP ASN stations were collected by drawing air through a 5-centimeter (2-inch) diameter glass-fiber filter at a constant flow rate of 49.5 liters (1.75 cubic feet [ft^3]) per minute at standard temperature and pressure. The actual flow rate and total volume were measured with an in-line air-flow calibrator. The filter is mounted in a holder that faces downward at a height of approximately 1.5 meters (m) (5 feet [ft]) above the ground. The total volume of air collected ranged from approximately 1,030 to 1,290 cubic meters (m^3) (36,000 to 45,000 ft^3), depending on the elevation of the station and changes in air temperature and/or pressure.

During 2016, CEMP air samples were collected on a biweekly basis from the 12 full-time stations. This sampling frequency results in the possible collection of 26 samples per year from each full-time station. At the 11 standby stations, air samples were collected on a quarterly basis (one 2-week sample per quarter), resulting in the collection of only four samples per year.

7.1.3 Air Sampling Results

7.1.3.1 Gross Alpha and Gross Beta

Analyses of gross alpha and beta in airborne particulate samples are used to screen for long-lived radionuclides in the air. The mean annual gross alpha activity across all sample locations was $1.26 \pm 0.26 \times 10^{-15}$ microcuries per milliliter (µCi/mL) ($4.66 \pm 0.96 \times 10^{-5}$ becquerels [Bq]/m^3) (Table 7-1). Gross alpha was detectable in all of the 2016 air samples, and overall, gross alpha levels of activity were similar to results from previous years. Figure 7-3 shows the long-term maximum, mean, and minimum alpha trend for all CEMP stations combined. Since 2009, the mean gross alpha results have been essentially unchanged following a slight decreasing trend from 2006 to 2009. This trend is also reflected by most of the stations on an individual basis.

Table 7-1. Gross alpha results for the CEMP offsite ASN in 2016

		Concentration (× 10^{-15} µCi/mL [3.7 × 10^{-5} Bq/m^3])			
Sampling Location	**Number of Samples**	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**
Alamo	26	1.80	0.91	0.73	3.97
Amargosa Valley	4	1.32	0.39	0.82	1.83
Beatty	26	1.19	0.43	0.51	2.43
Boulder City	4	1.17	0.65	0.45	2.20
Caliente	26	1.39	0.53	0.69	2.63
Cedar City	26	0.88	0.40	0.41	2.09
Delta	4	0.89	0.26	0.56	1.26
Duckwater	4	0.96	0.12	0.85	1.12
Ely	3	1.04	0.36	0.53	1.31
Goldfield	26	1.13	0.44	0.56	2.44
Henderson	4	1.22	0.43	0.78	1.93
Indian Springs	4	1.12	0.26	0.71	1.39

Table 7-2. Gross alpha results for the CEMP offsite ASN in 2016 (continued)

Sampling Location	Number of Samples	Concentration ($\times 10^{-15}$ µCi/mL [3.7×10^{-5} Bq/m^3]) Mean	Standard Deviation	Minimum	Maximum
Las Vegas	26	1.31	0.61	0.58	3.29
Mesquite	26	1.35	0.43	0.68	2.43
Milford	4	1.05	0.35	0.74	1.64
Overton	4	1.65	1.14	0.59	3.57
Pahrump	4	1.28	0.32	0.78	1.57
Pioche	26	1.31	0.87	0.49	4.82
Rachel	25	1.23	0.50	0.38	2.84
Sarcobatus Flats	26	1.90	0.93	0.57	4.88
St. George	26	1.28	0.55	0.58	2.54
Tecopa	4	1.49	0.21	1.33	1.85
Tonopah	24	1.02	0.29	0.44	1.82

Network Mean = 1.26 ± 0.26 × 10^{-15} µCi/mL
Mean *Minimum Detectable Concentration (MDC)*; see Glossary, Appendix B) = 0.31 × 10^{-15} µCi/mL
Standard Error of Mean MDC = 0.5 × 10^{-15} µCi/mL

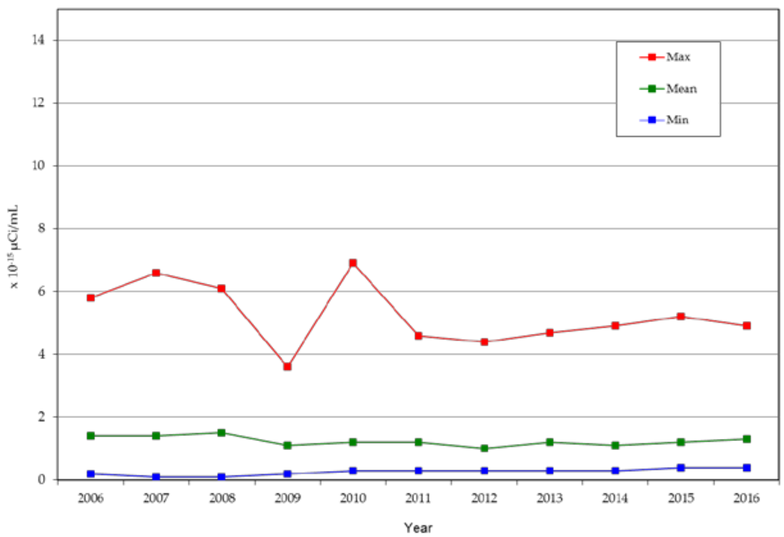

Figure 7-3. Historical trend for gross alpha analysis for all CEMP stations

The mean annual gross beta activity across all sample locations (Table 7-2) was 1.88 ± 0.22 × 10^{-14} µCi/mL (6.96 ± 0.81 × 10^{-4} Bq/m^3). Gross beta activity was detected in all air samples and, overall, was similar to previous years' levels. Figure 7-4 shows the long-term maximum, mean, and minimum beta trend for all stations combined. The 2011 peak in the maximum data, observed across all stations in the network, was due to the tsunami-damaged Fukushima Nuclear Power Plant accident in Japan. Except for 2011, mean gross beta results have been essentially level from 2006 to 2016. This trend is also reflected by most of the stations on an individual basis.

Table 7-2. Gross beta results for the CEMP offsite ASN in 2016

Sampling Location	Number of Samples	Concentration ($\times 10^{-14}$ µCi/mL [3.7×10^{-4} Bq/m^3]) Mean	Standard Deviation	Minimum	Maximum
Alamo	26	2.02	0.55	1.13	3.53
Amargosa Valley	4	1.95	0.29	1.65	2.34
Beatty	26	1.80	0.48	1.13	3.28
Boulder City	4	1.96	0.63	1.22	2.76
Caliente	26	2.04	0.49	1.42	3.60
Cedar City	26	1.53	0.42	0.97	3.03
Delta	4	1.85	0.29	1.35	2.06

Table 7-2. Gross beta results for the CEMP offsite ASN in 2016 (continued)

Sampling Location	Number of Samples	Concentration (× 10^{-14} µCi/mL [3.7 × 10^{-4} Bq/m^3]) Mean	Standard Deviation	Minimum	Maximum
Duckwater	4	1.78	0.20	1.44	1.98
Ely	4	1.23	0.20	0.95	1.39
Goldfield	26	1.73	0.42	1.10	2.98
Henderson	4	1.83	0.24	1.50	2.09
Indian Springs	4	1.84	0.32	1.51	2.18
Las Vegas	26	1.95	0.50	1.27	3.24
Mesquite	26	2.05	0.53	1.26	3.83
Milford	4	1.90	0.31	1.38	2.16
Overton	4	2.10	0.44	1.58	2.59
Pahrump	4	1.88	0.29	1.46	2.22
Pioche	26	1.62	0.47	0.89	3.20
Rachel	25	2.03	0.67	1.09	3.99
Sarcobatus Flats	26	1.97	0.50	1.22	3.57
St. George	26	2.24	0.57	1.34	3.84
Tecopa	4	2.30	0.29	1.80	2.60
Tonopah	24	1.64	0.47	1.12	3.20

Network Mean = 1.88 ± 0.22 × 10^{-14} µCi/mL **Mean MDC = 0.04 × 10^{-14} µCi/mL**
Standard Error of Mean MDC = 0.004 × 10^{-14} µCi/mL

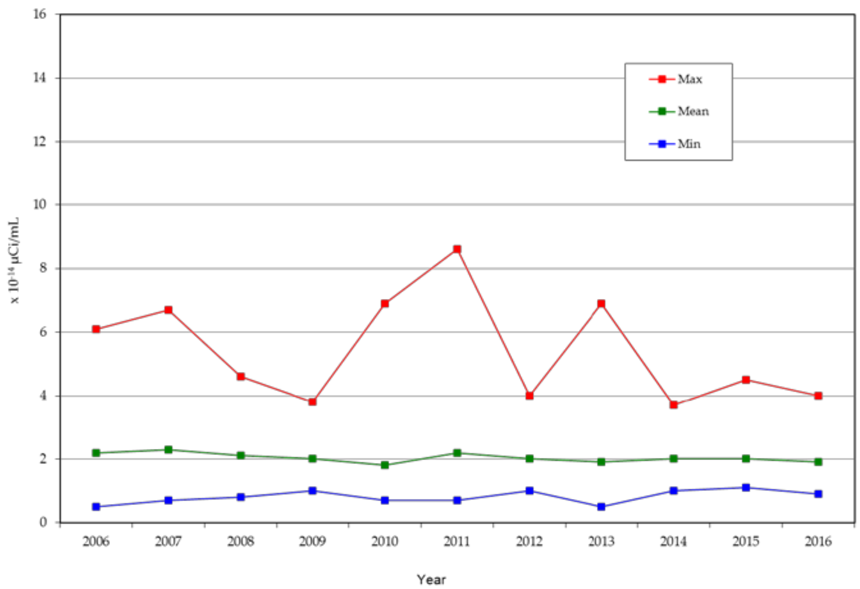

Figure 7-4. Historical trend for gross beta analysis for all CEMP stations

7.1.3.2 Gamma Spectroscopy

Gamma spectroscopy analysis was performed on all samples from the low-volume air sampling network. Generally, the filters were composited by station on a quarterly basis after gross alpha/beta analysis. As in previous years, man-made gamma-emitting radionuclides were not detected in any samples. In most of the samples, naturally occurring beryllium-7 (^{7}Be) was detectable. This radionuclide is produced by cosmic ray interaction with nitrogen in the atmosphere. The mean annual activity for ^{7}Be for the sampling network was 0.34 ± 0.09 × 10^{-13} µCi/mL.

7.1.4 TLD Results

TLDs measure ionizing radiation from all sources, including natural radioactivity from cosmic or terrestrial sources and from man-made radioactive sources. The TLDs are mounted in a Plexiglas holder approximately

1 m (3.3 ft) above the ground and are exchanged quarterly. TLD results are not presented for the Warm Springs Summit station at this time because its access is limited in the winter months. This does not allow for a proper quarterly change of the TLD as required. The total annual exposure for 2016 ranged from 76 milliroentgens (mR) (0.76 millisieverts [mSv]) at Pahrump, Nevada, to 157 mR (1.57 mSv) at Milford, Utah, with a mean annual exposure of 114 mR (1.14 mSv) for all operating locations. Results are summarized in Table 7-3 and are consistent with previous years' data. Figure 7-5 shows the long-term data trend for the CEMP stations as a whole. Overall, the TLD data show a generally increasing trend from 2010 to 2016, following a slightly decreasing trend from 2006 to 2010. The 2016 results are slightly lower than 2014.

Table 7-3. TLD monitoring results for the CEMP offsite ASN in 2016

Sampling Location	Number of Quarters	Estimated Annual Exposure (mR)[(a)]		
		Mean[(b)]	Minimum[(b)]	Maximum[(b)]
Alamo	4	116	108	124
Amargosa Valley	4	110	96	118
Beatty	4	145	133	153
Boulder City	4	112	104	116
Caliente	4	117	99	125
Cedar City	4	96	90	104
Delta	4	99	90	112
Duckwater	4	117	102	129
Ely	4	106	88	116
Goldfield	4	130	116	137
Henderson	4	122	108	128
Indian Springs	4	98	87	106
Las Vegas	4	100	88	106
Mesquite	4	106	99	116
Milford	4	145	138	157
Overton	4	102	92	107
Pahrump	4	85	76	92
Pioche	4	124	113	129
Rachel	4	126	112	141
Sarcobatus Flats	4	138	124	145
St. George	4	87	77	96
Tecopa	4	112	109	116
Tonopah	4	136	128	145

(a) To obtain daily exposure rates, divide annual exposure rates by 365.25
(b) Mean, minimum, and maximum values are from quarterly estimates

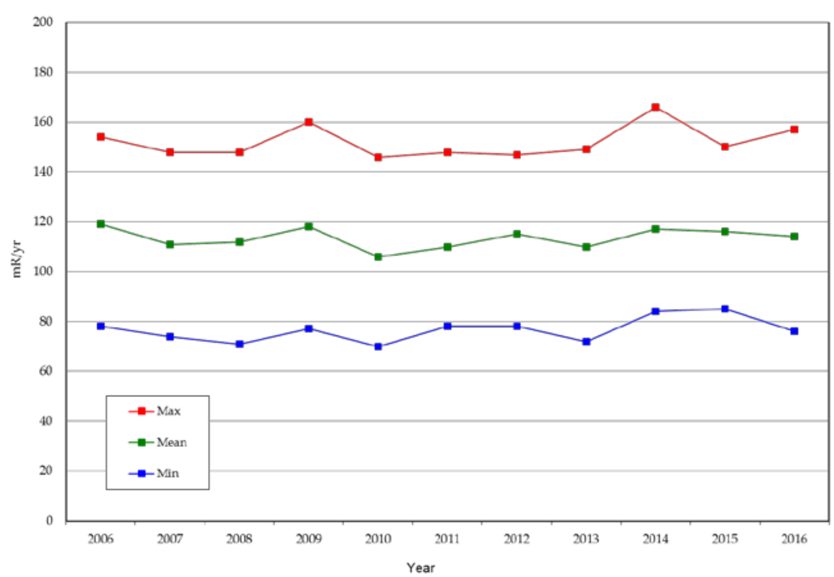

Figure 7-5. Historical trend for TLD analysis for all CEMP stations

7.1.5 PIC Results

The PIC data presented in this section are based on daily averages of gamma exposure rates from each station. Table 7-4 contains the maximum, minimum, and standard deviation of daily averages (in microroentgens per hour [µR/hr]) for the periods during 2016 when data were available. It also shows the average gamma exposure rate for each station during the year (in µR/hr) as well as the total annual exposure (in milliroentgens per year [mR/yr]). The exposure rate ranged from 71.83 mR/yr (0.72 mSv/yr) in Pahrump, Nevada, to 176.51 mR/yr (1.77 mSv/yr) at Milford, Utah. Background levels of environmental gamma exposure rates in the United States (from combined effects of terrestrial and cosmic sources) vary between 49 and 247 mR/yr (BEIR III 1980). Averages for selected regions of the United States were compiled by the U.S. Environmental Protection Agency and are shown in Table 7-5. The annual exposure levels observed at the CEMP stations in 2016 are well within these United States background levels, and are consistent with previous years' exposure rates.

Table 7-4. PIC monitoring results for the CEMP offsite ASN in 2016

Sampling Location	Daily Average Gamma Exposure Rate (µR/hr) Mean	Standard Deviation	Minimum	Maximum	Annual Exposure (mR/yr)
Alamo	13.40	0.32	12.3	14.5	117.38
Amargosa Valley	11.70	0.18	11.0	12.4	102.49
Beatty	17.00	0.31	16.1	17.9	148.92
Boulder City	16.20	0.17	15.5	16.9	141.91
Caliente	15.7	0.29	14.7	16.7	137.53
Cedar City	10.45	0.24	9.6	11.3	91.54
Delta	12.55	0.24	11.5	13.6	109.94
Duckwater	14.65	0.47	13.2	16.1	128.33
Ely	12.15	0.42	10.4	13.9	106.43
Goldfield	15.55	0.73	14.0	17.1	136.22
Henderson	13.75	1.41	12.5	15	120.45
Indian Springs	11.25	0.20	10.7	11.8	98.55
Las Vegas	10.4	0.85	8.6	12.2	91.10
Mesquite	11.8	0.18	11.2	12.4	103.37
Milford	20.15	1.70	16.3	24.0	176.51
Overton	12.1	0.21	11.4	12.8	106.00
Pahrump	8.2	0.18	7.6	8.8	71.83
Pioche	15.4	0.68	12.4	18.4	134.90
Rachel	14.85	0.32	13.4	16.3	130.09
Sarcobatus Flats	17.4	0.30	15.9	17.4	145.85
St. George	10.2	0.21	9.5	10.9	89.35
Tecopa	13.15	0.21	12.5	13.8	115.19
Tonopah	15.95	0.45	14.3	17.6	139.72
Warm Springs Summit	18.7	0.66	16.5	20.9	163.81

Table 7-5. Average natural background radiation (excluding radon) for selected U.S. cities

City	Annual Exposure (mR/yr)
Denver, CO	164.6
Fort Worth, TX	68.7
Las Vegas, NV	69.5
Los Angeles, CA	73.6
New Orleans, LA	63.7
Portland, OR	86.7
Richmond, VA	64.1
Rochester, NY	88.1
St. Louis, MO	87.9
Tampa, FL	63.7
Wheeling, WV	111.9

Source: http://www.wrcc.dri.edu/cemp/Radiation.html. "Radiation in Perspective," August 1990 (Access Date: 3/10/17)

7.1.6 Environmental Impact

Results of analyses conducted on data obtained from the CEMP network of low-volume particulate air samplers, TLDs, and PICs showed no measurable evidence at CEMP station locations of offsite impacts from radionuclides from NNSA/NFO activities. Activity observed in gross alpha and beta analyses of low-volume air sampler filters was consistent with previous years' results and is within the range of activity found in other communities of the United States that are not adjacent to man-made radiation sources. Likewise, no man-made gamma-emitting radionuclides were detected. TLD and PIC results remained consistent with previous years' background levels and are well within average background levels observed in other parts of the United States (see Table 7-5).

Occasional elevated gamma readings (10%–50% above normal average background) detected by the PICs in 2016 were always associated with precipitation events and/or low barometric pressure. Low barometric pressure can result in the release of naturally occurring radon and its daughter products from the surrounding soil and rock substrates. Precipitation events can result in the "rainout" of globally distributed radionuclides occurring as airborne particulates in the upper atmosphere. Figure 7-6, generated from the CEMP website, illustrates an example of this phenomenon.

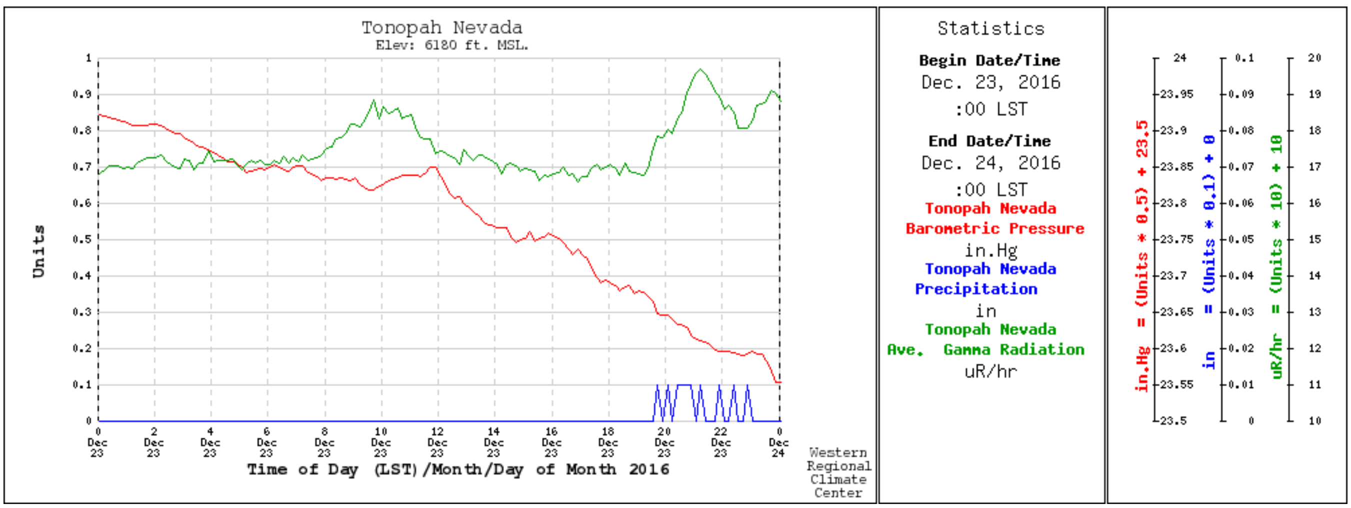

Figure 7-6. The effect of meteorological phenomena on background gamma readings at the Tonopah CEMP station

7.2 CEMP Surface and Groundwater Monitoring

The CEMP water monitoring program is a non-regulatory public informational and outreach program. It provides the public with water data regarding the presence of man-made radionuclides that could be the result of past nuclear testing on the NNSS. The CEMP monitors four groundwater wells that are downgradient of the NNSS (Figure 7-7). Water samples are collected by DRI personnel and analyzed for tritium. Tritium is one of the most abundant radionuclides generated by an underground nuclear test, and because it is a constituent of the water molecule itself, it is also one of the most mobile. DRI provides public access to water monitoring data through CEMP's website at http://www.cemp.dri.edu/.

7.2.1 Sample Locations and Methods

During August and September 2016, DRI sampled four wells. Sample locations (Figure 7-7) were selected based upon input from the CEMs participating in the CEMP project in communities located downgradient of the NNSS. All wells were sampled at a water delivery point (i.e., faucet). Each of these samples originated from water well distribution lines that connect to submersible pumps that sample the local groundwater system. Water was allowed to flow from each water delivery point for 5 to 15 minutes prior to sampling in order to purge stagnant water from the distribution lines. This process ensured that the resultant sample was representative of local groundwater. Table 7-6 describes the sample locations, the date they were sampled, and the sampling method.

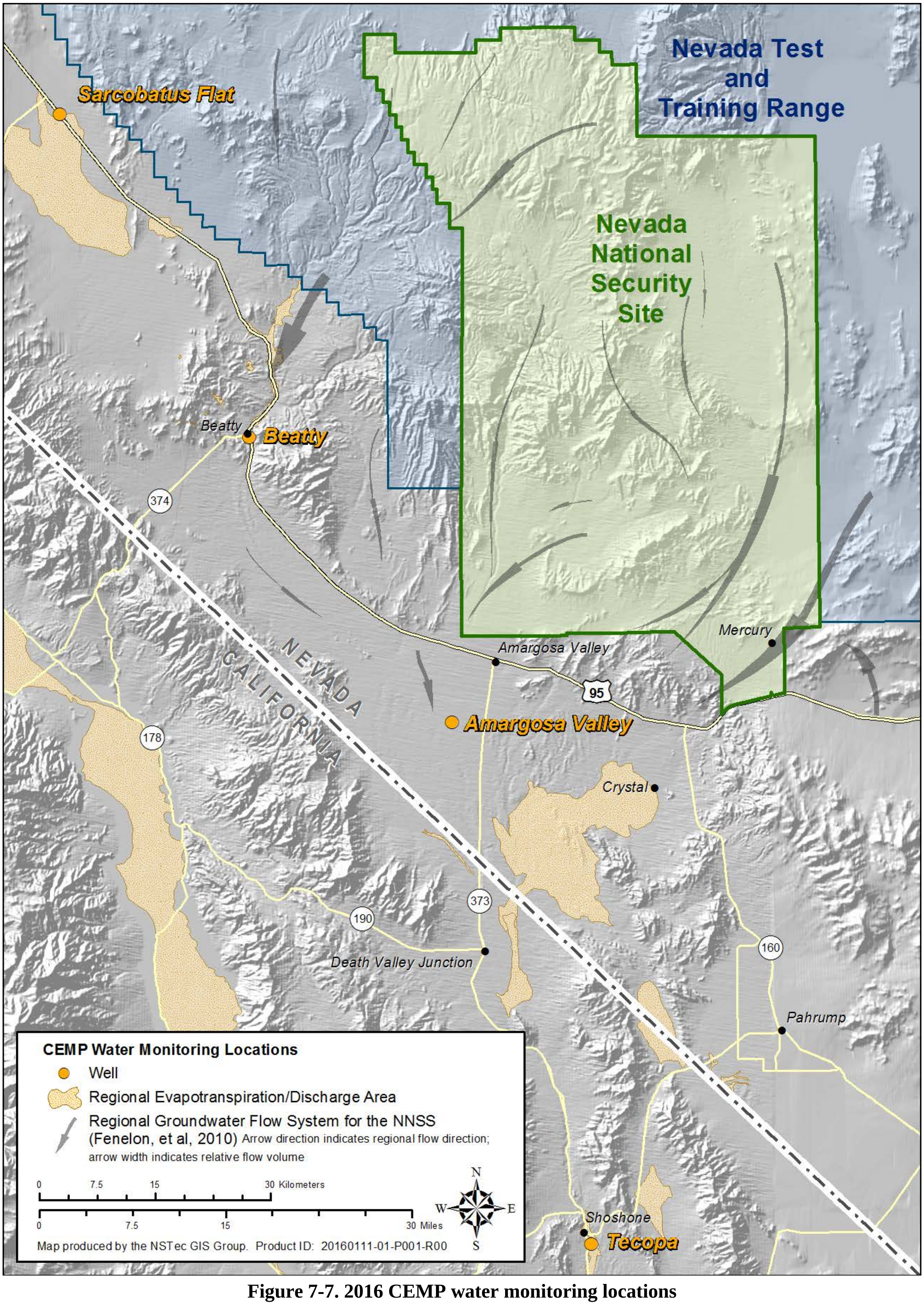

Figure 7-7. 2016 CEMP water monitoring locations

Table 7-6. CEMP water monitoring locations sampled in 2016

Monitoring Location Description	Latitude[(a)]	Longitude[(a)]	Date Sampled	Sample Collection Method
Amargosa Valley school well	36°34.16"	−116°27.66"	8/12/2016	By hand from sink in office of elementary school
Beatty Water and Sewer municipal water distribution system	36°54.93"	−116°45.66"	8/19/2016	By hand from distribution system; represents a blended sample from multiple municipal water supply wells.
Sarcobatus Flats well	37°16.76"	−117°01.10"	8/12/2016	By hand at residential source
Tecopa residential well	35°50.86"	−116°13.63"	9/2/2016	By hand at residential source

Samples collected in 2016 were analyzed using unenriched scintillation counting at ARS International laboratory in Port Allen, Louisiana. Unenriched scintillation counting is an Environmental Protection Agency (EPA)-approved method for tritium analysis. The ***decision level (L_C)*** (see Glossary, Appendix B) for this counting process was less than 146 picocuries per liter (pCi/L). The L_C is established solely based on the variability of multiple measures of samples used to establish laboratory background. If a sample exceeds this threshold, then it is considered to be distinguishable from background. The ***minimum detectable concentration*** (***MDC)*** (see Glossary, Appendix B) for tritium was approximately 299 pCi/L and is a more rigorous threshold that dictates that the sample be distinguishable from background at a confidence of 95%. The MDC considers both the variability associated with multiple measures of the background as well as the variability associated with multiple measures of the sample itself. The L_C and the MDC are less than 1% and 2% of the EPA limit for tritium in drinking water of 20,000 pCi/L, respectively. Chapter 15 discusses the quality assurance and control procedures used for sampling groundwater.

7.2.2 Results of Groundwater Monitoring

Tritium analyses from ARS International for the four groundwater samples yielded results that were all quantifiably below background (≤ the MDC of approximately 299 pCi/L). Public access to the monitoring data is available on the DRI CEMP website at http://www.cemp.dri.edu/.

7.3 Nye County Tritium Sampling and Monitoring Program

In 2014, NNSA/NFO began to investigate expanding its support of offsite community-based monitoring of wells in Nye County in response to the county’s request to become involved. As a result, the Nye County TSaMP was initiated in 2015. The DOE EM office issued a 5-year grant to Nye County for this program to monitor tritium in wells downgradient from the NNSS. The grant supports annual sampling of 10 wells in the first year and up to 20 wells every year thereafter. It also supports Nye County’s involvement in technical reviews of the UGTA corrective action program (see Chapter 11). To help determine sample well locations, Nye County has committed to coordinate with DRI, who conducts the CEMP, with the CEMP’s CEMs, and with Nye County citizens. Nye County communicates their TSaMP activities and results to the public through poster presentations at annual DOE EM-funded Groundwater Open House meetings (see Chapter 11, Section 11.6), through presentations at annual CEMP meetings, through articles published in the Pahrump Valley Times, and through this annually published report.

In 2016, Nye County sampled 18 wells and 2 springs (Figure 7-8). They include 10 “core” wells that were first sampled in 2015 and which will be sampled annually, and 10 additional locations (8 wells and 2 springs) (Table 7-7). Sample locations were selected based upon groundwater flow paths off of the NNSS, proximity of wells to downgradient communities, and recommendations provided by CEMs or Nye County citizens. Wells managed by Nye County and being sampled for tritium under the TSaMP were initially drilled as part of the Early Warning Drill Program (“EWDP” labelled wells), or as Nye County Groundwater Evaluation Wells (“NC-GWE” labelled wells). Nye County also takes water levels in these wells on a quarterly basis through funding from the Nye County Water District’s Water Level Measurement Program. Some locations selected for sampling under the TSaMP may include NNSA/NFO wells or locations that are also sampled under the NNSS Integrated Groundwater Sampling Plan (see Section 5.1) or under the CEMP.

All wells sampled in 2016 were sampled using either an air-powered submersible positive displacement pump or a 3-inch submersible electric pump. A minimum of three well volumes (16 to 1,158 gallons) was pumped from each

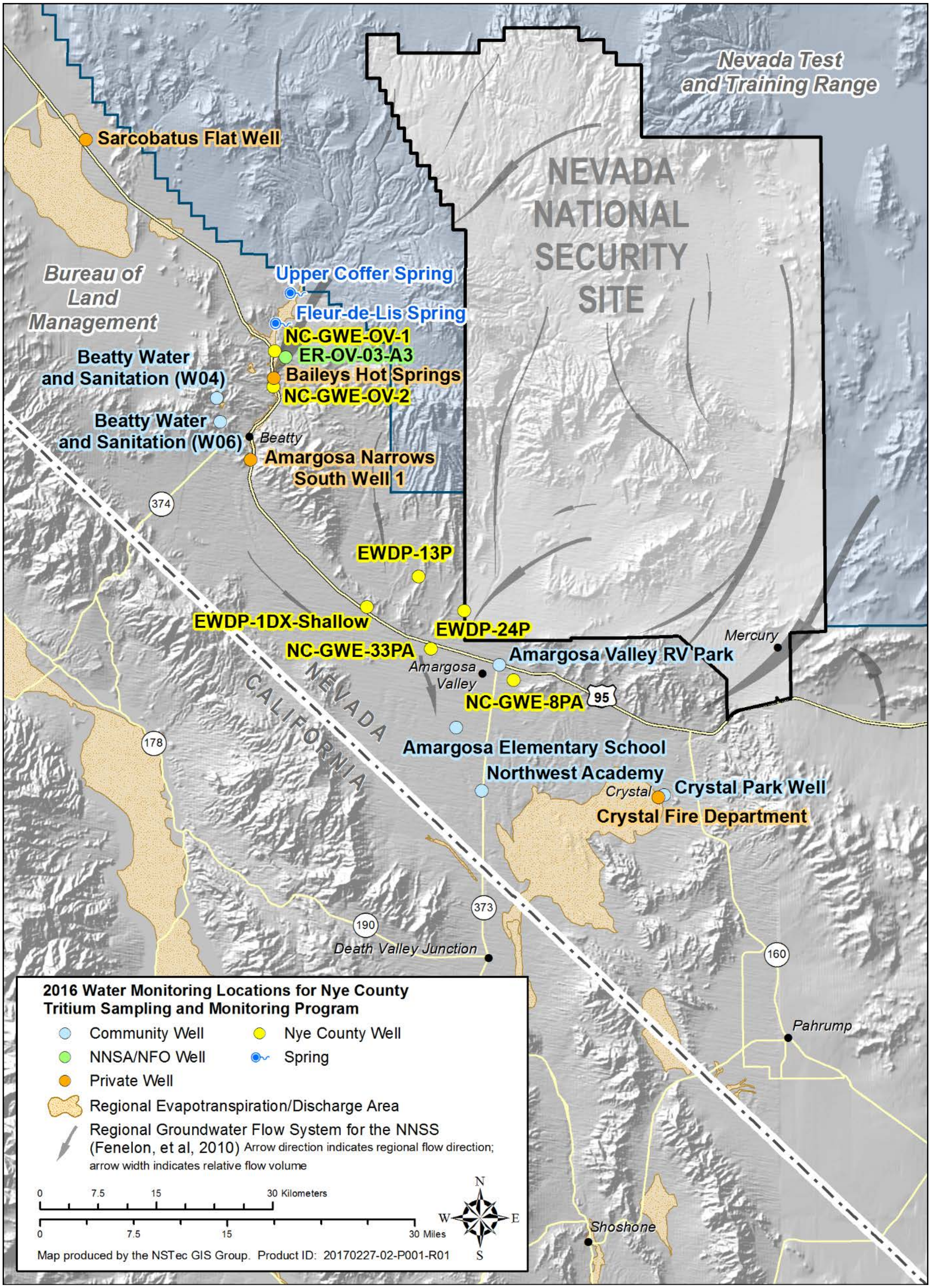

Figure 7-8. Nye County water monitoring locations

well prior to sampling in order to purge water from the pump tubing and well annulus. This process ensured that the resultant samples were representative of local groundwater conditions. Community wells, which are operating domestic or municipal wells, were sampled from the dedicated pump discharge. These wells were purged prior to sampling to insure that representative water samples were being obtained. The two springs sampled in 2016 are on private land and were sampled by taking the samples directly from the spring discharge.

The collected samples were analyzed for tritium by Radiation Safety Engineering, Inc., in Chandler, Arizona using an EPA-approved, unenriched scintillation counting method. The sample MDCs for this counting process was 288 pCi/L, which is less than 2% of the EPA limit for tritium in drinking water of 20,000 pCi/L. Analytical methods included the use of quality control samples such as duplicates, blanks, and spikes. Nye County's quality assurance procedures for the tritium sampling is documented in Test Plan TPN-11.8, "Groundwater Sampling and Analysis for the Nye County Tritium Sampling and Monitoring Program," and Work Plan WP-11, "Groundwater Chemistry Sampling and Analysis" (available on the Nye County website at http://www.co.nye.nv.us/index.aspx?NID=901).

All tritium analysis results were quantifiably below background, i.e., ≤ the MDC (Tables 7-7). Similar to the CEMP water sampling results (Section 7.2) and those of the Community wells within NNSA/NFO's water sampling network (Chapter 5, Section 5.1.3.5), Nye County's monitoring confirms that tritium from historical underground nuclear testing on the NNSS is not present in these wells.

Table 7-7. Nye County water monitoring locations sampled in 2016

Sample Locations	Latitude(a)	Longitude(a)	Date Sampled	Tritium Concentration (pCi/L)
Nye County Wells				
EWDP-1DX-Shallow	36° 42' 34"	-116° 35' 18"	11/16/16	<288
EWDP-13P*	36° 44' 40"	-116° 30' 50"	11/17/16	<288
			11/17/16 FD(b)	<288
			11/17/16 FB(c)	<288
EWDP-24P*	36° 42' 17"	-116° 26' 53"	11/8/16	<288
			11/8/16 FD	<288
NC-GWE-8PA*	36° 37' 28"	-116° 22' 38"	11/7/16	<288
NC-GWE-33PA	36° 39' 39"	-116° 29' 45"	11/16/16	<288
NC-GWE-OV-1*	37° 0' 22"	-116° 43' 15"	11/21/16	<288
NC-GWE-OV-2*	36° 57' 52"	-116° 43' 23"	12/16/16	<288
			12/16/16 FD	<288
NNSA/NFO Wells				
ER-OV-03-A3	36° 59' 56"	-116° 42' 19"	11/29/16	<288
			11/2916 FD	<288
Community Wells				
Amargosa Elementary School*	36° 34' 11"	-116° 27' 39"	12/1/16	<288
Amargosa Valley RV Park*	36° 38' 31"	-116° 23' 51"	11/21/16	<288
Beatty Water and Sanitation, Indian Springs Well (W04)*	36° 57' 6"	-116° 48' 16"	12/16/15	<288
Beatty Water and Sanitation, Summit Well (W06)	36° 55' 27"	-116° 47' 59"	12/12/16	<288
Crystal Park Well	36° 29' 26"	-116° 9' 42"	12/1/16	<288
Northwest Academy*	36° 29' 46"	-116° 25' 25"	12/21/15	<288
Private Wells				
Amargosa Narrows South Well 1	36° 52' 49"	-116° 45' 20"	11/28/16	<288
Baileys Hot Springs*	36° 58' 29"	-116° 43' 21"	11/21/16	<288
Crystal Fire Department	36° 29' 16"	-116° 10' 11"	12/1/16	<288
Sarcobatus Flat Well	37° 15' 3"	-116° 59' 43"	12/8/16	<288
Springs				
Fleur-de-Lis Spring	37° 2' 18"	-116° 42' 45"	12/13/16	<288
			12/13/16 FD	<288
			12/13/16 FB	<288
Upper Coffer Spring	37° 4' 26"	-116° 41' 28"	12/6/16	<288

* Represents "core" wells, which are sampled annually
(a) Coordinates are North American Datum 1983 (b) Field duplicate (c) Field blank

On April 4, 2016, the Pahrump Valley Times printed TSaMP's 2015 monitoring results (see TSaMP Article in PVT). On July 16, 2016, Nye County presented a poster at NNSA/NFO's Seventh Annual Groundwater Open House at the Amargosa Community Center in Nevada (see Page 20 of the 2016 meeting's compiled posters found at the NNSA/NFO Groundwater Open House web page). Nye County also gave a presentation describing the program and the 2015 results at an annual CEMP meeting in Tonopah, Nevada on July 30, 2016.

7.4 Environmental Impact

As in previous years, the wells and water supply systems within the CEMP and Nye County monitored wells downgradient of the NNSS showed no evidence of tritium contamination from past underground nuclear testing on the NNSS. However, in 2009, tritium was detected by NNSA/NFO off site above the tritium standard analysis method MDC in the UGTA characterization well, ER-EC-11, which is approximately 700 m (2,297 ft) west of the NNSS on the NTTR (see Chapter 11, Section 11.1.1.2 and Figure 11-4). Well ER-EC-11 was last monitored in 2014 and had a tritium concentration of 16,100 pCi/L. Three wells farther off site from the NNSS on the NTTR have been found to contain tritium at very low levels using enriched tritium analyses: wells ER-EC-6 (5.2 pCi/L), ER-EC-12 (4.2 pCi/L, and PM-3 (194 pCi/L) (see Chapter 5, Table 5-4 and Sections 5.1.3.1 and 5.1.3.3). Well PM-3 is the farthest well from the NNSS border (approximately 3.3 km or 2 mi). Additional sampling and analyses are needed to confirm these amounts of tritium. Groundwater characterization and modeling activities are ongoing and will be used to forecast the extent of offsite contamination over the next 1,000 years. The nearest CEMP water monitoring locations that are downgradient of the NNSS nuclear testing areas are Amargosa Valley and Beatty, approximately 70 km (43 mi) and 40 km (25 mi), respectively, southwest of Well ER-EC-11. The Amargosa Valley and Beatty wells are approximately 67 km (42 mi) and 38 km (24 mi), respectively, southwest of Well ER-EC-12, the closest of the NTTR wells mentioned above.

7.5 References

BEIR III, 1980. *The Effects on Populations of Exposure to Low Levels of Ionizing Radiation: 1980*. Committee on the Biological Effects of Ionizing Radiation III, National Academy Press, Washington, D.C.

Chapter 8: Radiological Biota Monitoring

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Historical atmospheric nuclear weapons testing, outfalls from underground nuclear tests, and radioactive waste disposal sites provide potential sources of radiation contamination and exposure to Nevada National Security Site (NNSS) plants and animals (biota). U.S. Department of Energy (DOE) Order DOE O 458.1, "Radiation Protection of the Public and the Environment," requires that DOE sites monitor radioactivity in the environment to ensure that the public does not receive a radiological dose greater than 100 millirems per year (mrem/yr) from all pathways of exposure, including the ingestion of contaminated plants and animals. DOE O 458.1 also requires monitoring to ensure aquatic and terrestrial plant and animal populations are protected from excessive radiological dose.

The U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO) land use practices on the NNSS discourage the harvest of plants or plant parts (e.g., pine nuts and wolfberries) for direct consumption by humans. Some edible plant material might be taken off site and consumed, but this is generally not allowed and, if it does occur, is very limited. Game animals on the NNSS might travel off the site and become available through hunting for consumption by the public, which makes the ingestion of game animals the primary potential biotic pathway for dose to the public.

Plants and game animals are monitored under the Routine Radiological Environmental Monitoring Plan (RREMP) (Bechtel Nevada [BN] 2003). They are sampled annually from contaminated NNSS sites to estimate doses to persons hypothetically consuming them, to measure the potential for radionuclide transfer through the food chain, and to determine if NNSS biota are exposed to radiation levels harmful to their own populations. Measurements of gamma-emitting radionuclides in soil are made at routinely monitored locations to monitor changes over time and to establish concentration ratios between soil and plants and animals. Biota and soil samples from the Radioactive Waste Management Sites (RWMSs) are also periodically collected to assess the integrity of waste disposal cells. This chapter describes the biota monitoring program designed to meet public and environmental radiation protection regulations (see Section 2.4) and presents the field sampling and analysis results from 2016. The estimated dose to humans potentially consuming NNSS plants and animals and the dose to biota from these radionuclides are presented in Chapter 9.

Radiological Biota Monitoring Goals
Collect and analyze biota samples for radionuclides to estimate the potential dose to humans who may consume plants or game animals from the NNSS (see Chapter 9 for the estimates of dose to humans).
Collect and analyze biota samples for radionuclides to estimate the absorbed radiation dose to NNSS biota (see Chapter 9 for the estimates of dose to NNSS plants and animals).
Collect and analyze soil samples at the Area 3 and Area 5 RWMSs to provide evidence that the burrowing activities of fossorial animals have or have not compromised the integrity of the soil covered waste disposal units.

8.1 Species Selection

The goal for vegetation monitoring is to sample the plants most likely to have the highest contamination within the NNSS environment. They are generally found inside demarcated radiological areas near the "ground zero" locations of historical aboveground or near-surface nuclear tests. The species selected for sampling represent the most dominant life forms (e.g., trees, shrubs, herbs, or grasses) at these sites. Woody vegetation (i.e., shrubs versus forbs or grasses) is sampled because it is reported to have deeper penetrating roots and higher concentrations of tritium (^3H) (Hunter and Kinnison 1998). Woody vegetation also is a major source of browse for game animals that might potentially migrate off site. Grasses and forbs are sampled when present because they are also a source of food for wildlife. Plant parts collected for analysis represent new growth over the past year. Pine nuts from singleleaf pinyon pine trees, which may be consumed by humans, are also sampled periodically.

When determining the potential dose to animals, the goal of sampling is to select species that are most exposed and most sensitive to the effects of radiation. In general, mammals and birds are more sensitive to radiation than fish, amphibians, or invertebrates (DOE Standard DOE-STD-1153-2002, "A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota"). Because of this, and because no native fish or amphibians are found on the NNSS, the species in Table 8-1 are used to assess potential dose to animals.

The game animals monitored to assess the potential dose to the public meet three criteria: (1) they are a species consumed by humans; (2) they have a home range that overlaps a contaminated site and, as a result, have the potential for relatively high radionuclide body burdens from exposure to contaminated soil, air, water, or plants at the contaminated site; and (3) they are sufficiently abundant at a site that an adequate tissue sample can be acquired for laboratory analysis. These criteria limit the candidate game animals to those listed in Table 8-1. Mule deer, pronghorn antelope, bighorn sheep, and predatory game animals such as mountain lions are only collected as the opportunity arises, that is, if they are found dead on the NNSS (e.g., killed by a predator or accidentally hit by a vehicle). Tissues from species analogous to big game, such as feral horses, may be collected opportunistically as well. If game animals are not sufficiently abundant at a particular site or at a particular time, non-game small mammals may be used as an analog (Table 8-1).

The sampling strategy used to assess the integrity of radioactive waste containment includes sampling plants, animals, and soil excavated by ants or small mammals on top of waste covers. Plants are generally selected by size with preference for larger shrubs, under the assumption that they have deeper roots and therefore would be more likely to penetrate buried waste. Small mammals selected for sampling meet three criteria: (1) they are fossorial (i.e., they burrow and live predominantly underground), (2) they have a home range small enough to ensure that they reside a majority of the time on the waste disposal site, and (3) they are sufficiently abundant at a site to acquire an adequate tissue sample for laboratory analysis. These criteria limit the animals to those listed in Table 8-1. Soils excavated by ants or small mammals are also selected for sampling on the basis of size, with preference for larger ant mounds and animal burrow sites under the assumption that these burrows are deeper and have a higher potential for penetrating waste.

Table 8-1. NNSS animals monitored for radionuclides

Small Mammals	Large Mammals	Birds
Game Animals Monitored for Dose Assessments		
Cottontail rabbit *(Sylvilagus audubonii)*	Mule deer *(Odocoileus hemionus)*	Mourning dove *(Zenaida* macroura)
Jackrabbit *(Lepus californicus)*	Pronghorn antelope *(Antilocapra americana)*	Chukar *(Alectoris chukar)*
	Mountain lion *(Puma concolor)*	Gambel's quail *(Callipepla gambelii)*
	Desert bighorn sheep *(Ovis canadensis nelsoni)*	
	Bobcat *(Lynx rufus)*	
Animals Monitored for Integrity of Radioactive Waste Containment or as Game Animal Analogs		
Kangaroo rats *(Dipodomys spp.)*		
Mice *(Peromyscus spp.)*		
Antelope ground squirrel *(Ammospermophilus leucurus)*		
Desert woodrat *(Neotoma lepida)*		

8.2 Site Selection

The monitoring program design focuses on sampling sites that have the highest concentrations of radionuclides in other media (e.g., soil and surface water) and have relatively high densities of candidate animals. The RREMP identifies five contaminated sites and their associated control sites. Each year, biota from one or two of these sites is sampled, and each of the sites is sampled once every 5 years. They are E Tunnel Ponds, Palanquin/Schooner Crater, Sedan Crater, T2, and Plutonium Valley (Figure 8-1), and each is associated with one type of a legacy contamination area (see list below). The control site selected for each contaminated site has similar biological and physical features. Control sites are sampled to document the radionuclide levels representative of background.

- **Runoff areas or containment ponds associated with underground or tunnel test areas.** Contaminated water draining from test areas can form surface water sources that are important given the limited availability of surface water on the NNSS. Therefore, they have a high potential for transferring radionuclides to plants and wildlife

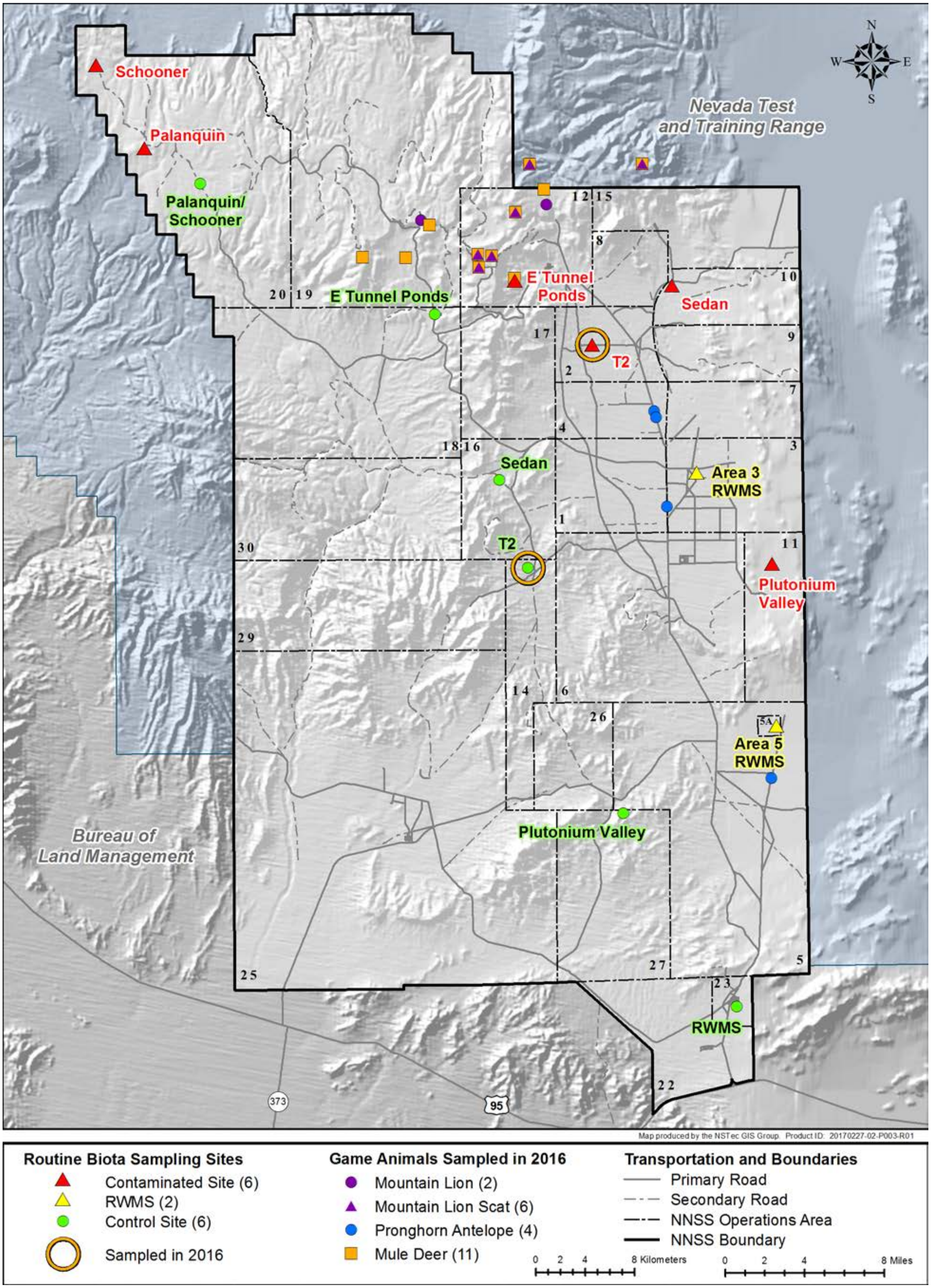

Figure 8-1. Radiological biota monitoring sites on the NNSS

seeking surface water. The associated monitoring site is E Tunnel Ponds below Rainier Mesa. It was last sampled in 2012.

- **Plowshare sites in alluvial fill at lower elevations with high surface contamination.** The historical ***Plowshare Program*** (see Glossary, Appendix B), conducted throughout the NNSS, explored the potential use of nuclear weapons for peaceful purposes. Subsurface nuclear detonations at these alluvial, low elevation sites have distributed contaminants over a wide area, usually in the lowest precipitation areas of the NNSS. The associated monitoring site is Sedan Crater in Yucca Flat. It was last sampled in 2015.
- **Plowshare sites in bedrock or rocky fill at higher elevations with high surface contamination.** Subsurface nuclear detonations at these Plowshare Program sites distributed contaminants over a wide area, usually in the highest precipitation areas of the NNSS. Two monitored sites are in this category: Palanquin Crater and Schooner Crater. Both sites were last sampled in 2013.
- **Atmospheric test areas.** These sites have highly disturbed soils due to the removal of topsoil during historical cleanup efforts and due to the sterilization of soils from heat and radiation during testing. The same areas were often used for multiple nuclear tests. The associated monitoring site is T2 in Yucca Flat. This contaminated site, along with its control site, was sampled in 2016.
- **Aboveground safety experiment sites.** These areas are typified by current radioactive soil contamination, primarily in the form of plutonium and uranium. The associated monitoring site is Plutonium Valley in Area 11. It was last sampled in 2014.

Soil sampling is also conducted periodically at radioactive waste disposal locations on the NNSS to assess whether fossorial small mammals are being exposed to buried wastes and, therefore, whether the integrity of waste containment is compromised. Two radioactive waste disposal facilities are sampled:

- **Area 3 RWMS.** Waste disposal cells within the Area 3 RWMS are subsidence craters resulting from underground nuclear testing. Two closed cells containing bulk low-level radioactive waste are craters U-3ax and U-3bl, which were combined to form the U-3ax/bl disposal unit (Corrective Action Unit 110). U-3ax/bl is covered with a vegetated, native alluvium closure cover that is at least 2.4 meters (m) (8 feet [ft]) thick. It was last sampled in 2014.
- **Area 5 RWMS.** Waste disposal has occurred at the Area 5 RWMS since the early 1960s. There are 11 closed disposal cells containing bulk low-level radioactive waste. The cells are unlined pits and trenches that range in depth from 4.6 to 15 m (15 to 48 ft). Efforts are currently being made to establish native vegetation on the cover cap of the 92-Acre Area, which caps multiple waste cells. The cover cap is approximately 2.4 m (8 ft) thick. Plants and animals from three different portions of the 92-Acre Area cover were last sampled in 2014.

8.3 2016 Sampling and Analysis

In 2016, the T2 site and its control site (Mid-Valley) were sampled for plants and animals (Figure 8-1). The T2 site is located in Area 2 in the north portion of the NNSS. Four nuclear weapons tests were conducted on the surface of the T2 site from 1952 to 1957 (NNSA/NFO 2015) All of these weapons were placed on towers and totaled 90 kilotons. Contamination resulting from these tests is primarily ^{241}Am, ^{137}Cs, ^{3}H, $^{239+240}$Pu, and ^{90}Sr. A control area for T2 is located about 18 kilometers (11.2 miles) south-southwest of the sample site in Mid-Valley, Area 14. Any candidate game species shown in Table 8-1 are likely to be present at the T2 and control sites.

Measurements of gamma-emitting radionuclides in soil were made at T2 and its control location on July 6, 2016. Of the two T2 locations sampled in 2016 (Point 68 and Point 78), Point 68 had been previously sampled in September 1982 by the Radionuclide Inventory and Distribution Program (RIDP (McArthur and Mead, 1987). Point 68 measurements enabled a direct comparison over time (see Section 8.3.3). All 2016 measurements were made using an uncollimated Canberra Model GX5520 germanium detector mounted downward looking on a tripod 1 meter (m) above ground level. The spectra were analyzed using Canberra Genie 2000 (version 3.4) and ISOCS (version 4.4) software with a 10 m circular plane geometry to a depth of 30 centimeters (cm) for the efficiency calibration.

In 2016, no biota or soil sampling was conducted at the Area 3 or Area 5 RWMSs. The last sampling of the RWMSs in 2014 did not suggest that burrowing animals had come into contact with buried waste (NSTec 2015).

8.3.1 Plants

Plants were sampled at T2 and its control site on July 6, 2016. Three composite samples were collected from each location. Plants were sampled over an area of about 0.22 hectares (0.54 acres) about 20 m north of the T2 atmospheric test locations. At the control site, plants were collected over a larger area (1.61 hectares [3.99 acres]). All samples consisted of about 150 to 500 grams (g) (5.3 to 17.6 ounces [oz]) of fresh-weight plant material and were composites of material from 5 to 23 plants of the same species. The species sampled (Table 8-2) represent the dominant vegetation at each site.

Plant leaves and stems were hand-picked and stored in airtight bags. Rubber gloves were used by samplers and changed between each composite sample collection. Samples were labeled and stored in an ice chest and delivered to the laboratory within 4 hours after collection. Water was separated from the samples by distillation. Plant water and dried plant tissues were submitted to a commercial laboratory for analysis; plant water was analyzed for ^{3}H and dried plant tissue was analyzed for ^{241}Am, ^{90}Sr, ^{238}Pu, $^{239+240}Pu$, and gamma emitting radionuclides (^{137}Cs).

Table 8-2. Plant samples collected in 2016

Common Name	Scientific Name	Name Code	T2	T2 Control
White burrobush	*Hymenoclea salsola*	HYSA	X	
Rayless goldenhead	*Acamptopappus sphaerocephalus*	ACSP	X	
Squirreltail	*Elymus elymoides*	ELEL		X
Virgin River brittlebush	*Encelia virginensis*	ENVI	X	
Rubber rabbitbrush	*Ericameria nauseosus*	ERNA		X

Radiological analysis results are shown in Table 8-3. The man-made radionuclides, ^{3}H ^{90}Sr, ^{137}Cs, ^{238}Pu, $^{239+240}Pu$, and ^{241}Am were detected in at least one sample of each plant species from the T2 site, and ^{90}Sr, ^{238}Pu, and $^{239+240}Pu$ were detected in 100% of the samples from T2. ^{137}Cs and ^{241}Am were detected in two of the three samples, and ^{3}H was detected in only one sample. ^{3}H concentrations were lower during 2016 compared to previous years (T2 sampled in 2002, 2006, and 2011) (Figure 8-2). Otherwise, there were no significant changes in concentrations of radionuclides in plants from T2. At the control site, the only man-made radionuclide detected in plants was $^{239+240}Pu$, and this was at a very low concentration (background level).

Table 8-3. Concentrations of man-made radionuclides in plants sampled in 2016

	Radionuclide Concentrations ± Uncertainty[(a)]					
Sample	**^{3}H (pCi/L)[(b)]**	**^{90}Sr (pCi/g)[(c)]**	**^{137}Cs (pCi/g)[(c)]**	**^{238}Pu (pCi/g)[(c)]**	**$^{239+240}Pu$ (pCi/g)[(c)]**	**^{241}Am (pCi/g)[(c)]**
T2						
ACSP	-298 ± 196	0.382 ± 0.051	0.113 ± 0.272	0.0986 ± 0.0231	0.2540 ± 0.0377	0.0312 ± 0.0281
ENVI	601 ± 230	0.852 ± 0.090	0.372 ± 0.139	0.0790 ± 0.0210	0.2600 ± 0.0377	0.0525 ± 0.0269
HYSA	-24 ± 210	0.468 ± 0.059	0.352 ± 0.143	0.0973 ± 0.0229	0.3400 ± 0.0453	0.0693 ± 0.0376
Average	93	0.567	0.279	0.0916	0.2847	0.0510
Average MDC[(d)]	361	0.039	0.229	0.0196	0.0080	0.0392
T2 Control						
ELEL	-207 ± 203	0.041 ± 0.027	-0.267 ± 0.810	0.0080 ± 0.0111	0.0062 ± 0.0064	0.0126 ± 0.0158
ERNA	-61 ± 195	0.008 ± 0.023	0.149 ± 0.345	0.0067 ± 0.0119	0.0048 ± 0.0057	0.0133 ± 0.0125
SPAM	8 ± 203	0.046 ± 0.031	0.000 ± 0.256	-0.0039 ± 0.0116	0.0106 ± 0.0075	0.0058 ± 0.0108
Average	-87	0.032	-0.039	0.0036	0.0072	0.0106
Average MDC[(d)]	359	0.043	0.690	0.0208	0.0094	0.0212

(a) ± 2 standard deviations
(b) picocuries per liter water from sample
(c) picocuries per gram dry weight of sample
(d) the average sample-specific ***minimum detectable concentration (MDC)*** (see Glossary, Appendix B)

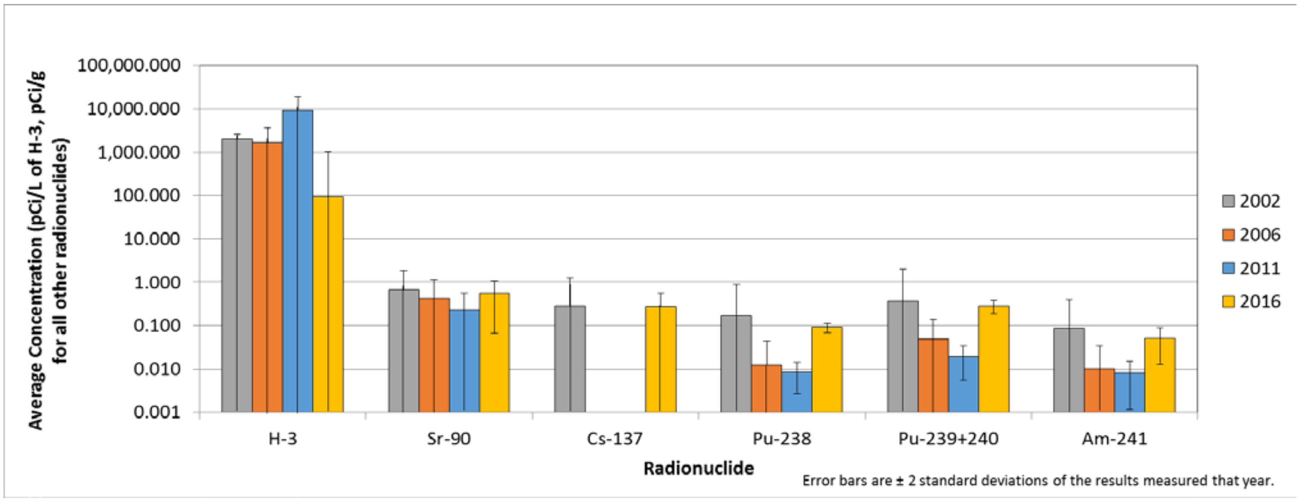

Figure 8-2. Concentrations of man-made radionuclides in plants from T2, 2002 - 2016

8.3.2 Animals

State and federal permits were secured to trap specific small mammals and birds in 2016 and to opportunistically sample large mammal mortalities on the NNSS. Animal trapping took place at the T2 and the T2 control locations from July 18 through July 21, 2016. All animal samples are described in Table 8-4. Two jackrabbits and one cottontail rabbit were collected from each of the sites. Four pronghorn antelope were accidentally killed by vehicles, and their muscle tissues were sampled. The entire bodies of the jackrabbits were homogenized and analyzed, although muscle is usually the only portion consumed by humans. The whole body analyses give a more conservative (higher) estimate of potential dose to someone consuming them (see Section 9.1.1.2). Water was distilled from the samples and submitted to a laboratory for ^{3}H analysis, and the remaining tissue samples were submitted for ^{90}Sr, ^{238}Pu, $^{239+240}$Pu, ^{241}Am, and gamma spectroscopy analysis.

In addition, mule deer and mountain lion samples were collected in conjunction with an ongoing mountain lion study (see Chapter 15, Table 15-2) to supplement the analysis of mountain lion habitat use and diet with information on their exposure to radionuclides. Two collared male mountain lions (NNSS8 and NNSS9) remained in the study during 2016. Numerous sites on the NNSS and the Nevada Test and Training Range (NTTR) where the mountain lions had made a kill (called kill sites) were visited, and tissue samples from the remains of their prey were sampled whenever possible; these consisted of 11 mule deer samples (Table 8-4). Such tissue samples were generally quite small, but there was enough muscle tissue available for analysis of ^{3}H, ^{90}Sr, ^{238}Pu, $^{239+240}$Pu, ^{241}Am, and gamma-emitting radionuclides. Blood samples from each of the two mountain lions captured and six mountain lion fecal samples (scat) from kill sites were also collected (Table 8-4). Water distilled from the blood and scat samples was analyzed for the presence of ^{3}H.

Table 8-4. Animal samples collected in 2016

Location	Sample	Collection Date	Sample Description
Routine Monitoring Samples			
T2	Cottontail	7/19/2016	Whole body
	Jackrabbit #1	7/19/2016	Whole Body
	Jackrabbit #2	7/19/2016	Whole Body
Sedan Control	Cottontail	7/21/2016	Whole body
	Jackrabbit #1	7/21/2016	Whole body
	Jackrabbit #2	7/21/2016	Whole body
Opportunistic Samples			
Area 2	Pronghorn	4/28/2016	Muscle from hindquarter of one-year-old male killed by vehicle
Area 5	Pronghorn	6/14/2016	Muscle from hindquarter of immature male killed by vehicle
Area 3	Pronghorn	8/1/2016	Muscle from hindquarter of mature male killed by vehicle
Area 4	Pronghorn	9/26/2016	Muscle from hindquarter of mature female killed by vehicle

Table 8-4. Animal samples collected in 2016 (continued)

Location / Kill Site	Sample	Collection Date	Sample Description
Mountain Lion Study Samples			
Area 12 / NNSS 9-2	Mule deer	8/31/2016	Muscle from front leg of adult male killed by mountain lion NNSS9
Area 19 / NNSS 9-3	Mule deer	9/1/2016	Muscle from front leg of immature (unknown sex) deer killed by NNSS9
Area 19 / NNSS 9-11	Mule deer	9/19/2016	Muscle from front leg of adult male killed by NNSS9
Area 19 / NNSS 9-12	Mule deer	9/29/2016	Muscle from front leg of adult male killed by NNSS9
Area 12 / NNSS 9-16	Mule deer	10/05/2016	Muscle from hindquarter of adult female killed by NNSS9
Area 12 / NNSS 9-22	Mule deer	10/18/2016	Muscle from front leg of immature (unknown sex) deer killed by NNSS9
Area 12 / NNSS 9-23	Mule deer	11/01/2016	Muscle from hindquarter of adult male killed by NNSS9
Area 12 / NNSS 8-5	Mule deer	11/09/2016	Muscle from front leg of adult female killed by mountain lion NNSS8
Area 12 / NNSS 9-26	Mule deer	11/09/2016	Muscle from front leg of adult male killed by NNSS9
NTTR / NNSS 9-28	Mule deer	11/30/2016	Muscle from front leg of adult male killed by NNSS9
NTTR / NNSS 8-6	Mule deer	12/01/2016	Muscle from front leg of adult male killed by NNSS8
Area 12	Mountain lion (NNSS8)	7/22/2016	Water distilled from blood sample from mountain lion during capture
Area 12 / NNSS 8-5	Mountain lion (NNSS8)	11/09/2016	Water from scat taken near adult female mule deer kill
NTTR / NNSS 8-6	Mountain lion (NNSS8)	12/01/2016	Water from scat taken near adult male mule deer kill
Area 19	Mountain lion (NNSS9)	8/3/2016	Water distilled from blood sample from mountain lion during capture
Area 12 / NNSS 9-2	Mountain lion (NNSS9)	8/31/2016	Water from scat taken near adult male mule deer kill
Area 12 / NNSS 9-22	Mountain lion (NNSS9)	10/18/2016	Water from scat taken near immature (unknown sex) mule deer kill
Area 12 / NNSS 9-23	Mountain lion (NNSS9)	11/01/2016	Water from scat taken near adult male mule deer kill
NTTR / NNSS 9-28	Mountain lion (NNSS9)	11/30/2016	Water from scat taken near adult male mule deer kill

Man-made radionuclides were detected in all rabbits collected from T2, in two rabbits from the T2 control site, in one pronghorn (Area 2), in 10 of the 11 mule deer, and in both mountain lions (Table 8-5). In rabbits from T2, ^{90}Sr, ^{238}Pu, and $^{239+240}$Pu were detected. These were also detected in mule deer along with ^{3}H and ^{241}Am. Only ^{3}H was detected in the pronghorn antelope. Activity levels in mule deer and mountain lion samples were dominated by ^{3}H. Because all mule deer were sampled within 14 km of the E-Tunnel ponds in Area 12, a source of ^{3}H-contaminated water, and there appeared to be a relationship between the concentrations in mule deer with distance from the ponds (Figure 8-3), it is likely that these ponds are the source of tritium in the deer and the mountain lions preying on them (Table 8-6). The source of the tritium in the pronghorn antelope from Area 2 is uncertain, but is likely from contaminated vegetation in Yucca Flat such as that around the Sedan Crater in Area 10.

Table 8-5. Concentrations of man-made radionuclides in animals sampled during routine monitoring in 2016

Sample	Radionuclide Concentrations ± Uncertainty[(a)] ^{3}H (pCi/L)[(b)]	^{90}Sr (pCi/g)[(c)]	^{238}Pu (pCi/g)[(c)]	$^{239+240}$Pu (pCi/g)[(c)]	^{241}Am (pCi/g)[(c)]
T2					
Cottontail rabbit	-177 ± 202	0.127 ± 0.034	0.0237 ± 0.0117	0.0315 ± 0.0155	0.0124 ± 0.0093
Jackrabbit #1	-208 ± 195	0.050 ± 0.028	0.0064 ± 0.0102	0.0229 ± 0.0097	0.0025 ± 0.0192
Jackrabbit #2	-249 ± 207	0.081 ± 0.029	0.0056 ± 0.0108	0.0288 ± 0.0109	0.0094 ± 0.0149
Average Concentration	-211	0.086	0.0119	0.0277	0.0081
Average MDC[(d)]	372	0.042	0.0169	0.0117	0.0256
T2 Control					
Cottontail rabbit	-185 ± 177	0.016 ± 0.024	0.0079 ± 0.0088	0.0053 ± 0.0050	0.0020 ± 0.0153
Jackrabbit #1	-58 ± 180	0.025 ± 0.023	0.0072 ± 0.0098	0.0009 ± 0.0054	0.0565 ± 0.0269
Jackrabbit #2	-180 ± 208	0.021 ± 0.024	0.0785 ± 0.0223	0.0058 ± 0.0062	-0.0018 ± 0.0118
Average Concentration	-141	0.020	0.0312	0.0040	0.0189
Average MDC[(d)]	343	0.039	0.0179	0.0090	0.0289

Table 8-5. Concentrations of man-made radionuclides in animals sampled during routine monitoring in 2016 (continued)

	Radionuclide Concentrations ± Uncertainty[a]				
Sample	**^{3}H (pCi/L)[b]**	**^{90}Sr (pCi/g)[c]**	**^{238}Pu (pCi/g)[c]**	**$^{239+240}$Pu (pCi/g)[c]**	**^{241}Am (pCi/g)[c]**
Opportunistic Sampling					
Pronghorn (Area 2)	1,950 ± 298	-0.016 ± 0.023	0.0076 ± 0.0088	0.0017 ± 0.0048	-0.0032 ± 0.0056
Pronghorn (Area 5)	139 ± 212	0.012 ± 0.026	0.0003 ± 0.0014	0.0006 ± 0.0014	-0.0005 ± 0.0012
Pronghorn (Area 3)	-138 ± 177	-0.005 ± 0.016	0.0019 ± 0.0056	0.0035 ± 0.0068	0.0003 ± 0.0041
Pronghorn (Area 4)	373 ± 233	-0.055 ± 0.046	0.0087 ± 0.0103	0.0035 ± 0.0097	0.0000 ± 0.0077
Average Concentration	581	-0.016	0.0046	0.0023	-0.0008
Average MDC[d]	318	0.058	0.0099	0.0099	0.0100

(a) ± 2 standard deviations
(b) picocuries per liter water from sample
(c) Picocuries per gram wet weight of sample
(d) Average sample specific MDC

Table 8-6. Concentrations of man-made radionuclides in animals sampled during the mountain lion study in 2016

	Radionuclide Concentrations ± Uncertainty[a]				
Location / Kill Site	**^{3}H (pCi/L)[b]**	**^{90}Sr (pCi/g)[c]**	**^{238}Pu (pCi/g)[c]**	**$^{239+240}$Pu (pCi/g)[c]**	**^{241}Am (pCi/g)[c]**
Mule deer					
Area 12 / NNSS 9-2	23,400 ± 2,190	0.009 ± 0.009	0.0023 ± 0.0015	0.0042 ± 0.0020	0.0029 ± 0.0024
Area 19 / NNSS 9-3	1,630 ± 294	0.031 ± 0.014	0.0014 ± 0.0011	0.0060 ± 0.0025	0.0034 ± 0.0030
Area 19 / NNSS 9-11	566 ± 183	0.013 ± 0.008	0.0017 ± 0.0013	0.0086 ± 0.0030	0.0036 ± 0.0023
Area 19 / NNSS 9-12	33 ± 136	-0.016 ± 0.026	0.0021 ± 0.0029	0.0010 ± 0.0046	0.0012 ± 0.0024
Area 12 / NNSS 9-16	70,800 ± 6,350	-0.002 ± 0.026	0.0010 ± 0.0020	0.0049 ± 0.0044	0.0134 ± 0.0082
Area 12 / NNSS 9-22	904 ± 218	-0.001 ± 0.012	0.0014 ± 0.0011	0.0024 ± 0.0014	0.0014 ± 0.0016
Area 12 / NNSS 9-23	21,200 ± 2,000	0.031 ± 0.033	0.0024 ± 0.0028	0.0040 ± 0.0036	0.0048 ± 0.0068
Area 12 / NNSS 8-5	20,100 ± 1,890	0.021 ± 0.024	0.0012 ± 0.0075	0.0018 ± 0.0048	0.0004 ± 0.0023
Area 12 / NNSS 9-26	9,480 ± 969	-0.002 ± 0.016	0.0001 ± 0.0020	0.0009 ± 0.0014	0.0000 ± 0.0012
NTTR / NNSS 9-28	6,240 ± 736	0.024 ± 0.019	0.0043 ± 0.0024	0.0270 ± 0.0060	0.0066 ± 0.0042
NTTR / NNSS 8-6	405 ± 207	-0.006 ± 0.015	0.0004 ± 0.0015	0.0330 ± 0.0067	0.0033 ± 0.0029
Average Concentration	14,069	0.009	0.0017	0.0085	0.0037
Average MDC[d]	265	0.031	0.0032	0.0029	0.0037
Mountain lion (NNSS 8)					
Area 12	839 ± 588	---	---	---	---
Area 12 / NNSS 8-5	9,890 ± 1,000	---	---	---	---
NTTR / NNSS 8-6	6,170 ± 729	---	---	---	---
Average Concentration	5,633	(Mountain lion samples were only analyzed for ^{3}H)			
Average MDC[d]	502				
Mountain lion (NNSS 9)	2,500 ± 973	---	---	---	---
Area 19	2,510 ± 358	---	---	---	---
Area 12 / NNSS 9-2	48,900 ± 4,430	---	---	---	---
Area 12 / NNSS 9-22	27,500 ± 2,550	---	---	---	---
Area 12 / NNSS 9-23	7,420 ± 852	---	---	---	---
NTTR / NNSS 9-28	2,500 ± 973	---	---	---	---
Average Concentration	17,766				
Average MDC[d]	499				

(a) ± 2 standard deviations
(b) picocuries per liter water from sample
(c) Picocuries per gram wet weight of sample
(d) Average sample specific MDC

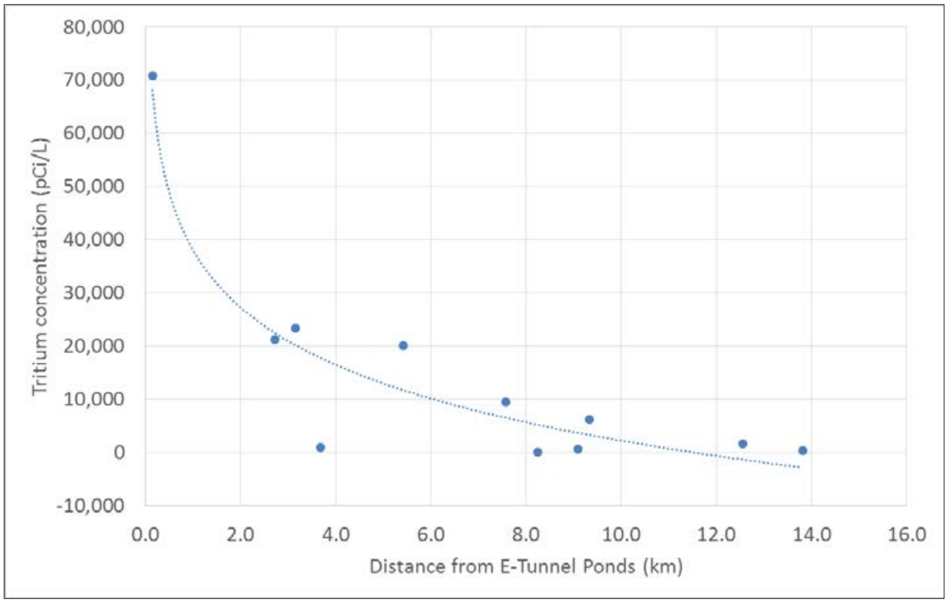

Figure 8-3. ^{3}H concentrations in mule deer versus the distance they were sampled from the E-Tunnel Ponds

8.3.3 Soil

Results from measurements of gamma-emitting radionuclides in soil at T2 are listed in Table 8-7. One natural radionuclide (potassium-40 [^{40}K]) is reported because it is ubiquitous and has a very long half-life (1,251,000,000 years). It is therefore a good marker for comparison between measurements because it should not change through time. Man-made radionuclides detected were Cobalt-60 (^{60}Co), ^{137}Cs, europium-152 (^{152}Eu), and ^{241}Am. The decay-corrected activity in soil measured in 1982 is very close to the values measured in July 2016, when the uncertainty of the measurements is considered (Table 8-7). This suggests that very little change in concentrations of man-made radionuclides in the soil has occurred in the past 34 years.

Ratios of plant-to-soil concentrations were calculated as pCi/g dry plant concentration divided by pCi/g dry soil concentration. Soil concentrations were converted to pCi/g by taking the activity per area reported in Table 8-7 and dividing them by the number of grams of soil in 1 square meter (m^2) to a depth of 30 cm (450,000 g) (soil density = 1.5 grams per cubic centimeter [g/cm^3]). The ratios for ^{137}Cs (0.0223) and ^{241}Am (0.0071) were the only ratios calculated because they were the only man-made radionuclides detected in both soil and plants. No gamma-emitting radionuclides were detected in animals from T2. These values can be useful in estimating concentrations in plants and animals on the NNSS (particularly near T2) based on soil concentrations.

Table 8-7. Gamma-emitting radionuclides detected in soil at T2

	Activity (nanocuries per square meter [nCi/m^2])[(a)]		
	February 1982[(b)]	July 2016	
Radionuclide	Point 68	Point 68	Point 78
^{40}K	7,029	7,120 ± 669	6,844 ± 649
^{60}Co	41	49 ± 9	68 ± 10
^{137}Cs	4,858	5,593 ± 643	5,671 ± 664
^{152}Eu	8,044	6,189 ± 246	9,562 ± 348
^{241}Am	2,066	3,233 ± 661	2,360 ± 486

(a) ± uncertainty (2 standard deviations)

(b) RIDP measurements from 1982 were corrected for physical decay of radionuclides to July 2016. ^{241}Am includes ingrowth from the decay of plutonium-241.

8.4 Data Assessment

Biota sampling results confirm that man-made radionuclide concentrations are higher at the T2 location compared with its control location. Though NNSS-related radionuclides are detected in some plants and animals, the levels pose negligible risk to humans and biota. Mobile game animals (mountain lions, mule deer, and pronghorn antelope) are shown to uptake radionuclides from NNSS sources but the potential dose to a person hunting and consuming these animals is well below dose limits to members of the public (see Section 9.1.1.2). Also, radionuclide concentrations were below levels considered harmful to the health of the plants and animals; the dose resulting from observed concentrations were less than 2 percent of dose limits set to protect populations of plants and animals (see Section 9.2).

8.5 References

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Chapter 9: Radiological Dose Assessment

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The U.S. Department of Energy (DOE) requires DOE facilities to estimate the radiological dose to the general public and to plants and animals in the environment caused by past or present facility operations. These requirements are specified in DOE Orders DOE O 458.1, "Radiation Protection of the Public and the Environment," and DOE O 435.1, "Radioactive Waste Management" (see Table 2-1 of Chapter 2). To estimate these radiological doses, radionuclide concentration data gathered on the Nevada National Security Site (NNSS) are used along with dose conversion factors published in DOE Technical Standard DOE-STD-1196-2011, "Derived Concentration Technical Standard." The dose conversion factors take into account the different population fractions of age and sex to give representative dose coefficients for a reference person within the U.S. population. The 2016 data used are presented in Chapters 4, 5, 6, and 8 of this report, and include the results for onsite monitoring of air, water, direct radiation, and biota, and for offsite monitoring of groundwater. The independent offsite air and groundwater data presented in Chapter 7, Community-Based Offsite Monitoring, provide extra assurance to the public that estimated doses do not underestimate potential offsite exposures to NNSS-related radiation. The specific goals for the dose assessment component of radiological monitoring are shown below.

Radiological Dose Assessment Goals
Determine if the maximum radiation dose to a member of the general public from airborne radionuclide emissions at the NNSS complies with the Clean Air Act, National Emission Standards for Hazardous Air Pollutants (NESHAP) limit of 10 millirems per year (mrem/yr) (0.1 millisieverts per year [mSv/yr]).
Determine if radiation levels from the Radioactive Waste Management Sites (RWMSs) comply with the 25 mrem/yr (0.25 mSv/yr) dose limit to members of the public as specified in DOE Manual DOE M 435.1-1, "Radioactive Waste Management Manual."
Determine if the total radiation dose (***total effective dose equivalent [TEDE]***, see Glossary, Appendix B) to a member of the general public from all possible pathways (direct exposure, inhalation, ingestion of water and food) as a result of NNSS operations complies with the limit of 100 mrem/yr (1 mSv/yr) established by DOE O 458.1.
Determine if the radiation dose (in a unit of measure called a ***rad*** [see Glossary, Appendix B]) to NNSS biota complies with the following limits set by DOE-STD-1153-2002, "A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota." < 1 rad per day (rad/d) for terrestrial plants and aquatic animals < 0.1 rad/d for terrestrial animals

9.1 Dose to the Public

This section identifies the possible pathways by which the public could be exposed to radionuclides due to past or current NNSS activities. It describes how field monitoring data are used with other NNSS data sources (e.g., radionuclide inventory data) to provide input to the dose estimates and presents the estimated 2016 public dose attributable to U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO) activities from each pathway and all pathways combined. The public dose due to radioactive waste operations on the NNSS is also assessed, and a description of the program that controls the release of NNSS materials having residual radioactivity into the public domain is provided.

9.1.1 Dose from Possible Exposure Pathways

As prescribed in the *Routine Radiological Environmental Monitoring Plan* (Bechtel Nevada [BN] 2003), air, groundwater, and biota are routinely sampled to document the amount of radioactivity in these media and to provide data that can be used to assess the radiation dose received by the general public from several pathways.

The potential pathways by which a member of the general public residing off site might receive a radiation dose resulting from past or present NNSS operations include the following:

- Inhalation of, ingestion of, or direct external exposure to airborne radionuclide emissions transported off site by wind
- Ingestion of wild game animals that drink from surface waters and/or eat vegetation containing NNSS-related radioactivity
- Ingestion of plants containing radioactivity from NNSS-related activities
- Drinking water from underground ***aquifers*** (see Glossary, Appendix B) containing radionuclides that have migrated from the sites of past underground nuclear tests or waste management sites
- Exposure to direct radiation along the borders of the NNSS

The subsections below address all of the potential pathways and their contribution to public dose estimated for 2016.

9.1.1.1 Dose from NNSS Air Emissions

Six air particulate and tritium (^{3}H) sampling stations located near the boundaries and the center of the NNSS are approved by the U.S. Environmental Protection Agency (EPA) Region 9 as ***critical receptor samplers*** (see Glossary, Appendix B) to demonstrate compliance with the NESHAP public dose limit of 10 mrem/yr (0.1 mSv/yr) from air emissions. The annual average concentration of an airborne radionuclide must be less than its NESHAP Concentration Level for Environmental Compliance (abbreviated as compliance level [CL]) (see Table 4-1 of Section 4.1.1). The CL for each radionuclide represents the annual average concentration of that radionuclide in air that would result in a TEDE of 10 mrem/yr. If multiple radionuclides are detected at a station, then compliance with NESHAP is demonstrated when the sum of the fractions (determined by dividing each radionuclide's concentration by its CL and then adding the fractions together) is less than 1.0.

The critical receptor sampling stations can be thought of as worst case for an offsite receptor because these samplers are much closer to emissions sources. Table 9-1 displays the distances between the critical receptor monitoring stations and points where members of the public potentially live, work, and/or go to school. The distance between the sampling location and the closest onsite emission location (see Chapter 4, Figure 4-1) is also listed.

Table 9-1. Distance between critical receptor air monitoring stations and nearest points of interest

Critical Receptor Station	Distance[(a)] and Direction[(b)] to Nearest Offsite Locations and Onsite Emission Location			
	Residence	Business/Office	School	NNSS Emission Source
Area 6, Yucca	47 km SW Amargosa Valley	38 km SSE American Silica[(c)]	54 km SE Indian Springs	6.3 km SSE Area 6, National Criticality Experiments Research Center
Area 10, Gate 700	49 km ENE Medlin's Ranch	56 km NNE Rachel	75 km SSE Indian Springs	2.4 km WSW Area 10, Sedan Crater
Area 16, Substation 3545	46 km SSW Amargosa Valley	46 km SSW Amargosa Valley	58 km SSW Amargosa Valley	14 km ENE Area 3, RWMS
Area 20, Schooner	36 km WSW Sarcobatus Flat	20 km WSW Tolicha Peak	56 km SSW Beatty	0.2 km SE Area 20, Schooner Crater
Area 23, Mercury Track	24 km SW Crystal	6.0 km SE American Silica	31 km SSW Indian Springs	0.2 km ESE Area 23, Building 652
Area 25, Gate 510	4 km S Amargosa Valley	3.5 km S Amargosa Valley	15 km SW Amargosa Valley	5.1 km NE Area 25, nearest portion of Grouped Area Sources

(a) Distance is shown in kilometers (km). For miles, multiply by 0.62.
(b) N=north, S=south, E=east, W=west in all direction combinations shown
(c) The American Silica mine was not active during 2016 but is the closest business to the NNSS.

In 2016, the man-made radionuclides detected in samples from at least one of the six critical receptor air monitoring stations included ^{3}H, cesium-137 (^{137}Cs), americium-241 (^{241}Am), plutonium-238 (^{238}Pu), and plutonium-239+240 ($^{239+240}Pu$) (see Section 4.1.4). The annual average concentrations of these radionuclides were well below their CLs, and the sum of fractions for each location were all less than 1.0 (see Table 4-9 of Section 4.1.5). As in previous years, the 2016 data from the six critical receptor stations show that the NESHAP public dose limit of 10 mrem/yr (0.1 mSv/yr) was not exceeded.

The shortest distance between where a member of the public resides and a critical receptor monitoring station is 4 km (2.5 miles [mi]): between the Gate 510 sampler in the southwest corner of the NNSS and the northern edge of the community of Amargosa Valley. Because it is the closest, the results from the Gate 510 sampler (see Table 4-9) are believed to be most representative of air concentrations to which the public is continuously exposed. Scaling the 0.0034 sum of fractions for the Gate 510 station to the 10 mrem/yr (0.1 mSv/yr) limit gives an estimated dose of 0.034 mrem/yr (0.00034 mSv/yr) from radionuclides in air. More detailed information regarding the estimation of the dose to the public from airborne radioactivity in 2016 from all activities conducted by NNSA/NFO on the NNSS and its Nevada support facilities is reported in National Security Technologies, LLC (NSTec) (2017).

9.1.1.2 Dose from Ingestion of Game Animals from the NNSS

Two game species, mule deer and mourning doves, have been shown to travel off the NNSS and be available to hunters (Giles and Cooper 1985; NSTec 2009). Because of this, game animals on the NNSS are sampled annually near known radiologically contaminated areas to give conservative (worst-case) estimates of the level of radionuclides that hunters may consume if these animals are harvested off of the NNSS. In 2016, the following animals were sampled (see Figure 8-1 and Tables 8-4, 8-5, and 8-6 of Chapter 8):

- Two jackrabbits and one cottontail rabbit from T2 (Area 2)
- Two jackrabbits and one cottontail rabbit from the T2 Control location (Area 14)
- Four pronghorn antelope accidentally killed by vehicles (one each from Areas 2, 3, 4, and 5)
- Eleven mule deer killed by mountain lions: six from Area 12, three from Area 19, and two from the Nevada Test and Training Range (NTTR)
- Eight samples from two mountain lions who part of a research project: six scat samples and two blood samples. Blood samples were collected prior to the animals being released and radionuclide concentrations in blood were assumed equal to that in muscle tissue.

The potential ***committed effective dose equivalent (CEDE)*** (see Glossary, Appendix B) to an individual from consuming game animals was calculated for each animal sampled in 2016. The following assumption/parameters were used to estimate dose:

- Analysis results from all samples were included in calculating dose from consuming a particular species as long as the radionuclide was detected, i.e., the analysis result was above the ***minimum detectable concentration (MDC),*** (see Glossary, Appendix B) in at least one sample of that species at a particular location. The opportunistic samples are grouped as all being from the same location (NNSS).
- If the analytical result for a radionuclide concentration in the sample was a negative value (resulting from a background measurement higher than what was observed in the sample), then the concentration for that sample was set to zero.
- An individual consumes all meat from one of each species of animal sampled during 2016: one jackrabbit (513 grams [g]), one cottontail rabbit (167 g), one pronghorn antelope (20.0 kilograms [kg]), one mule deer (35.4 kg), and one mountain lion (21.3 kg) during the year.
- The moisture content of the muscle tissue samples of all species is 73%.
- Dose coefficients for a reference person as defined by DOE-STD-1196-2011 are used; they are for a hypothetical person representing an aggregate of individuals in the U.S. population.
- The entire committed dose is considered to be received during the calendar year.

Dose coefficients (mrem per picocurie [pCi] ingested), based on values listed in DOE-STD-1196-2011, were multiplied by the amount of radioactivity (pCi) potentially ingested to obtain the potential dose (CEDE) (Table 9-2).

The average and maximum CEDEs for each monitored location and for each animal species opportunistically sampled are presented in Table 9-2. No man-made radionuclides were detected in the cottontail rabbit from the T2 control site, the mule deer from the mountain lion kill site Area 19 / NNSS9-12, or in the three pronghorns sampled in Areas 3, 4, and 5 (see Table 8-5 of Chapter 8). Dose from consuming these animals, therefore, is essentially zero, and they are not displayed in Table 9-2. Based on the 2016 samples, an individual who consumes one animal of each sampled species from each location (where opportunistic large game samples were considered to be from one location, i.e., the entire NNSS) may receive an estimated dose of 0.73 mrem (0.0073 mSv) based on the averages. To put this dose in perspective, the dose from naturally occurring cosmic radiation received during a 2-hour airplane flight at 39,000 feet is about 1 mrem (0.01 mSv). From consuming just one animal, the maximum would come from the mule deer sampled at the mountain lion kill site NTTR / NNSS 9-28, which is just north of Area 12 on the NTTR (see Table 8-6 of Chapter 8), and would result in a dose of 1.50 mrem (0.015 mSv).

Table 9-2. Hypothetical CEDE from ingesting game animals sampled in 2016

		Committed Effective Dose Equivalent (mrem)[a]						Location/Species	
Samples	**Sample Location or Kill Site**	**^{3}H [b]**	**^{90}Sr**	**^{238}Pu**	**$^{239+240}$Pu**	**^{241}Am**	**Total**	**Average**	**Max**
Cottontail	T2 (Area 2)	ND[c]	0.0028	0.0039	0.0056	ND	0.0123	0.0123	0.0123
Jackrabbit#1	T2 (Area 2)	ND	0.0034	0.0032	0.0125	ND	0.0191	0.0216	0.0241
Jackrabbit#2		ND	0.0055	0.0028	0.0157	ND	0.0241		
Jackrabbit#1	T2 Control Area (Area 14)	ND	ND	0.0036	0.0000	0.0255	0.0291	0.0341	0.0392
Jackrabbit#2		ND	ND	0.0392	0.0000	0.0000	0.0392		
Opportunistic samples from accidental road kills:									
Pronghorn antelope	Area 2	0.0022	ND	ND	ND	ND	0.0022	0.0022	0.0022
Opportunistic samples from mountain lion kill sites:									
Mule deer	Area 12 / NNSS 9-2	0.0470	0.0445	0.0794	0.1568	0.0891	0.4167	0.6212	1.4964
Mule deer	Area 19 / NNSS 9-3	0.0033	0.1470	0.0474	0.2244	0.1053	0.5274		
Mule deer	Area 19 / NNSS 9-11	0.0011	0.0615	0.0577	0.3254	0.1118	0.5575		
Mule deer	Area 12 / NNSS 9-16	0.1421	0.0000	0.0336	0.1839	0.4174	0.7770		
Mule deer	Area 12 / NNSS 9-22	0.0018	0.0000	0.0490	0.0920	0.0430	0.1859		
Mule deer	Area 12 / NNSS 9-23	0.0425	0.1480	0.0826	0.1508	0.1489	0.5728		
Mule deer	Area 12 / NNSS 8-5	0.0403	0.0971	0.0399	0.0667	0.0128	0.2568		
Mule deer	Area 12 / NNSS 9-26	0.0190	0.0000	0.0046	0.0345	0.0000	0.0581		
Mule deer[d]	NTTR / NNSS 9-28	0.0125	0.1111	0.1486	1.0193	0.2049	1.4964		
Mule deer	NTTR / NNSS 8-6	0.0008	0.0000	0.0139	1.2447	0.1037	1.3630		
Mountain lion (NNSS 8)	Area 12 / NNSS 8-5[e]	0.0120	NA[f]	NA	NA	NA	0.0120	0.0356	0.0592
Mountain lion (NNSS 9)	Area 12 / NNSS 9-22[e]	0.0592	NA	NA	NA	NA	0.0592		
CEDE from consuming one animal of each species per location = 0.73 mrem (using averages) and 1.63 mrem (using maximums)									

(a) Based on dose coefficients in Appendix A of DOE-STD-1196-2011 for a reference person.
(b) Based on assumption that the water content of all muscle tissue samples is 73%.
(c) Not detected, reported analytical result was less than the sample-specific MDC.
(d) Radionuclide levels from this mule deer sample yielded the highest CEDE (1.5 mrem) of any single animal sampled in 2016.
(e) Used the single maximum ^{3}H concentration reported among multiple scat samples collected (2 scat samples from mountain lion NNSS 8 and 4 scat samples for NNSS 9).
(f) Not analyzed.

A person may consume animals from locations on the NNSS other than where samples were collected in 2016; therefore, Table 9-3 presents the maximum CEDE for humans consuming various species of wildlife from all animals sampled from 2001–2016. While it is possible that someone could consume an animal from the NNSS, the probability is low. Table 9-3 gives a worst-case scenario based on radionuclide analyses of NNSS game animal samples over the past 16 years.

The highest CEDE from consuming just one animal (3.23 mrem or 0.0323 mSv) would be from the mule deer sampled in 2014 from Area 19 (Table 9-3). This represents 3.23% of the annual dose limit for members of the public and is about three times the dose one would receive from naturally occurring cosmic radiation during a 2-hour airplane flight at 39,000 feet.

Table 9-3. Maximum CEDEs to a person hypothetically ingesting NNSS game animals sampled from 2001–2016

Game Animal	Sample Location	Year Sampled	Amount Consumed	CEDE for Consumption of One Animal (mrem)
Bobcat	Area 25 (roadkill)	2012	all muscle	0.032
Chuckar	Area 12 (E-Tunnel)	2001	breast muscle	0.006
Cottontail rabbit	Area 20 (Schooner)	2013	whole body	0.032
Gambel's quail	Area 2 (T2)	2002	all muscle	0.004
Jackrabbit	Area 10 (Sedan)	2015	all muscle	1.298
Mountain lion	NTTR (natural mortality of study lion NNSS4)	2013	all muscle	0.095
Mourning dove	Area 20 (sump of Well U-20n)	2003	breast muscle	0.032
Mule deer	Area 19 (killed by a mountain lion)	2014	all muscle	3.228
Pronghorn antelope	Area 10 (roadkill)	2015	all muscle	2.869

9.1.1.3 Dose from Ingestion of Plants from the NNSS

Current NNSS land use practices discourage the harvest of plants or plant parts for direct consumption by humans. However, it is possible that individuals with access might collect and consume edible plant material. One species in particular, the pinyon pine tree, produces pine nuts that are harvested and consumed across the western United States. Pinyon pine trees grow throughout regions of higher elevation on the NNSS. During 2013, pine nuts were sampled from three locations on the NNSS (Area 15, Area 17, and in Area 12 near the E Tunnel Ponds). The estimated dose from consuming them was shown to be extremely low (0.00056 mrem or 0.0000056 mSv) and a negligible contribution to the total potential dose to a member of the public (NSTec 2014). No other edible plant materials have been collected for analysis on the NNSS in recent history, and no edible plants were sampled in 2016.

9.1.1.4 Dose from Drinking Contaminated Groundwater

The 2016 groundwater monitoring data indicate that groundwater from offsite private and community wells and springs has not been impacted by past NNSS nuclear testing operations (see Sections 5.1.3.5, 7.2, and 7.3). No man-made radionuclides have been detected in any sampled wells accessible to the offsite public or in sampled private wells or springs. These field monitoring data also agree with the forecasts of current groundwater flow and contaminant transport models discussed in Chapter 11 (see Section 11.1). Therefore, drinking water from underground aquifers containing radionuclides is not a possible pathway of exposure to the public residing off site.

9.1.1.5 Dose from Direct Radiation Exposure along NNSS Borders

The direct exposure pathway from gamma radiation to the public is monitored annually (see Chapter 6). In 2016, the only place where the public has the potential to be exposed to direct radiation from NNSS operations is at Gate 100, the primary entrance to the site on the southern NNSS border. Trucks hauling radioactive materials, primarily low-level waste (LLW) being shipped for disposal at the Area 5 RWMS, park outside Gate 100 while waiting for entry approval. Only during these times is there a potential for exposure to the public due to NNSS activities. However, no member of the public resides or remains full-time at the Gate 100 truck parking area. Therefore, dose from direct radiation is not included as a possible pathway of exposure to the public residing off site.

9.1.2 Dose from Waste Operations

DOE M 435.1-1 states that LLW disposal facilities shall be operated, maintained, and closed so that a reasonable expectation exists that annual dose to members of the public shall not exceed 10 mrem through the air pathway and 25 mrem through all pathways for a 1,000-year compliance period after closure of the disposal units. Given that the RWMSs are located well within the NNSS boundaries, no members of the public could access these areas for significant periods of time. However, for purposes of documenting potential impacts, the possible pathways for radionuclide movement from waste disposal facilities are monitored.

During 2016, external radiation from waste operations measured near the boundaries of the Area 3 and Area 5 RWMSs could not be distinguished from background levels at those locations (see Section 6.3.4 of Chapter 6). Area 3 and Area 5 RWMS operations would have contributed negligible external exposure to a hypothetical person residing near the boundaries of these sites and no dose to the offsite public.

The dose from the air pathway can be estimated from air monitoring results from stations near the RWMSs (see Figure 4-2 of Chapter 4 and Table 10-4 of Chapter 10). Mean concentrations of radionuclides in air at the Area 3 and Area 5 environmental sampler locations were, at the most, only 9.6% of their CLs (see Table 10-4). Scaling this to the 10-mrem dose that the CL represents would be 0.96 mrem (0.0096 mSv) to a hypothetical person residing near the boundaries of the RWMS, and the dose would be much lower to the offsite public.

There is no exposure, and therefore no dose, to the public from groundwater beneath waste disposal sites on the NNSS. Groundwater monitoring indicates that man-made radionuclides have not been detected in wells accessible to the offsite public or in private wells or springs (see Section 5.1.3.5 of Chapter 5 and Sections 7.2 and 7.3 of Chapter 7). Also, groundwater and vadose zone monitoring at the Area 3 and Area 5 RWMSs, conducted to verify the performance of waste disposal facilities, have not detected the migration of radiological wastes into groundwater (see Sections 10.1.7 and 10.1.8 of Chapter 10). Based on these results, potential doses to members of the public from LLW disposal facilities on the NNSS from all pathways are negligible.

9.1.3 Total Offsite Dose to the Public from all Pathways

The DOE-established radiation dose limit to a member of the general public from all possible pathways as a result of DOE facility operations is 100 mrem/yr (1 mSv/yr) excluding background radiation, while considering air transport, ingestion, and direct exposure pathways. For 2016, the only plausible pathways of public exposure to man-made radionuclides from current or past NNSS activities included the air transport pathway and the ingestion of game animals and plants. The doses from these pathways are combined in Table 9-4 to present an estimate of the total 2016 dose to the ***maximally exposed individual (MEI)*** (see Glossary, Appendix B) residing off site.

In the recent past, the MEI for the air pathway was considered to be a hypothetical person residing at the critical receptor station with the highest dose (Schooner). However, in an effort to give a more realistic estimate, the 0.034 mrem/yr (0.00034 mSv/yr) dose estimate for the Gate 510 critical receptor station is now used for the dose estimate for an offsite MEI (see Section 4.1.5 of Chapter 4). If the offsite MEI is assumed to also eat wildlife from the NNSS, additional dose would be received. The additional dose may be 0.0022 mrem (0.000022 mSv) from eating a pronghorn antelope having radionuclide concentrations similar to that of the pronghorn sampled in 2016 in Area 2 (Table 9-2) and could range up to 3.23 mrem (0.0323 mSv) if a person ate a mule deer having elevated radionuclide concentrations like the mule deer sampled in 2014 in Area 19 (Table 9-3). The maximum dose someone would receive from eating a single animal sampled in 2016 would be 1.50 mrem (0.015 mSv) from the mule deer sampled November 30, 2016, north of Area 12 on the NTTR (Table 9-2, footnote d). Since this is a 2016 result, it will be used for the game ingestion pathway dose for 2016. When the 0.034 mrem (0.00034 mSv) dose from the air pathway is added, the TEDE to this hypothetical MEI from all exposure pathways combined due to NNSA/NFO activities would be 1.53 mrem/yr (0.0153 mSv/yr) (Table 9-4).

Table 9-4. Estimated radiological dose to a hypothetical MEI of the general public from 2016 NNSS operations

Pathway	Dose to MEI (mrem/yr)	Dose to MEI (mSv/yr)	Percent of DOE 100 mrem/yr Limit
Air[(a)]	0.034	0.00034	0.034
Water[(b)]	0	0	0
Wildlife[(c)]	1.50	0.015	1.5
Direct[(d)]	0	0	0
All Pathways	**1.53**	**0.0153**	**1.53**

(a) Based on annual average concentrations at the compliance station nearest the offsite public (see Table 4-9, Section 4.1.5)
(b) Based on all offsite groundwater sampling conducted by NNSA/NFO to date (see Section 5.1)
(c) Based on consuming one animal sampled in 2016 which would result in the highest dose (Table 9-2)
(d) Based on 2016 gamma radiation monitoring data at the NNSS entrance (see Section 6.3.1)

The total dose of 1.53 mrem/yr to the hypothetical MEI is 1.53% of the DOE limit of 100 mrem/yr and about 0.43% of the total dose that the MEI receives from natural background radiation (360 mrem/yr [3.6 mSv/yr]) (Figure 9-1). Natural background radiation consists of cosmic radiation, terrestrial radiation, radiation from radionuclides within the composition of the human body (primarily potassium-40), and radiation from the inhalation of naturally occurring radon and its progeny. The cosmic and terrestrial components of background radiation shown in Figure 9-1 were estimated from the annual mean radiation exposure rate measured with a pressurized ion chamber (PIC) at Indian Springs by the CEMP (96.4 milliroentgens per year [mR/yr], rounded to 96 mR/yr; see Table 7-4 of Chapter 7). The radiation exposure in air, measured by the PIC in units of mR/yr, is conservatively approximated to be equivalent to the unit of mrem/yr for tissue. The portion of the background dose from the internally deposited, naturally occurring radionuclides and from the inhalation of radon and its daughters were estimated at 31 mrem/yr (0.31 mSv/yr) and 229 mrem/yr (2.29 mSv/yr), respectively (Figure 9-1), using the approximations by the National Council on Radiation Protection and Measurements (2006).

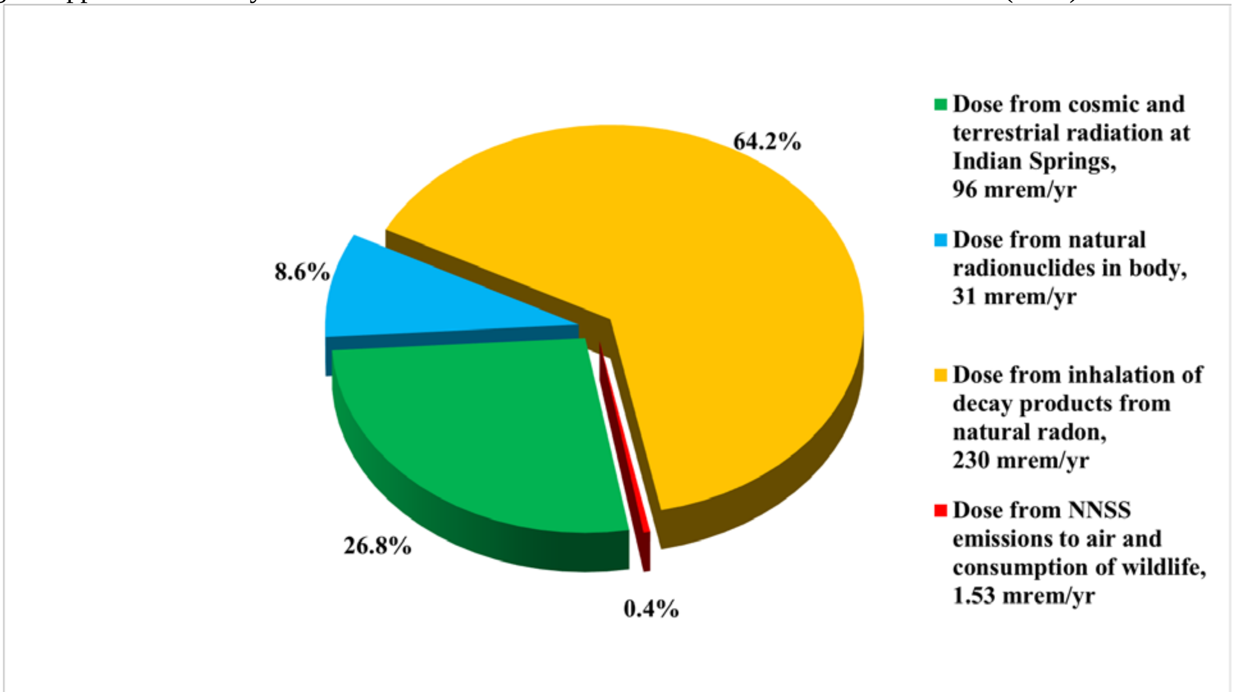

Figure 9-1. Comparison of radiation dose to the MEI from the NNSS and natural background (percent of total)

9.1.4 Collective Population Dose

The ***collective population dose*** (see Glossary, Appendix B) to residents within 80 km (50 mi) of the NNSS emission sources was not estimated in 2016. DOE approved the discontinuance of reporting collective population dose from NNSS operations after 2004 because it is so low for the NNSS. It has been below 0.6 person-rem/yr for the period from 1992, when it was first calculated and reported to DOE, through 2004.

DOE recommended that NNSA/NFO should consider reporting collective population dose once again if ever it exceeds 1.0 person-rem/yr (DOE 2004). It will be recalculated when either the radionuclide emissions from NNSS activities or the population within 80 km (50 mi) of the NNSS increase significantly (e.g., ≥ 50%), both of which are estimated annually (see Section 1.7 of Chapter 1 for population estimates).

9.1.5 Release of Property Containing Residual Radioactive Material

In addition to discharges to the environment, the release of DOE property containing residual radioactive material is a potential contributor to the dose received by the public. The release of property off the NNSS is controlled. No vehicles, equipment, structures, or other materials can be released from the NNSS for unrestricted public use unless the amount of residual radioactivity on such items is less than the authorized limits. The default authorized limits are specified in the *Nevada Test Site Radiological Control Manual* (Radiological Control Manager's Council 2012) and are consistent with the limits set by DOE O 458.1. These limits are shown in Table 9-5.

All NNSA/NFO contractors use a graded approach for release of material and equipment for unrestricted public use. Items are either surveyed prior to release to the public, or a process knowledge evaluation is conducted to verify that the material has not been exposed to radioactive material or beams of radiation capable of generating radioactive material. In some cases, both a radiological survey and a process knowledge evaluation are performed (e.g., a radiological survey is conducted on the outside of the item, and a process knowledge form is signed by the custodian to address inaccessible surfaces). Items are evaluated/surveyed prior to shipment to the NNSA/NFO property/excess warehouse. All contractors also complete material surveys prior to release and transport to the Area 23 landfill. The only exception is for items that could be internally contaminated; these items are submitted to Waste Generator Services for disposal using one of the facilities that can accept LLW. Excess items that can be free-released are either donated to interested state agencies, federal agencies, or universities; redeployed to other onsite users; or sold on an auction website.

In 2016, 232 pieces of laboratory equipment, 16 vehicles, 2 pieces of heavy equipment, 11 trailers, 34.9 miles of ground surface laid cable, and 359,500 pounds of scrap metal were released off site to the public. No released items had residual radioactivity in excess of the limits specified in Table 9-5.

Independent verification of radiological surveys and process knowledge evaluations performed by NSTec (the Management and Operating contractor) is achieved through NNSA/NFO program oversight and through assessments. DOE O 458.1, which includes the process of releasing property to the public, has been incorporated into the site's Radiological Control Manager's Council Internal Assessment Schedule, and DOE O 458.1 assessments are scheduled to occur once every 3 years. An assessment was conducted in 2016, and NNSS property release activities were found to be in compliance with the order. The next assessment is scheduled for 2019.

Table 9-5. Allowable total residual surface contamination for property released off the NNSS

	Residual Surface Contamination (dpm/100 cm^2)[(a)]		
Radionuclide	**Removable**	**Average[(b)] (Fixed & Removable)**	**Maximum Allowable[(c)] (Fixed & Removable)**
Transuranics, ^{125}I, ^{129}I, ^{226}Ra, ^{227}Ac, ^{228}Ra, ^{228}Th, ^{230}Th, ^{231}Pa	20	100	300
Th-natural, ^{90}Sr, ^{126}I, ^{131}I, ^{133}I, ^{223}Ra, ^{224}Ra, ^{232}U, ^{232}Th	200	1,000	3,000
U-natural, ^{235}U, ^{238}U, and associated decay products, alpha emitters (α)	1,000 α	5,000 α	15,000 α
Beta (β)-gamma (γ) emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except ^{90}Sr and others noted above	1,000 β+γ	5,000 β+γ	15,000 β+γ
^{3}H and tritiated compounds	10,000	N/A	N/A

(a) Disintegrations per minute per 100 square centimeters (cm^2)
(b) Averaged over an area of not more than 100 cm^2
(c) Applicable to an area of not more than 100 cm^2

Source: Radiological Control Manager's Council (2012)

9.2 Dose to Aquatic and Terrestrial Biota

DOE requires that their facilities evaluate the potential impacts of radiation exposure to biota in the vicinity of DOE activities. To assist in such an evaluation, DOE's Biota Dose Assessment Committee developed DOE-STD-1153-2002. This standard established the following radiological dose limits for plants and animals. Dose rates equal to or less than these are expected to have no direct, observable effect on plant or animal reproduction:

- 1 rad/d (0.01 grays per day [Gy/d]) for aquatic animals
- 1 rad/d (0.01 Gy/d) for terrestrial plants
- 0.1 rad/d (1 milligray per day) for terrestrial animals

DOE-STD-1153-2002 also provides concentration values for radionuclides in soil, water, and sediment that are to be used as a guide for determining if biota are potentially receiving radiation doses that exceed the limits. These concentrations are called the Biota Concentration Guide (BCG) values. They are defined as the minimum concentration of a radionuclide that would cause dose limits to be exceeded using very conservative uptake and exposure assumptions.

NNSS biologists use the graded approach described in DOE-STD-1153-2002. The approach is a three-step process consisting of a data assembly step, a general screening step, and an analysis step. The analysis step consists of site-specific screening, site-specific analysis, and site-specific biota dose assessment. The following information is required by the graded approach:

- Identification of terrestrial and aquatic habitats on the NNSS that have radionuclides in soil, water, or sediment
- Identification of terrestrial and aquatic biota on the NNSS that occur in contaminated habitats and are at risk of exposure
- Measured or calculated radionuclide concentrations in soil, water, and sediment in contaminated habitats on the NNSS that can be compared to BCG values to determine the potential for exceeding biota dose limits
- Measured radionuclide concentrations in NNSS biota, soil, water, and sediment in contaminated habitats on the NNSS to estimate site-specific dose to biota

A comprehensive biota dose assessment for the NNSS using the graded approach was reported in the *Nevada Test Site Environmental Report 2003* (BN 2004). This dose assessment demonstrated that the potential radiological dose to biota on the NNSS was not likely to exceed dose limits. Data from monitoring air, water, and biota across the NNSS suggest that NNSS surface conditions have not have not significantly changed; therefore, this biota dose evaluation conclusion remains the same for 2016.

9.2.1 2016 Site-Specific Biota Dose Assessment

The site-specific biota dose assessment phase of the graded approach centers on the actual collection and analysis of biota. To obtain a predicted internal dose to biota sampled in 2016, the RESRAD-BIOTA, Version 1.5, computer model (DOE 2004) was used. Maximum concentrations of man-made radionuclides detected in plant and animal tissue (see Table 8-3 and Table 8-5 in in Chapter 8) were used as input to the model. External dose was based on the measured annual exposure rate using the maximum quarterly thermoluminescent dosimeter (TLD) measurement made closest to each biota sampling site (see Table 6-1 of Chapter 6), minus the average NNSS background exposure rate (see Table 6-2 of Chapter 6). If the average background exposure rate was higher than the monitored location, then man-made external dose was set to zero. The TLD locations used are shown in Table 9-6.

The 2016 site-specific estimated dose rates to biota were all below the DOE limits for both plants and animals (Table 9-6). The highest dose was predicted for plants at T2 in Area 2 followed by animals (jackrabbits and cottontail rabbit) at that location. External dose accounted for an average of 57% of the total dose over all.

Table 9-6. Site-specific dose assessment for terrestrial plants and animals sampled in 2016

	Estimated Radiological Dose (rad/d)		
Location [a]	**Internal [b]**	**External [c]**	**Total**
Terrestrial Plants			
T2 (Area 2) (3 species)	0.0017925	0.00086	0.00265
T2 Control (Area 14) (3 species)	0.0000566	0.00008	0.00014
		DOE Dose Limit:	**1**
Terrestrial Animals			
T2 (Area 2) (2 jackrabbits and 1 cottontail rabbit)	0.0003100	0.00086	0.00117
T2 Control (Area 14) (2 jackrabbits and 1 cottontail rabbit)	0.0007672	0.00008	0.00085
Mule Deer (max observed)	0.0001635	0.00034	0.00051
Pronghorn (animal receiving maximum dose) (Area 2)	0.0000004	0.00006	0.00006
		DOE Dose Limit:	**0.1**

(a) For information on plants and animals sampled, see Chapter 8, Tables 8-3 and 8-5

(b) Based on maximum concentrations of each man-made radionuclide detected in plant or animal sampled at that location

(c) Based on TLD measured exposure rates at or near the sample location (see Chapter 6).

9.3 Dose Assessment Summary

Radionuclides in the environment from past or present NNSS activities result in a potential dose to the public or biota much lower than the dose limits set to protect health and the environment. The estimated dose to the MEI for 2016 was 1.53 rem/yr (0.0153 mSv/yr), which is 1.53% of the dose limit set to protect human health. Dose to biota at the NNSS sites sampled in 2016 were less than 2% of dose limits set to protect plant and animal populations. Based on the low potential doses from NNSS radionuclides, impacts from those radionuclides are expected to be negligible.

9.4 References

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Chapter 10: Waste Management

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Several federal and state regulations govern the safe management, storage, and disposal of radioactive, hazardous, and solid wastes generated or received on the Nevada National Security Site (NNSS) (see Table 2-1 of Chapter 2). This chapter describes the waste management operations conducted by Environmental Management of the U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO), and summarizes the activities performed in 2016 to meet all environmental/public safety regulations and to meet the major goals of the program shown below.

Waste Management Goals
Manage and safely dispose of ***low-level waste (LLW)***, ***mixed low-level waste (MLLW)*** (see Glossary, Appendix B), and non-radioactive classified waste/matter, which are generated by NNSA/NFO, other U.S. Department of Energy (DOE) approved generators, and selected U.S. Department of Defense (DoD) operations.
Manage and safely store ***transuranic (TRU)*** (see Glossary, Appendix B) and mixed transuranic (MTRU) wastes generated on site for eventual shipment to the Waste Isolation Pilot Plant (WIPP) in Carlsbad, New Mexico.
Manage, safely store, and ship ***hazardous waste (HW)*** (see Glossary, Appendix B) generated on the NNSS to approved offsite treatment/storage/disposal facilities, and treat by open detonation explosive ordnance wastes generated on the NNSS.
Ensure that wastes received for disposal meet NNSS waste acceptance criteria.
Evaluate, design, construct, maintain, and monitor closure covers for radioactive waste disposal units at the Area 3 and Area 5 Radioactive Waste Management Sites (RWMSs).
Manage radiation doses from the Area 3 RWMS and the Area 5 Radioactive Waste Management Complex (RWMC) to the levels specified in DOE Manual DOE M 435.1-1, “Radioactive Waste Management Manual.”
Manage and safely dispose of solid/sanitary wastes generated by NNSA/NFO operations.
Manage underground storage tanks (USTs) to prevent environmental contamination.
Ensure that disposal systems meet performance objectives.

10.1 Radioactive Waste Management

The NNSS radioactive waste management facilities include the ***Area 5 RWMC*** (see Glossary, Appendix B) and the Area 3 RWMS. They operate as Category II non-reactor nuclear facilities. The Area 5 RWMC (Figure 10-1) includes the Area 5 RWMS and the Waste Examination Facility (WEF). This section describes the facilities and processes that comprise the safe receipt, storage, disposal, and disposal unit monitoring of radioactive wastes at the NNSS.

10.1.1 Area 5 RWMS

The Area 5 RWMS is a DOE-owned radioactive waste disposal facility. It encompasses approximately 740 acres (ac), including 200 ac of historical and active disposal cells used for burial of LLW, MLLW, Non-Radiological Classified (NRC) waste, and Non-Radiological Classified Hazardous (NRCH) waste, and 540 ac of land available for future radioactive disposal cells. Waste disposal at the Area 5 RWMS occurred in a 92-ac portion of the site starting in the early 1960s. This “92-Acre Area” (Figure 10-1) consists of 31 disposal cells and 13 Greater Confinement Disposal (GCD) boreholes and was used for disposal of waste in drums, soft-sided containers, large cargo containers, and boxes. The 92-Acre Area was filled and permanently closed in 2011. Closure covers for the 92-Acre Area were seeded in the fall of 2011. They have been monitored and reseeded in several failed attempts to produce

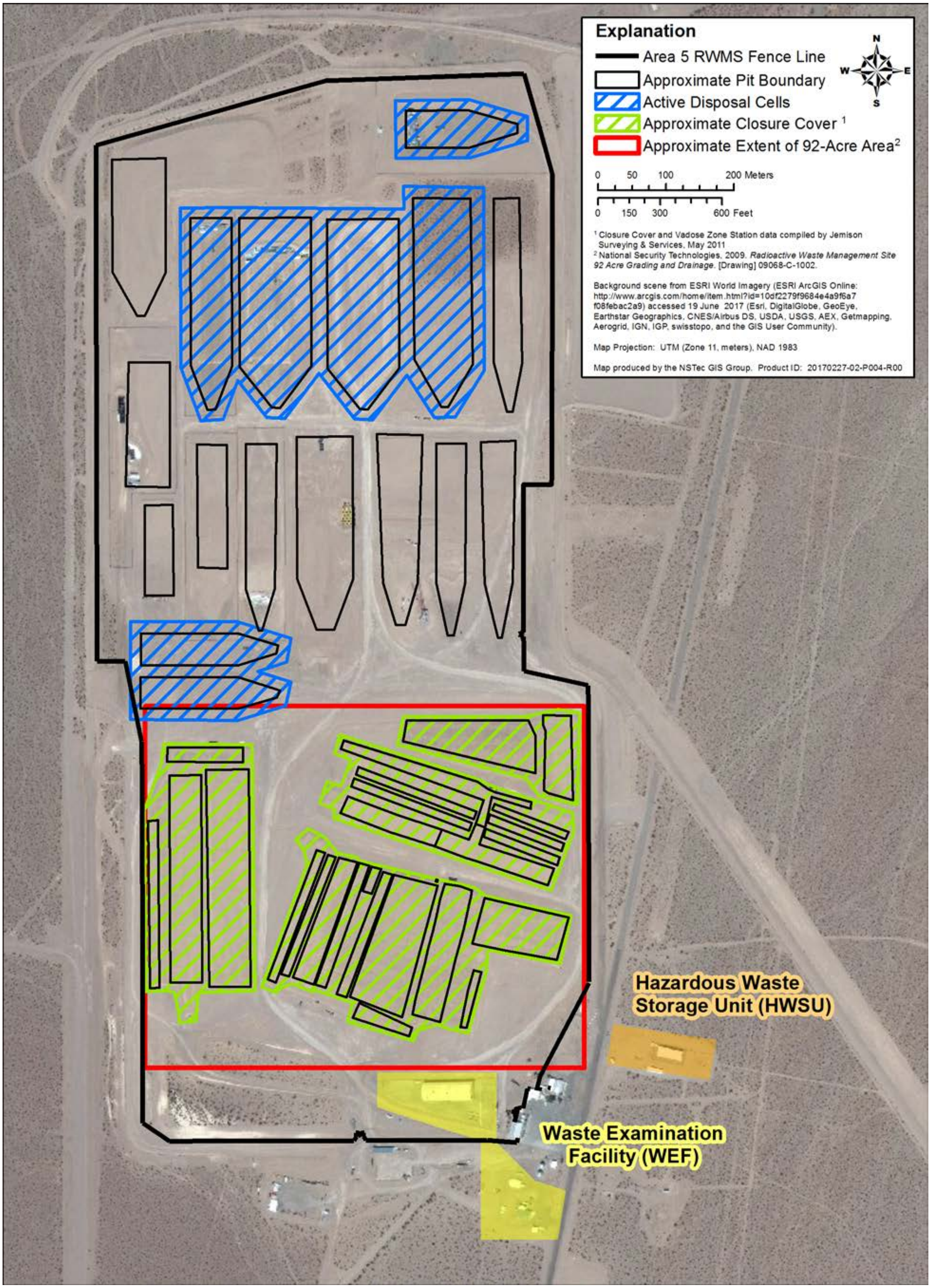

Figure 10-1. The Area 5 RWMC

covers supporting sustainable native plant populations. In 2016, NNSA/NFO began investigating other strategies for successfully revegetating these closure covers.

Seven cells, developed immediately north and west of the 92-Acre Area, have been receiving wastes since 2010. They include six LLW cells (Cells 19, 20, 21, 22, 27, and 28) and a MLLW cell (Cell 18). All active Area 5 RWMS cells can accept radioactive waste contaminated with non-regulated polychlorinated biphenyl (PCB) bulk product waste, but only Cell 18 can accept waste contaminated with regulated PCB remediation waste as well as asbestos-contaminated MLLW. Cells 18, 19, 20, 22, 27, and 28 can accept asbestos-contaminated LLW. All disposal cells that were active in 2016 are shown in Table 10-1. MLLW disposal services are expected to continue at the Area 5 RWMS until the remaining needs of the DOE complex are met.

Disposal Cell 18 is operated under a Resource Conservation and Recovery Act (RCRA) Part B Permit (NEV HW0101), which authorizes the disposal of up to 25,485 cubic meters (m^3) (899,994 cubic feet [ft^3]) of MLLW and NRCH. The volume and weight of wastes that Cell 18 received in 2016 are shown in Table 10-1. A cumulative total of 14,513 m^3 (512,521 ft^3) of MLLW/NRCH has been disposed in Cell 18 through the end of 2016. Quarterly reports were submitted to the State of Nevada in 2016 to document the weight in tons of MLLW/NRCH disposed each quarter in Cell 18.

In 2016, the Area 5 RWMS received shipments containing a total of 27,113 m^3 (957,495 ft^3) of radioactive waste for disposal (Table 10-1), which included both NRC and NRCH waste. The majority of waste disposed was received from offsite generators. The total number of waste shipments during fiscal year (FY) 2016 (October 1, 2015–September 30, 2016) were reported in an annual transportation report (NSTec 2017a). In 2016, all offsite waste generators delivering MLLW for disposal in Cell 18 that contained regulated quantities of PCBs were issued Certificates of Disposal, as required under the Toxic Substances Control Act.

Table 10-1. Total waste volumes received and disposed at the Area 5 RWMS in calendar year 2016

Waste Type	Disposal Cell(s)	Volume Received and Disposed in m^3 (ft^3)	
LLW and NRC	Cells 19, 20, 21, 22, 27, and 28	25,363	(895,695)
MLLW and NRCH (includes regulated PCB-contaminated LLW)	Cell 18	1,750	(61,800); 907 tons[(a)]
	Total	27,113	(957,495)

(a) Fees paid to the state for HW generated at the NNSS and MLLW wastes received for disposal are based on weight

10.1.2 WEF

The operational units of the WEF include the TRU Pad, TRU Pad Cover Building (TPCB), TRU Loading Operations Area, WEF Yard, WEF Drum Holding Pad, Sprung Instant Structure (SIS), and the Visual Examination and Repackaging Building (VERB). The WEF was used for the staging, characterization, repackaging, and offsite shipment of legacy TRU wastes that had been stored for many years at the NNSS. This activity was completed in 2009.

Currently, The SIS, VERB, TRU Pad, and TPCB are authorized for the safe storage of radioactive mixed waste under the current RCRA Permit (NEV HW0101). The TPCB also accepts TRU/MTRU waste from NNSS generators including the Joint Actinide Shock Physics Experimental Research (JASPER) facility. The TPCB stores the waste until it is characterized for disposal at the WIPP in Carlsbad, New Mexico. In 2016, the TRU waste remaining in storage at the TPCB consisted of two experimental spheres from Lawrence Livermore National Laboratory and 32 standard waste boxes from JASPER.

10.1.3 Area 3 RWMS

Disposal operations at the Area 3 RWMS (Figure 10-2) began in the late 1960s. The Area 3 RWMS consists of seven subsidence craters configured into five disposal cells. Each subsidence crater was created by an underground nuclear weapons test. Until July 1, 2006, when the site was placed into inactive status, the site was used for disposal of bulk LLW, such as soils or debris, and waste in large cargo containers. The site consists of the following seven craters:

2 Disposal Cells (Inactive Status):	1 Closed Cell:	2 Undeveloped Cells:
U-3ah/at	U-3ax/bl	U-3az
U-3bh	(Corrective Action Unit 110)	U-3bg

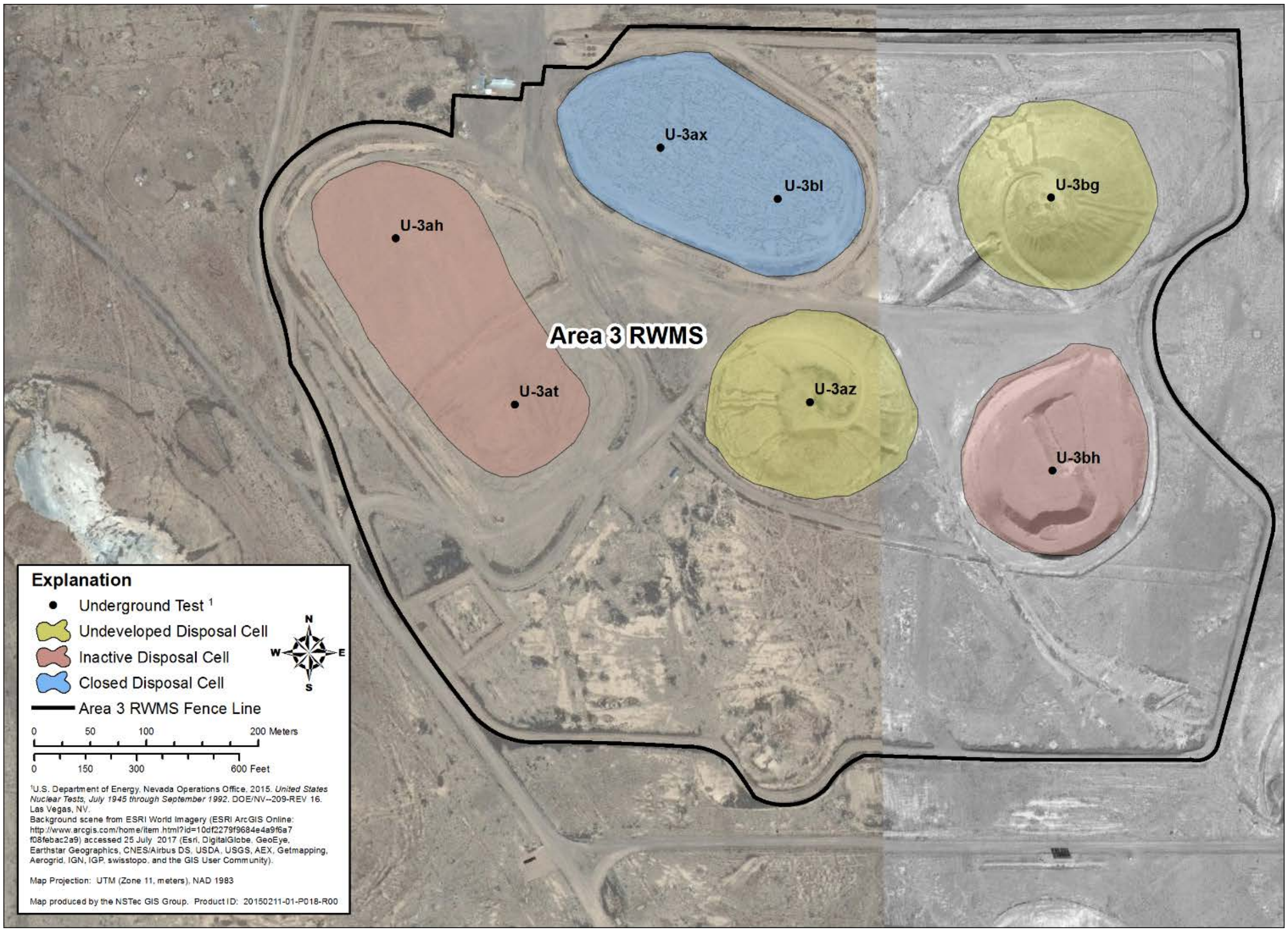

Figure 10-2. The Area 3 RWMS

10.1.4 Waste Characterization

All generators of waste streams must demonstrate eligibility for waste to be disposed at the NNSS, submit profiles characterizing specific waste streams, meet the NNSS Waste Acceptance Criteria (WAC), and receive programmatic approval from NNSA/NFO for their site waste certification programs.

Characterization is performed by approved NNSA/NFO waste generators using knowledge of the generating process, sampling and analysis, or non-destructive analysis. Following the characterization of a waste stream, the approved NNSA/NFO waste generator develops a waste profile. The waste profile delineates the pedigree of the waste, including, but not limited to, a description of the waste generating process, physical and chemical characteristics, radioactive isotope activity and quantity, and packaging information. The waste profile is reviewed by the Waste Acceptance Review Panel for eventual approval or disapproval by NNSA/NFO. The approved waste generator then packages and ships approved waste streams in accordance with U.S. Department of Transportation requirements to the Area 5 RWMC or to an offsite facility for treatment, if necessary, prior to its return shipment for disposal at the Area 5 RWMC.

In 2016, LLW, MLLW, and classified waste/matter were characterized by approved waste generators for the following general waste stream categories:

- Lead Solids
- Sealed Sources
- Miscellaneous Debris
- Contaminated PCB Waste
- Compactable Trash
- Amalgamated Mercury
- Depleted Uranium
- Contaminated Asbestos Waste
- Non-radioactive Classified Matter/Waste
- HEPA Exhaust and Intake Filters
- Radioactive Hazardous Classified Matter/Waste

An incident occurred in 2016, which necessitated the removal of a waste container from Cell 21 that had been shipped from Nuclear Fuel Services (NFS) in Tennessee to the NNSS in 2015. NFS had identified the container as having non-hazardous LLW, and it was received at the Area 5 RWMC in accordance with the WAC. In 2016, NFS notified NSTec and NNSA/NFO that they had mischaracterized the package in question and that it is hazardous LLW, not permitted for disposal in Cell 21, and not packaged to be RCRA compliant. All appropriate investigative actions were taken, the container was returned to NFS, and an occurrence report was submitted to DOE by NSTec regarding the incident (see Table 2-8, Report No. EM-NNVSO-NST-2016-0016, in Chapter 2). During NFS's extent-of-condition evaluation, questions arose regarding the characterization of additional containers that have been received at the NNSS. The process to resolve this issue is still ongoing and the State of Tennessee and the State of Nevada are involved in this process. The final path forward has not been determined.

10.1.5 Mixed Waste and Classified Non-Radioactive Hazardous Matter Verification

Waste verification is an inspection process that confirms the waste stream data supplied by approved waste generators before MLLW or non-radioactive classified HW is accepted for disposal at the NNSS. Verification may involve visual inspection, Real-Time Radiography (RTR), and/or chemical screening on a designated percentage of MLLW or non-radioactive classified hazardous matter. The objectives of waste verification include verifying that HW treatment objectives are met, confirming that waste containers do not contain free liquids, and ensuring that waste containers are at least 90% full, per RCRA and State of Nevada requirements. Offsite-generated waste is verified either when the waste is received at the NNSS or when it is still at a generator facility or a designated treatment, storage, or disposal facility. The first choice for the method of verification is visual inspection at the site of generation.

In 2016, offsite visual inspections were completed on 27 MLLW packages from eight separate waste streams, on two radioactive classified hazardous matter packages from one matter stream, and on three non-radioactive classified hazardous matter packages from one matter stream. No RTR or chemical screening was required in 2016. One onsite visual inspection on one waste stream was conducted in 2016. No MLLW or non-radioactive classified hazardous matter packages were rejected during 2016.

10.1.6 Performance Assessments, Analyses, and Annual Reviews

To assess and forecast the long-term performance of NNSS disposal sites, NNSA/NFO conducts a Performance Assessment (PA) and a Composite Analysis (CA). A PA is a systematic analysis of the potential risks posed by a waste disposal facility to the public and to the environment for LLW disposed after 1988. A CA is an assessment of the risks posed by all wastes disposed in a LLW disposal facility and by all other sources of residual contamination that may interact with the disposal site. NNSA/NFO maintains current PAs and CAs for the Area 3 and Area 5 RWMSs (Table 10-2). The *Maintenance Plan for the Performance Assessments and Composite Analyses for the Area 3 and Area 5 Radioactive Waste Management Sites at the NNSS* (National Security Technologies, LLC [NSTec], 2007) requires an annual review to assess the adequacy of the PAs and CAs, and results are submitted annually to the DOE Office of Environmental Management. The Disposal Authorization Statements for the Area 3 and Area 5 RWMSs also require that annual reviews be made and that secondary or minor unresolved issues be tracked and addressed as part of the Maintenance Plan.

In 2016, NNSA/NFO performed an annual review of the Area 3 and Area 5 RWMS PAs and CAs. Operational factors (e.g., waste forms and containers, facility design), closure plans, monitoring results, and research and development activities in or near the facilities were also reviewed. The FY 2016 annual summary report to DOE (NSTec 2017b) presented data and conclusions that verified the adequacy of both the Area 3 and Area 5 PAs and CAs. Table 10-2 lists the key documents that must be current and in place for RWMS disposal operations to occur. In 2016, all of these key documents were maintained.

Table 10-2. Key documents required for Area 3 RWMS and Area 5 RWMS disposal operations

Disposal Authorization Statement
Disposal Authorization Statement for Area 5 RWMS, December 2000
Disposal Authorization Statement for Area 3 RWMS, October 1999

Table 10-2. Key documents required for Area 3 RWMS and Area 5 RWMS disposal operations (continued)

Performance Assessment
Addendum 2 to Performance Assessment for Area 5 RWMS, June 2006
Performance Assessment/Composite Analysis for Area 3 RWMS, Revision 2.1, October 2000
2016 Annual Summary Report for Area 3 and 5 RWMSs at NNSS (Review of Performance Assessments and Composite Analyses), February 2017

Composite Analysis
Composite Analysis for Area 5 RWMS, September 2001
Performance Assessment/Composite Analysis for Area 3 RWMS, Revision 2.1, October 2000

NNSS Waste Acceptance Criteria
NNSS Waste Acceptance Criteria, Revision 10a, February 2015

Integrated Closure and Monitoring Plan
Closure Plan for the Area 3 RWMS at the NNSS, September 2007
Closure Plan for the Area 5 RWMS at the NNSS, September 2008

Documented Safety Analysis
Documented Safety Analysis (DSA) for the NNSS Areas 3 and 5 Radioactive Waste Facilities, Revision 5, Change Notice 4, May 2012
Safety Evaluation Report (SER) Addendum C, Revision 0, for the Visual Examination and Repackaging Building Addendum to the Area 5 RWMC DSA and Technical Safety Requirements (TSR) for the Area 5 RWMC TRU Waste Activities, November 2008
Visual Examination and Repackaging Building Addendum to the Area 5 RWMC DSA, Revision 0, Change Notice 3, November 2008
SER Addendum C, Revision 0, for the NNSS Areas 3 and 5 Radioactive Waste Facility DSA, Revision 5, Change Notice 3, and TSR Revision 7, Change Notice 3, January 2012
TSR for the Area 5 RWMC TRU Waste Activities, Revision 10, Change Notice 4, May 2012
TSR for the Areas 3 and 5 RWMS LLW Activities, Revision 7, Change Notice 4, May 2012

10.1.7 Groundwater Monitoring

Disposal Cell 18 is operated according to RCRA standards for the disposal of MLLW. Title 40 Code of Federal Regulations (CFR) Part 264, Subpart F (40 CFR 264.92) requires groundwater monitoring to verify the performance of Cell 18 to protect groundwater from buried HW. Wells UE5 PW-1, UE5 PW-2, and UE5 PW-3 are monitored for this purpose. Investigation levels (ILs) for five indicators of groundwater contamination (Table 10-3) were established by NNSA/NFO and the Nevada Division of Environmental Protection (NDEP) for these three wells in 1998. All samples collected semiannually in 2016 from the wells had contaminant levels below their ILs (Table 10-3). Static water levels and general water chemistry parameters are also monitored. All sample analysis results are presented in NSTec (2017c). The tritium levels were very low, all below their sample-specific ***minimum detectable concentration (MDC)*** (see Glossary, Appendix B) of between 216 and 255 pCi/L. (Table 5-5 of Chapter 5 presents the sample-specific MDCs for each water sample collected from these wells in 2016.) No groundwater contamination from Cell 18 is indicated by the 2016 results.

Table 10-3. Results of groundwater monitoring of UE5 PW-1, UE5 PW-2, and UE5 PW-3 in 2016

Parameter	Investigation Level (IL)	Sample Levels[(a)]
pH	< 7.6 or > 9.2 S.U.[(b)]	8.15 to 8.41 S.U.
Specific conductance (SC)	0.440 mmhos/cm[(c)]	0.348 to 0.374 mmhos/cm
Total organic carbon (TOC)	1 mg/L[(d)]	<0.33 mg/L
Total organic halides (TOX)	50 µg/L[(e)]	<3.3 µg/L
Tritium (^{3}H)	2,000 pCi/L[(f)]	ND[(g)]

(a) Levels shown are the lowest and highest values for each well for each sample date. Source: NSTec (2017c)
(b) S.U. = standard unit(s) (for measuring pH)
(c) mmhos/cm = millimhos per centimeter
(d) mg/L = milligrams per liter
(e) µg/L = microgram(s) per liter
(f) pCi/L = picocuries per liter
(g) ND = not detected; levels were below sample-specific MDCs

10.1.8 Vadose Zone Monitoring

Monitoring of the ***vadose zone*** (see Glossary, Appendix B) is conducted at the RWMC to demonstrate that (1) the PA assumptions at the RWMSs are valid regarding the hydrologic conceptual models used, including soil water contents, and upward and downward flux rates; and (2) there is negligible infiltration and percolation of precipitation into zones of buried waste at the RWMSs. Vadose zone monitoring (VZM) offers many advantages over groundwater monitoring, including detecting potential problems long before groundwater resources would be impacted, allowing corrective actions to be made early, and being less expensive than groundwater monitoring. The components of the VZM program include the Drainage ***Lysimeter*** (see Glossary, Appendix B) Facility northwest of U-3ax/bl, the Area 5 Weighing Lysimeter Facility southwest of the Area 5 RWMS, two meteorology towers, and instruments at eight depth levels at six locations in four waste disposal cell covers that measure water content and water potential profiles. Data from all of these components are used to monitor the natural water balance at the RWMSs. Descriptions of the VZM components and the results of monitoring in 2016 are reported in NSTec (2017d). All VZM results in 2016 continued to demonstrate that there is negligible infiltration of precipitation into zones of buried waste at the RWMC and that the performance criteria of the waste disposal cells are being met to prevent contamination of groundwater and the environment.

10.1.9 Assessment of Radiological Dose to the Public

DOE M 435.1-1 states that LLW disposal facilities shall be operated, maintained, and closed so that a reasonable expectation exists that annual dose to members of the public shall not exceed 10 millirem (mrem) through the air pathway and 25 mrem through all pathways for a 1,000-year compliance period after closure of the disposal units. Given that the RWMSs are located well within the NNSS boundaries, no members of the public can currently access these areas for significant periods of time to acquire a dose exceeding the 10 or 25 mrem annual limit. To document compliance with DOE M 435.1-1, however, the possible pathways for radionuclide movement from waste disposal facilities are monitored. Long-term compliance with the DOE M 435.1-1 dose limits is evaluated by performance assessment modeling. As discussed below, waste operations would contribute negligible exposure to a hypothetical person residing near the boundaries of the RWMSs and would contribute no dose to the offsite public.

10.1.9.1 Dose from Air and Direct Radiation

Air samplers operate continuously to collect air particulates and atmospheric moisture near each RWMS. These samples are analyzed for radionuclides, and results are used to assess potential dose. Details of the air sampling and a summary of the analysis results can be found in Chapter 4. In 2016, three environmental sampling stations operated in/near the Area 3 RWMS (U-3ax/bl S, Bilby Crater, and Kestrel Crater N), and two air monitoring stations operated near the Area 5 RWMS (DoD and RWMS 5 Lagoons). The dose from the air pathway was estimated based on the highest annual mean concentration results for each measured radionuclide from among these five stations in order to estimate a worst-case dose for a member of the public at either of the RWMSs.

The highest annual mean concentration of each measured radionuclide among the five stations, and the station at which the highest concentration occurred, are shown in Table 10-4. The highest concentration of any radionuclide was 3,180 microcuries per milliliter (µCi/mL) for ^{3}H at RWMS 5 Lagoons. All four of the highest mean concentrations shown in Table 10-4 were far below their established National Emission Standards for Hazardous Air Pollutants (NESHAP) Concentration Levels for Environmental Compliance (CLs) (Table 10-4, fourth column). The highest mean concentration of each measured radionuclide is divided by its respective CL to obtain a “fraction of CL” (Table 10-4, right-most column). The fractions are then summed, and if the sum is less than 1, it demonstrates that the NESHAP dose limit of 10 mrem/yr was not exceeded at a location having all those radionuclides at those concentrations. Summing the fractions of CLs gives 0.10 (rounded up), which is only 10% of the limit in this worst-case scenario. Scaling this to the 10 mrem dose that the CLs represent would mean that a hypothetical person residing near the RWMS would receive an annual dose of about 1.0 mrem/yr from the air pathway.

Table 10-4. Highest annual mean concentrations of radionuclides detected in 2016 at Area 3 and Area 5 RWMS

Radionuclide	RWMS Sampler with Highest Concentration	Highest Annual Mean Concentration ($\times 10^{-15}$ µCi/mL)	NESHAP CL[(a)] ($\times 10^{-15}$ µCi/mL)	Fraction of CL
^{3}H	RWMS 5 Lagoons	1,000	1,500,000	0.0007
^{238}Pu	DoD	0.00495	2.1	0.0024
^{239}Pu	U-3ax/bl S	0.157 ($^{239+240}Pu$)	2	0.0785
^{241}Am	U-3ax/bl S	0.0271	1.9	0.0143
			Sum of Fractions:	**0.0959**

(a) CL values represent an annual average concentration that would result in a total effective dose equivalent of 10 mrem/yr, the federal dose limit to the public from all radioactive air emissions (from Table 2, Appendix E of 40 CFR 61, "National Emission Standards for Hazardous Air Pollutants," 1999).

Thermoluminescent dosimeters (TLDs) (see Glossary, Appendix B) are used to measure ionizing radiation exposure at 5 locations in and around the Area 3 RWMS and 12 locations in and around the Area 5 RWMS. The TLDs have three calcium sulfate elements used to measure the total exposure rate from penetrating gamma radiation, including background radiation. The penetrating gamma radiation makes up the deep dose, which is compared to the 25 mrem/yr limit when background exposure is subtracted. Details of the direct radiation monitoring can be found in Chapter 6. During 2016, the external radiation measured near the boundaries of the Area 3 and Area 5 RWMSs could not be distinguished from background levels (see Section 6.3.4). Area 3 and Area 5 RWMS operations would have contributed negligible external exposure to a hypothetical person residing near the boundaries of these sites and no dose to the offsite public.

10.1.9.2 Dose from Groundwater

Groundwater and vadose zone monitoring at the RWMSs is conducted to verify the performance of waste disposal facilities. Such monitoring has not detected the migration of radiological wastes into groundwater (see Sections 10.1.7 and 10.1.8). Also, the results of monitoring offsite public and private wells and springs indicate that man-made radionuclides have not been detected in any public or private water supplies (see Table 5-4 of Chapter 5, and Sections 7.2 and 7.3 of Chapter 7). Based on these results, potential doses to members of the public from LLW disposal facilities on the NNSS from groundwater, and from all pathways combined, are negligible.

10.2 Hazardous Waste Management

HW regulated under RCRA is generated at the NNSS from a broad range of activities, including onsite laboratories, site and vehicle maintenance, communications operations, and environmental restoration of historical contaminated sites. The RCRA Part B Permit NEV HW0101 regulates the operation of the Area 5 Mixed Waste Disposal Unit (MWDU), consisting of a Subtitle C landfill (Cell 18) and 3,000-gallon leachate collection tank, the Area 5 Hazardous Waste Storage Unit (HWSU), and the Area 11 Explosive Ordnance Disposal Unit (EODU) facilities. Included in the RCRA Part B permit is authorization for the storage of MLLW at the Mixed Waste Storage Unit (MWSU), which comprises the following four facilities at the Area 5 RWMC: the TPCB and TRU Pad, the SIS Building, the VERB, and the Drum Holding Pad.

The HWSU (Figure 10-1) is a pre-fabricated, rigid-steel-framed, roofed shelter that is permitted to store a maximum of 61,600 liters (16,273 gallons) of approved waste at a time. HW generated at NNSA/NFO environmental restoration sites off the NNSS (e.g., at the Tonopah Test Range) or generated at the North Las Vegas Facility are direct-shipped to approved disposal facilities. HW generated on the NNSS is also direct-shipped from sites on the NNSS (i.e., not from the HWSU) if the sites generate bulk, non-packaged HW that is not accepted at the HWSU for storage. HW would also be direct-shipped from NNSS sites in the unlikely case when the waste volume capacity of the HWSU is approaching its permitted limits. Satellite Accumulation Areas (SAAs) and 90-day Hazardous Waste Accumulation Areas (HWAAs) are used at the NNSS for the temporary storage of HW prior to direct shipment off site or to the HWSU.

The EODU is permitted to treat explosive ordnance wastes by open detonation of not more than 45.4 kilograms (100 pounds) of approved waste at a time, not to exceed one detonation event per hour. Conventional explosive wastes are generated at the NNSS from explosive operations at construction and experiment sites, the NNSS firing range, the resident national laboratories, and other activities.

10.2.1 2016 Hazardous Waste Activities

The RCRA permit requires preparation of a U.S. Environmental Protection Agency Biennial Hazardous Waste Report of all HW volumes generated and disposed or stored at the NNSS. This report is prepared for odd-numbered years only. It was most recently prepared for 2015 and electronically submitted to the State of Nevada on February 1, 2016. The next biennial report will be prepared for 2017 and submitted to the state in 2018. An annual waste volume report was prepared in 2016 and submitted to the State of Nevada in March 2017 (NSTec 2017e). It includes the amount of wastes received in calendar year 2016 at the Area 5 MWDU, MWSU, HWSU; and Area 11 EODU.

Table 10-5 presents the quantities of HW generated either on or off site that were managed (received, stored, shipped, or disposed) at the various NNSS waste units during calendar year 2016. It includes the tons of MLLW received and disposed on site in MWDU Cell 18; the tons of MLLW received at the MWSU; the tons of MLLW shipped off site from the MWSU for disposal; the tons of HW with and without PCBs received, stored, and shipped off site from the HWSU; and the tons of HW stored and then shipped off site from one or more HWAAs. In 2016, no HW was direct-shipped from NNSS HWAAs or SAAs. Quarterly 2016 HW volume reports were submitted on schedule to NDEP.

No waste explosive ordnance were detonated at the EODU in 2016.

Table 10-5. HW managed at the NNSS in 2016

Unit	Amount Received (tons)[(a)]	Amount Shipped (tons)	Amount Disposed (tons)
MWDU Cell 18	907	0	907
MWSU	0	0	--
HWSU	0.79	0.71	--
HWSU – PCB Waste	0.137	0.10	--
HWAA	NA[(b)]	0	--
EODU	0	0	0

(a) Fees paid to the state for HW generated at the NNSS and MLLW wastes received for disposal are based on weight (tons).

(b) Not applicable; amounts of HW received at HWAAs are not tracked, only the length of time they are stored and the amounts shipped off from all HWAAs combined are tracked.

Each year, NDEP performs a Compliance Evaluation Inspection (CEI) of the RCRA permitted HW units at the NNSS. On April 25 and 26, 2016, NDEP conducted its CEI of the waste units listed in Table 10-5 as well as of closed historic RCRA waste management units at the NNSS (see Section 11.4 of Chapter 11). The 2016 CEI documented that NNSA/NFO was compliant with the NNSS Part B Permit.

10.3 Underground Storage Tank (UST) Management

RCRA regulates the storage, transportation, treatment, and disposal of HW to prevent contaminants from leaching into the environment from USTs. Nevada Administrative Code NAC 459.9921–459.999, "Storage Tanks," enforces the federal regulations under RCRA pertaining to the maintenance and operation of USTs and the regulated substances contained in them so as to prevent environmental contamination. NNSA/NFO operates one deferred UST and three excluded USTs at the Device Assembly Facility; one fully regulated UST at the Area 6 Helicopter pad, which is not in service; and three fully regulated USTs, one deferred UST, and three excluded USTs at the Remote Sensing Laboratory–Nellis (RSL-Nellis). NDEP has oversight authority of the NNSS USTs, and the Southern Nevada Health District has oversight authority of USTs in Clark County (see Section A.2.3 of Appendix A regarding UST management at RSL-Nellis). NDEP usually conducts inspections of NNSS USTs once every 3 years. In 2016 NDEP inspected the USTs at the NNSS and no issues were identified. No NNSS USTs were upgraded or removed in 2016.

10.4 Solid and Sanitary Waste Management

Three landfills for solid waste disposal were operated at the NNSS in 2016. The landfills are regulated and permitted by the State of Nevada (see Table 2-3 for list of permits). No liquids, HW, or radioactive waste are accepted in these landfills. They include:

- Area 6 Hydrocarbon Landfill – accepts hydrocarbon-contaminated wastes, such as soil and absorbents.
- Area 9 U10c Solid Waste Landfill – designated for industrial waste such as construction and demolition debris and asbestos waste under certain circumstances.
- Area 23 Solid Waste Landfill – accepts municipal-type wastes such as food waste and office waste. Regulated asbestos-containing material is also permitted in a special section. The permit allows disposal of no more than an average of 20 tons/day at this site.

These landfills are designed, constructed, operated, maintained, and monitored in adherence to the requirements of their state permits. NDEP visually inspects the landfills and checks the records on an annual basis to ensure compliance with the permits. No non-compliance issues were noted during the July 2016 NDEP inspection. The amount of waste disposed in each solid waste landfill is shown in Table 10-6. Biannual reports for the Area 23 Solid Waste Landfill were submitted in July 2016 and January 2017 to NDEP (NSTec 2016, 2017f).

The vadose zone is monitored at the Area 6 Hydrocarbon Landfill and the Area 9 U10c Solid Waste Landfill. VZM is performed once annually in lieu of groundwater monitoring to demonstrate that contaminants from the landfills are not leaching into the groundwater. VZM in 2016 indicated that there was no soil moisture migration and, therefore, no waste leachate migration to the water table. Annual 2016 soil moisture monitoring reports for the Area 6 and Area 9 sites were submitted in May 2017 to NDEP (NSTec 2017g, 2017h).

Table 10-6. Quantity of solid wastes disposed in NNSS landfills in 2016

Waste Disposed in Landfills in Metric Tons (Tons)		
Area 6	**Area 9**	**Area 23**
170.1 (187.5)	798.4 (880.0)	852.2 (939.4)

10.5 References

National Security Technologies, LLC, 2007. *Maintenance Plan for Performance Assessments and Composite Analyses of the Area 3 and Area 5 Radioactive Waste Management Sites at the Nevada Test Site*. DOE/NV/25946--091, prepared for U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office, Las Vegas, NV. OSTI ID: 914419

National Security Technologies, LLC, 2016. *January–June 2016 Biannual Solid Waste Disposal Site Report for the Nevada National Security Site Area 23 Sanitary Landfill*, prepared for U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office, Las Vegas, NV, July 2016.

National Security Technologies, LLC, 2017a. *4th Quarter/Annual Transportation Report FY2016, Waste Shipments to and from the Nevada National Security Site (NNSS), Radioactive Waste Management Complex*. DOE/NV/25946--3103, prepared for U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office, Las Vegas, NV, January 2017.

National Security Technologies, LLC, 2017b. *2016 Annual Summary Report for the Area 3 and 5 Radioactive Waste Management Sites at the Nevada National Security Site (Review of Performance Assessments and Composite Analyses)*. DOE/NV/25946--3145, prepared for U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office, Las Vegas, NV, March 2017.

National Security Technologies, LLC, 2017c. *Nevada National Security Site 2016 Data Report: Groundwater Monitoring Program Area 5 Radioactive Waste Management Site*. DOE/NV/25946--3113, prepared for U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office, Las Vegas, NV.

National Security Technologies, LLC, 2017d. *Nevada National Security Site 2016 Waste Management Monitoring Report, Area 3 and Area 5 Radioactive Waste Management Site*. DOE/NV/25946--3312, prepared for U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office, Las Vegas, NV.

National Security Technologies, LLC, 2017e. *RCRA Permit for a Hazardous Waste Management Facility Permit Number NEV HW0101, Annual Summary/Waste Minimization Report, Calendar Year 2016, Nevada National Security Site, Nevada.* DOE/NV/25946--3131, prepared for U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office, Las Vegas, NV, February 2017.

National Security Technologies, LLC, 2017f. *July–December 2016 Biannual Solid Waste Disposal Site Report for the Nevada National Security Site Area 23 Sanitary Landfill*, prepared for U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office, Las Vegas, NV, January 2017.

National Security Technologies, LLC, 2017g. *Annual Soil Moisture Monitoring Report for the Area 9 U10c Landfill, Nevada National Security Site, Nevada, for the Period March 2016 – February 2017,* prepared for U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office, Las Vegas, NV.

National Security Technologies, LLC, 2017h. *Annual Soil Moisture Monitoring Report for the Area 6 Hydrocarbon Landfill, Nevada National Security Site, Nevada, for the Period March 2016–February 2017,* prepared for U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office, Las Vegas, NV.

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Chapter 11: Environmental Restoration

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Environmental Management (EM) Operations of the U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO) is responsible for evaluating and implementing corrective actions on those portions of the Nevada National Security Site (NNSS), the Nevada Test and Training Range (NTTR), and the Tonopah Test Range (TTR) that have been impacted by atmospheric and underground nuclear tests conducted from 1951 to 1992. These sites are referred to as corrective action sites (CASs). Environmental restoration (ER) strategies and corrective actions are developed based on the nature and extent of contamination, the risks posed by that contamination, and future land use. EM is responsible for approximately 3,000 CASs in Nevada.

CASs are broadly organized into four categories based on the source of contamination: Underground Test Area (UGTA) sites, Industrial sites, Soils sites, and Nevada Offsites. Multiple CASs are grouped into corrective action units (CAUs) according to location, physical and geological characteristics, and/or contaminants. UGTA is the largest component of NNSA/NFO's EM Operations and includes five CAUs of 878 CASs that are directly related to groundwater in the geographical areas of past underground nuclear testing. Industrial sites are facilities and land that may have become contaminated as a result of activities conducted in support of nuclear testing, and include disposal wells, inactive tanks, contaminated waste sites, inactive ponds, muck piles, spill sites, drains and sumps, and ordnance sites. Soils sites include areas where nuclear tests have resulted in extensive surface and/or shallow subsurface contamination that include radioactive materials as well as possibly oils, solvents, heavy metals, and contaminated instruments and test structures used during testing activities. Nevada Offsites are associated with underground nuclear testing at the Project Shoal Area and the Central Nevada Test Area, located in northern and central Nevada, respectively. Nevada Offsites are managed by the U.S. Department of Energy (DOE) Office of Legacy Management.

In April 1996, the DOE, the U.S. Department of Defense, and the State of Nevada entered into a Federal Facility Agreement and Consent Order (FFACO) to address the environmental restoration of CASs. Appendix VI of the FFACO (as amended), describes the strategy that will be employed to plan, implement, and complete environmental corrective actions (i.e., to "close" the CASs). ER activities follow a formal work process described in the FFACO. The State of Nevada is a participant throughout the closure process, and the Nevada Site Specific Advisory Board (NSSAB) is kept informed of the progress made. The NSSAB is a formal volunteer group of interested citizens and representatives who provide informed recommendations to NNSA/NFO EM. The NSSAB's comments are strongly considered throughout the corrective action process. This section summarizes actions taken by EM towards the closure of UGTA, Industrial, and Soils sites in 2016.

Environmental Restoration Objectives for All Sites
Characterize sites contaminated by NNSA/NFO nuclear testing activities.
Remediate contaminated sites in accordance with FFACO-approved planning documents.
Conduct post-closure monitoring of sites in accordance with FFACO closure documents.

11.1 UGTA Sites

From 1951 to 1992, more than 800 underground tests (UGTs), some involving multiple detonations, were conducted at the NNSS (NNSA/NFO 2015a). Most were conducted hundreds of feet above groundwater;

however, over 200 were within or near the ***water table*** (see Glossary, Appendix B). The test locations (i.e., CASs) are grouped into five CAUs based primarily on geographically distinct areas of underground testing (Figure 11-1). ***Closure-in-place*** (see Glossary, Appendix B) with institutional controls (e.g., restricting land and groundwater access) and monitoring is considered to be the only feasible corrective action for these sites because cost-effective groundwater technologies have not been developed to effectively remove or stabilize deep subsurface radiological contaminants.

Corrective actions for each CAU begin with data collection and analysis activities, called characterization studies. In addition, water levels, which are routinely measured in wells throughout the NNSS and surrounding area, are evaluated to determine groundwater flow directions (e.g., Fenelon et al. 2010) (Figure 11-2). The characterization studies, NNSS water-level monitoring data, and regional three-dimensional groundwater flow models (International Technology Corporation 1996; Belcher and Sweetkind 2010) provide the basis for developing models of the hydrogeologic setting, the radiological ***source term*** (see Glossary, Appendix B), and flow and contaminant transport for each CAU. The spatial extent of these models for each CAU is presented in Figure 11-3. The numerous surface and subsurface investigations and computer modeling conducted for UGTA CAUs are performed by various participating organizations including National Security Technologies, LLC (NSTec); Los Alamos National Laboratory (LANL); Lawrence Livermore National Laboratory (LLNL); the U.S. Geological Survey (USGS); the Desert Research Institute (DRI); and Navarro Research and Engineering, Inc. (Navarro).

The groundwater flow and contaminant transport models will ultimately be used to design monitoring well networks and land-use restrictions that protect the public. For four of the five UGTA CAUs, these models will be used to identify ***contaminant boundaries*** (see Glossary, Appendix B) that forecast areas that potentially could exceed the Safe Drinking Water Act (SDWA) maximum contaminant levels for ***radionuclides*** (see Glossary, Appendix B) over the next 1,000 years. Such contaminant boundary forecasts are not required by the FFACO for the Rainier Mesa/Shoshone Mountain CAU due to the determination that field data are, and will be, insufficient to develop models which could reliably identify a contaminant boundary in this geologically complex area (NNSA/NFO 2013). For this CAU, the models must instead demonstrate that institutional controls will not be challenged by radionuclides originating from UGTs conducted in the CAU within the 1,000-year compliance period.

As required under the FFACO, after characterization activities and model development have been completed, the following items will be sequentially identified/defined for each CAU in agreement between DOE and the Nevada Division of Environmental Protection (NDEP): a ***regulatory boundary*** (see Glossary, Appendix B) objective statement, regulatory boundary(ies), and ***use-restriction boundaries*** (see Glossary, Appendix B). UGTA corrective actions for all CAUs are expected to be completed by fiscal year (FY) 2030 (October 1, 2029–September 30, 2030).

Environmental Restoration Objectives for UGTA Sites

Develop a regional three-dimensional computer groundwater model to identify immediate risks and provide a basis for developing more detailed CAU-specific models.

Develop CAU-specific models of groundwater flow and contaminant transport that geographically cover the five former NNSS underground nuclear testing areas.

Identify contaminant boundaries[a] (which support regulatory decision-making processes) where contaminants are forecasted to exceed the SDWA limits at any time within a 1,000-year compliance period.

Negotiate regulatory objectives and regulatory boundaries to protect the public and environment from the effects of radioactive contaminant migration.

Negotiate use-restriction boundaries to restrict access to contaminated groundwater.

Develop a long-term closure monitoring network to verify consistency with the flow and transport models, compliance to the regulatory boundary, and protection of human health and the environment.

[a] The identification of contaminant boundaries are objectives for all UGTA CAUs except for the Rainier Mesa/Shoshone Mountain CAU, for which it must be demonstrated that institutional controls will not be challenged by radionuclides from UGTs conducted in the CAU within the 1,000-year compliance period.

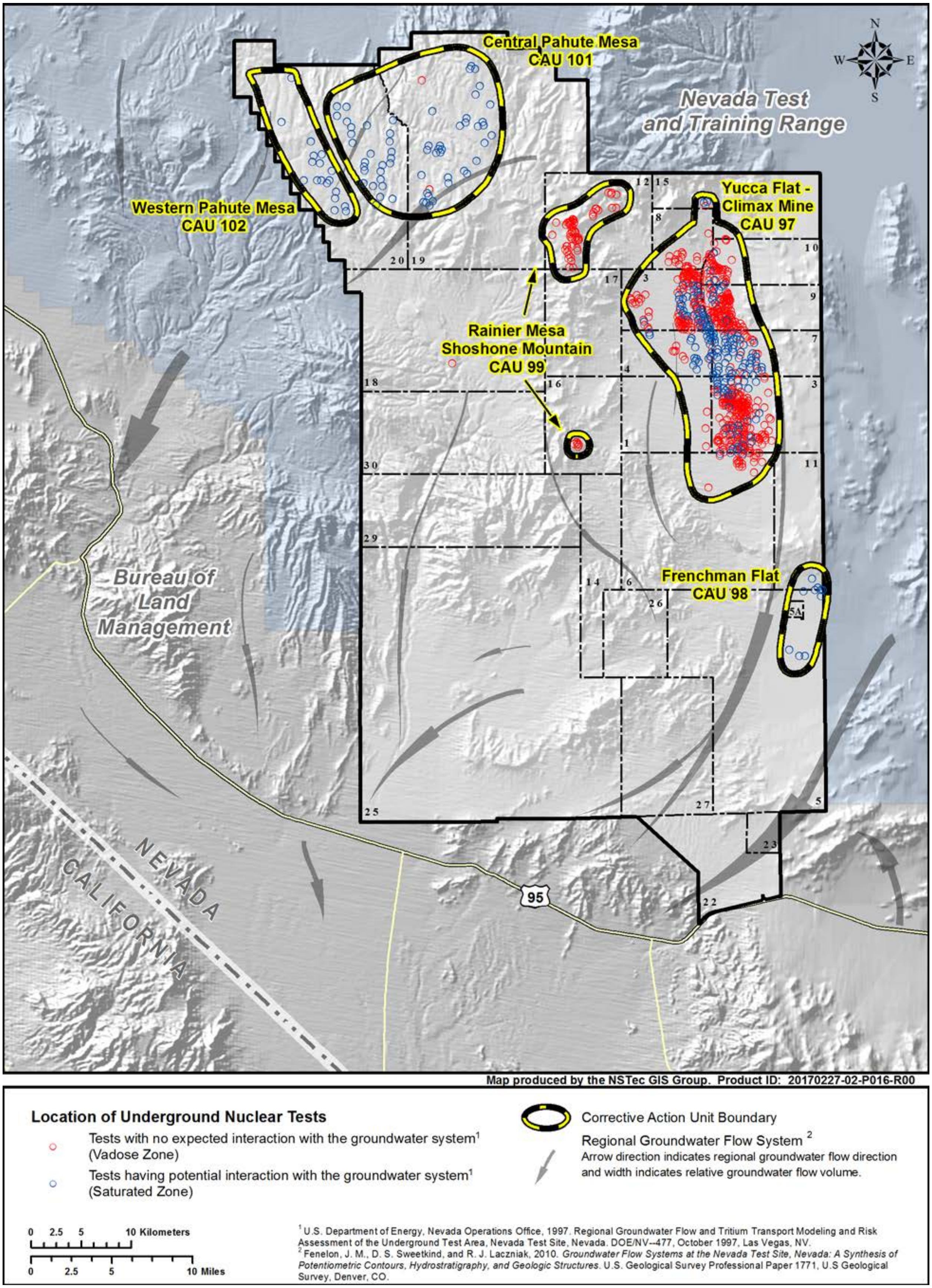

Figure 11-1. UGTA CAUs on the NNSS

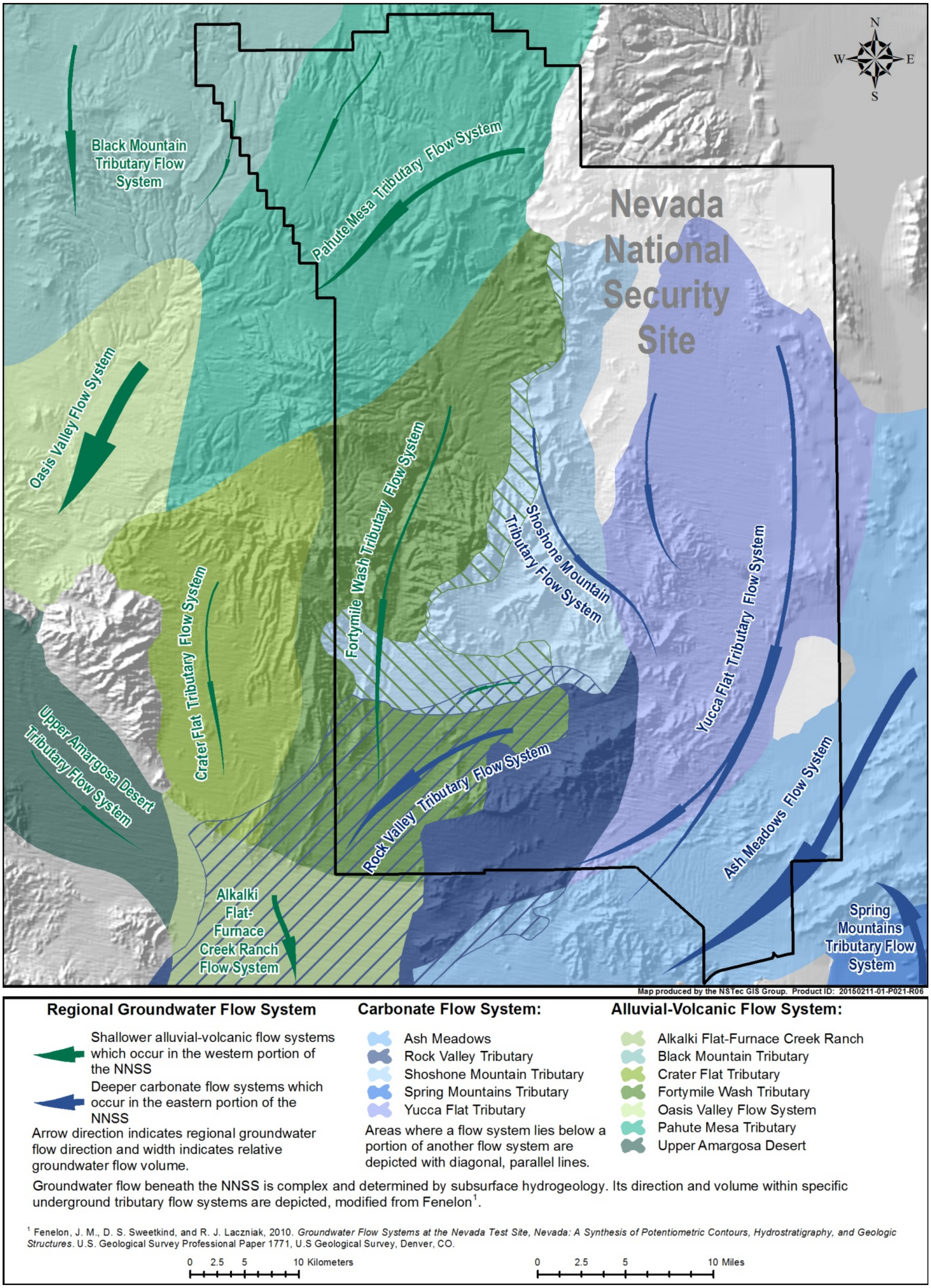

Figure 11-2. Groundwater flow systems of the NNSS

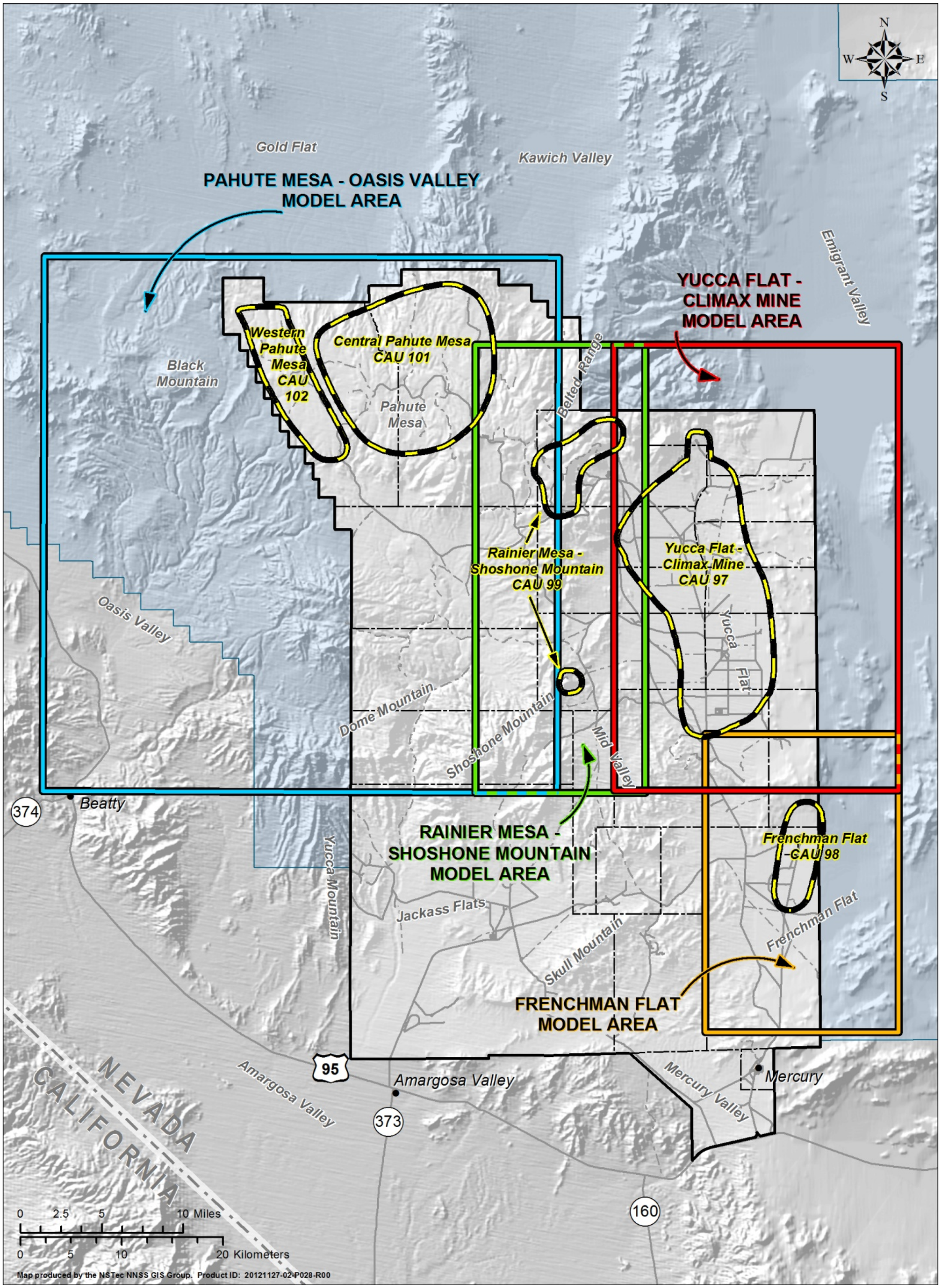

Figure 11-3. Location of UGTA model areas

11.1.1 UGTA CAU Corrective Action Activities

The UGTA CAU closure strategy is a process of conducting characterization and modeling studies during an *investigation stage* to support 1,000-year contaminant boundary forecasts. Sufficient confidence in the flow and transport models and supporting data must be demonstrated to earn NDEP's approval to advance from the investigation stage to the *model evaluation stage* and then to the *closure stage* for each CAU. The long-term monitoring program and institutional controls to protect the public from consuming potentially contaminated groundwater are initiated in the closure stage. The five UGTA CAUs are in various stages of this process. The following subsections provide the status of actions taken to date toward the closure-in-place of each CAU. The results of annual groundwater sampling, conducted for the purposes of characterizing groundwater within the CAUs and monitoring groundwater downgradient of them, are presented and discussed in Chapter 5, Sections 5.1.2 and 5.1.3.

11.1.1.1 Frenchman Flat CAU

The Frenchman Flat CAU is the first of the five UGTA CAUs at the NNSS to reach closure. The Closure Report was approved by the NDEP in July 2016. This is the culmination of 20 years of characterization, modeling, and model evaluation. The Closure Report describes the final contaminant, use restriction, and regulatory boundaries agreed upon by NNSA/NFO and NDEP for the Frenchman Flat CAU. It also specifies the monitoring program that will be followed for the first 5 years. Three types of monitoring are performed for the Frenchman Flat CAU: water quality monitoring, water level monitoring, and institutional control monitoring. The results are used to determine if the use-restriction boundaries remain protective of human health and the environment, and to evaluate consistency with the groundwater flow and contaminant transport models that support the use restrictions. Though the Frenchman Flat CAU is closed, the UGTA closure strategy calls for continued monitoring and periodic evaluations to assess if the corrective action decision is working.

A summary of monitoring activities and results is in Section 11.1.2. The first long-term monitoring report for Frenchman Flat, presenting results from 2016, will be published in 2017.

11.1.1.2 Central and Western Pahute Mesa CAUs

The Central and Western Pahute Mesa CAUs are in the middle of the investigation stage of the closure process. In 2009, a Phase I Central and Western Pahute Mesa Transport Model (Stoller-Navarro Joint Venture 2009) was completed for the Pahute Mesa–Oasis Valley model area. An additional phase of data collection and model development (Phase II) was needed in order to establish the necessary confidence to move forward with the closure process. Phase II data collection activities were recommended by an ad hoc subcommittee that included the NNSA/NFO UGTA Federal Activity Lead, UGTA participants (NSTec, DRI, LLNL, LANL, Navarro, and USGS), a representative from NDEP, and two representatives of NSSAB.

A Phase II Central and Western Pahute Mesa Corrective Action Investigation Plan (CAIP) was completed in 2009 (NNSA/NSO 2009) that outlines the investigations that are currently being implemented. The program's objective was to institute a second phase of data collection to test the assumptions of the Phase I groundwater flow and contaminant transport models, improve the quality of data used in the models, and increase confidence in the transport model results used to forecast contaminant boundaries. Thirteen locations for new wells, including one contingency well (ER-20-11) were proposed, ten of which were drilled between 2009 and 2012. Development, testing, and sampling the ten Phase II wells was completed in May 2014. Drilling of an additional Phase II well, ER-20-12, was initiated in October 2015 and was completed in January 2016. Well development and testing of the ER-20-12 main completion zone was also completed in 2016.

The Phase I Central and Western Pahute Mesa Transport Model forecasts that ***tritium*** (see Glossary, Appendix B) and carbon-14 may migrate off the NNSS from the Central and Western Pahute Mesa CAUs within 50 years of the first nuclear detonation (1965) and that offsite concentrations of tritium may be above the SDWA limit of 20,000 picocuries per liter (pCi/L) within the 1,000-year compliance period (Figure 11-4). To date, the maximum concentration of tritium observed offsite is at Well ER-EC-11 on the NTTR. Tritium at ER-EC-11 was reported as 16,100 pCi/L in 2014 (see Table 5-4, Section 5.1.2, Chapter 5). Well ER-EC-11 is located approximately 716.3 m

(2,350 ft) west of the NNSS boundary (see Figure 5-2, Chapter 5) and approximately 3.2 km (2 mi) from the nearest underground nuclear tests, Benham and Tybo, which were conducted in 1968 and 1975, respectively. Tritium detected in ER-20-11 (see Table 5-4, Chapter 5) is also believed to represent the downgradient extension of the Benham-Tybo contaminant plume. This contaminant plume was first encountered at ER-20-5 (DOE/NV 1997) and further defined by ER-20-7 (NNSA/NSO 2010a), ER-EC-11 (NNSA/NSO 2010b), ER-20-11 (Navarro 2016a), and ER-20-8/20-8#2 (NNSA/NSO 2011). This cluster of contaminated wells is increasing the understanding of flow and transport of radionuclides from UGTs on Pahute Mesa. The discovery of tritium at Well ER-20-11 indicates that the contaminant plume forecasted by Phase I flow and transport modeling may be more southerly (ER-20-5 to ER-20-7 to ER-20-11; see Figure 11-4) than previously modeled. Phase II flow and transport modeling will include the new data from the Phase II drilling initiative, and will reflect the recent tritium measurements.

The new Phase II well, ER-20-12, is located in the far northwestern portion of the NNSS approximately 2.3 kilometers (km) (1.4 miles [mi]) south-southwest of the Handley UGT and approximately 5.1 km (3.2 mi) north-northeast of PM-3. The presence of tritium was detected in PM-3 in 2010, and the Handley UGT was believed to be the source of this tritium. The objective for well ER-20-12 is to evaluate tritium migration from the Handley UGT to PM-3. Well ER-20-12 was specifically designed to determine the deepest contaminated ***aquifer*** (see Glossary, Appendix B); the vertical distribution of tritium in the well; the lithology, stratigraphy, and hydraulic characteristics of units intersected by the borehole; and to monitor the most productive, laterally extensive aquifers that contain tritium. The borehole penetrated several aquifers and ***confining units*** (see Glossary, Appendix B) and was completed with the main casing located in the unit most likely to be responsible for tritium migration. The tritium within this unit was reported as 34,000 pCi/L. Well ER-20-12 also contains four piezometers that access three additional hydrogeologic units (two piezometers access two depths within the same unit). The deepest piezometer, accessing the Belted Range aquifer, was pumped and sampled in 2016. The tritium concentrations in the duplicate samples were 18,600 and 18,900 pCi/L. Bailed samples were collected from the additional three piezometers, and the tritium concentrations range from 267 to 39,200 pCi/L (the 39,200 pCi/L value is reported in Table 5-4 of Chapter 5). Further sampling is planned for 2017. The presence of tritium in Well ER-20-12 and the existence of strong hydraulic connections between ER-20-12 and PM-3 make it very likely that the tritium observed in PM-3 was derived from the Handley UGT.

Investigations described in the Phase II CAIP continued throughout 2016. Analysis of faults and fracture characteristics and of hydraulic properties of selected hydrostratigraphic units is being used to enhance conceptual models for the Phase II hydrostratigraphic framework model as well as to provide attributes for specific aquifers on and immediately downgradient of Pahute Mesa. In 2016, the USGS published a document that delineates the Pahute Mesa–Oasis Valley (PMOV) groundwater basin, where recharge occurs, moves downgradient, and discharges to Oasis Valley, Nevada. Delineating the boundary of the PMOV groundwater basin is necessary to adequately assess the potential for transport of radionuclides from Pahute Mesa to Oasis Valley (Fenelon et al. 2016). The USGS also published a report analyzing the hydraulic properties of volcanic rocks in the southern portion of Area 20 and in areas off site to the south (Garcia et al. 2017). Additional characterization activities performed in 2016 included sampling groundwater, measuring water levels, and performing a variety of analyses tasks to evaluate the Phase II geologic, hydrologic, and chemistry data.

11.1.1.3 Rainier Mesa/Shoshone Mountain CAU

The Rainier Mesa/Shoshone Mountain CAU is near the end of the investigation stage of the closure process. An alternative modeling strategy to close the Rainier Mesa/Shoshone Mountain CAU, unique from the other UGTA CAUs, was accepted by NDEP in 2013. The alternative strategy replaces the requirement to develop sophisticated models to forecast potential contaminated volumes (i.e., contaminant boundaries) with the requirement to develop simpler models to forecast potential distances of radionuclide transport.

This revised strategy was developed as concerns were raised about whether the original strategy was achievable because of the significant geologic complexity and uncertainty in important model parameters. In addition, the overall perceived risks at this CAU were judged to be low because: 1) the radionuclide inventory is comparatively low and separated from the regional water table at all source locations; 2) the CAU is geographically isolated

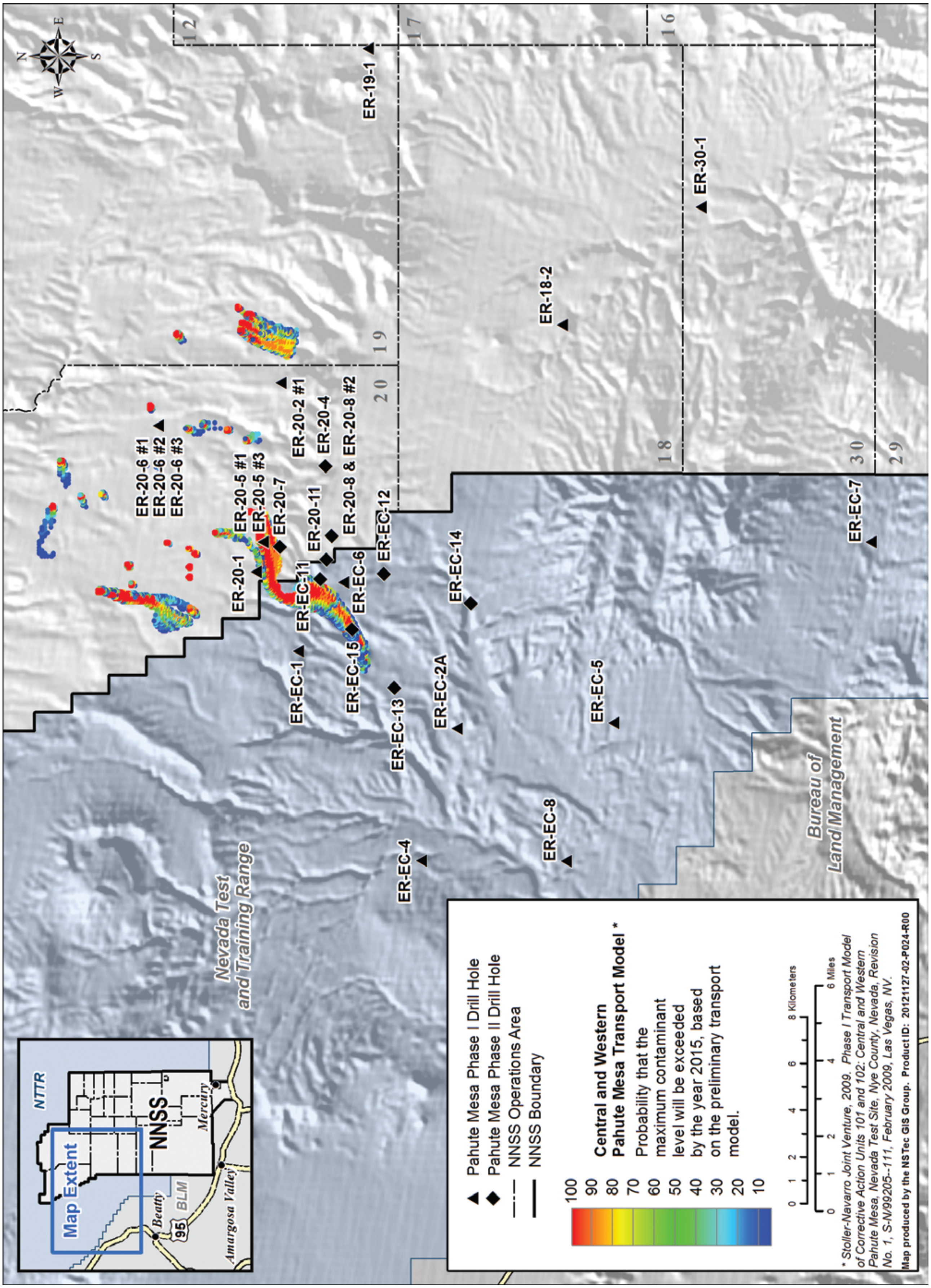

Figure 11-4. Results of Phase I Central and Western Pahute Mesa transport modeling

within the NNSS and farthest removed of all CAUs from potential down-gradient receptors; and 3) initial CAI simulations indicated that radionuclides would not approach NNSS boundaries in the next 1,000 years.

The alternative modeling strategy also allows advancement from the investigation stage directly to the closure stage following a successful peer review. The new process of achieving closure is expected to save several years and several million dollars over the original process, while still protecting human health and the environment over the 1,000-year compliance period required by the FFACO.

Implementation of the revised strategy continued in 2016. Simplified models of radionuclide transport along potential transport pathways from source locations in Rainier Mesa are being developed. The potential flow paths are identified based on the hydrogeological conceptual model and regional groundwater flow information. Tritium observations in wells in the vicinity of the flow paths (ER-19-1, ER-12-3, and TW-1; see Figure 5-3 of Chapter 5) are being compared to the simulation results. Documentation and preemptive committee review of the models and model results is planned to be completed in 2017.

Wells ER-12-3 and ER-12-4, which monitor the perched water system near N and T Tunnels in Rainier Mesa, respectively, were sampled in 2016. Tritium was reported at 27.3 pCi/L and 7.62 pCi/L in the ER-12-3 and ER-12-4 samples, respectively (see Table 5-4 of Chapter 5). A sample was also collected in 2016 from the Early Detection well ER-19-1 located within the flowpath 2.3 km (1.4 mi) from UGT Clearwater, the nearest upgradient UGT. Tritium was reported at 3.31 pCi/L from ER-19-1 (Table 5-4), only slightly above the detection limit (3.01 pCi/L) and is considered highly uncertain; it is likely that no tritium is present in this well. With the exception of samples from ER-12-3, ER-12-4, ER-19-1, and the tunnels where UGTs took place (U-12n vent holes and E Tunnel discharge), tritium has not been observed in samples from any other groundwater sampling locations in the Rainier Mesa/Shoshone Mountain CAU (see Table 5-4). The 2016 tritium data are being used to verify the simplified models of radionuclide transport within this CAU.

11.1.1.4 Yucca Flat/Climax Mine CAU

The last step of the closure process's investigation stage for the Yucca Flat/Climax Mine CAU was completed in 2016. External peer review of the groundwater flow and transport model and the supporting data was completed. Extensive studies were conducted during 2016 in response to recommendations made by the external peer review committee. These studies included drilling three new wells, collecting additional data, reanalyzing existing data and models, and modeling, and are documented in *Response to External Peer Review Team Report for Corrective Action Unit 97: Yucca Flat/Climax Mine, Nevada National Security Site, Nye County, Nevada* (Navarro 2016b). Following publication of this report, NDEP concurred with NNSA/NFO that the peer review requirement of the FFACO UGTA closure strategy was adequately addressed. The next step in the FFACO process is the NDEP decision on whether the CAU model is acceptable to advance to the next FFACO UGTA closure strategy stage. The decision to advance to the model evaluation stage was made in early 2017.

The focus of model evaluation is to reduce uncertainty in the contaminant boundary extent and build confidence in the final models to support regulatory decisions including identifying use-restriction boundaries, regulatory boundary objectives, and regulatory boundaries; and siting monitoring wells during closure. In 2016, a committee was assembled to identify data collection activities to address key model uncertainties during the model evaluation stage. The proposed activities include evaluating geologic, hydrologic, and radionuclide data from three new and several existing wells (Kwicklis 2016). In addition, reevaluation of the results for a previously performed multiple-well aquifer test was determined as an important activity for the model evaluation stage.

Drilling of three new model evaluation wells in Yucca Flat (ER-2-2, ER-4-1, and ER-3-3) was completed in 2016. These wells are located near detonations identified as the most likely to have impacted the regional carbonate aquifer within the Yucca Flat basin. Understanding radionuclide transport to the regional carbonate aquifer was identified as the highest priority for siting the wells because it is the only pathway for radionuclides to migrate out of the basin. No tritium was detected in the carbonate aquifer at ER-3-3 and ER-4-1 (designated as Characterization Wells; Table 5-4). ER-2-2 was plugged and abandoned because of difficulties encountered during drilling (designated as an Inactive Well; Table 5-4). A sample was collected from the regional carbonate aquifer at ER-2-2 prior to its plugging, and the tritium was reported as 13.3 pCi/L. The value was reported as an estimate because laboratory quality control measurements exceeded the acceptable criteria. While the tritium in the regional aquifer is very low or nonexistent, elevated tritium was reported for samples collected from more shallow depths in volcanic rock units at ER-2-2 (up to 23,400,000 pCi/L) and ER-4-1 (up to 59,600 pCi/L). The lack of tritium migration from the shallow volcanic rock units to the deeper carbonate aquifer demonstrates the effectiveness of the confining units that overlie the carbonate aquifer as barriers to contaminant migration. The lack of tritium at ER-3-3 also indicates that contaminant migration within the Yucca Fault is limited. Both of these observations verify the conceptual model that UGTs that do not intersect the carbonate aquifer have a negligible impact on migration within the regional carbonate aquifer and thus outside of the basin.

11.1.2 Post-Closure Monitoring of Frenchman Flat

The Closure Report for the Frenchman Flat CAU (NNSA/NFO 2016a), approved by NDEP in 2016, specifies a monitoring program that will be followed for the first 5 years post-closure. Three types of monitoring are performed under this program: water quality monitoring, water level monitoring, and institutional control monitoring. The objective of these monitoring activities is to determine if the use-restriction boundaries identified for Frenchman Flat CAU (Figure 11-5) remain protective of human health and the environment. Additionally, the water quality and water level monitoring is used to evaluate consistency with the groundwater flow and contaminant transport conceptual and numerical models. Such consistency is important because the models are the primary basis for the use-restriction boundaries. The Frenchman Flat CAU contaminant and regulatory boundaries are also identified in Figure 11-5.

The Frenchman Flat Post-Closure Monitoring Network includes the following 17 wells, 5 of which are sampled for water quality and water levels (Q/L), 1 for only water quality (Q), and 11 for only water levels (L):

- ER-5-3 Deep Piezometer (L)
- ER-5-3 Main (Upper Zone) (L)
- ER-5-3 Shallow Piezometer (Q)
- ER-5-3-2 (Q/L)
- ER-5-3-3 (L)
- ER-5-4 Main (L)
- ER-5-4 Piezometer (L)
- ER-5-4-2 (L)
- ER-5-5 (Q/L)
- RNM-1 (L)
- RNM-2S (Q/L)
- UE-5n (Q/L)
- WW-5A (L)
- WW-5B (L)
- WW-4 (L)
- WW-4A (L)
- ER-11-2 (Q/L)

The six wells sampled for water quality include three Characterization, two Source/Plume, and one UGTA inactive well within the CAU. The suite of contaminants for which each of the six wells were sampled, based on their well type, is described in Chapter 5, Section 5.1.1, and the 2016 analytical results for tritium are presented in Table 5-4 of Section 5.1.2. Tritium is present only in the two Source/Plume wells already identified as containing contamination as a result of a radionuclide migration experiment (wells RNM-2S and UE-5n). The tritium concentration in both wells is slowly decreasing, consistent with forecasts from the contaminant transport model.

Depth to water measured in 2016 in all of the 16 water level monitoring wells is consistent with measurements taken in recent years. A declining water level trend exists in most of the wells completed in the alluvium and is primarily attributed to drawdown from basin-scale pumping. Groundwater has been pumped from wells in the central and southern part of the Frenchman Flat basin since the 1950s. Groundwater gradients calculated from the 2016 measured water levels are generally consistent with the south-southeastward flow direction of the Frenchman Flat groundwater flow model.

The objective of the Frenchman Flat CAU regulatory boundary is to protect receptors downgradient of the Rock Valley fault system from radionuclide contamination. Although contaminants resulting from underground nuclear testing are not forecast to migrate out of the basin within the next 1,000 years, the Rock Valley fault system is the expected groundwater migration pathway. The negotiated regulatory boundary (Figure 11-5) is established at the interface of the Alluvial/Volcanic aquifer and the Rock Valley fault. If radionuclides reach this boundary, NNSA/NFO is required to submit a plan to NDEP which will meet the CAU's regulatory boundary objectives. All monitoring results indicate that the regulatory boundary objective has been met.

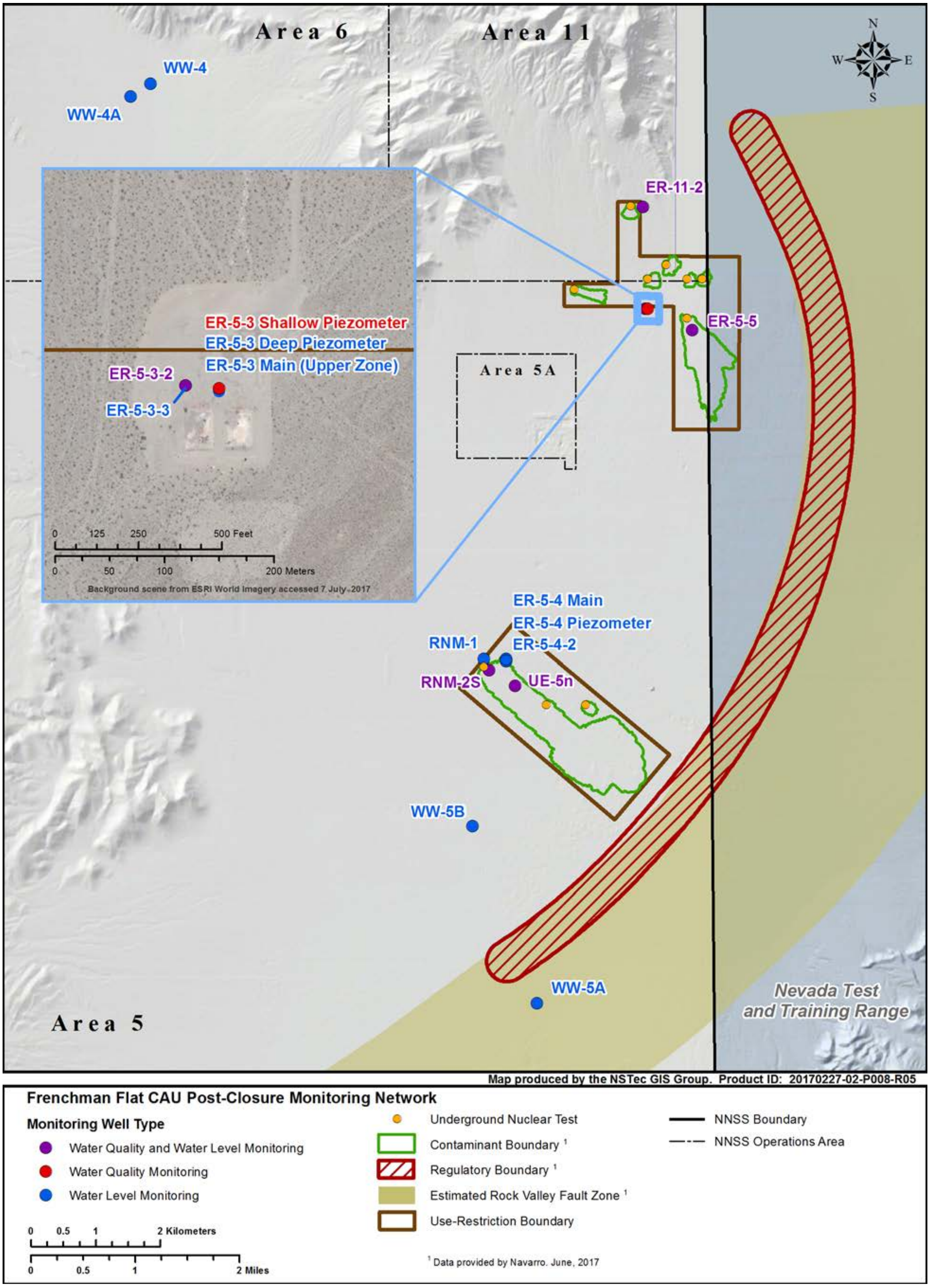

Figure 11-5. Frenchman Flat CAU post-closure monitoring network

Institutional control monitoring confirmed that, as of the end of January 2017, use restrictions are recorded in NNSA/NFO and USAF land management systems and that no activities within Frenchman Flat basin are occurring that could potentially affect the contaminant boundaries. A survey of groundwater resources in basins surrounding Frenchman Flat similarly identified no current or pending development that would indicate the need to increase monitoring activities or otherwise cause concern for the closure decision. The use restrictions continue to prevent exposure of the public, workers, and the environment to contaminants of concerns by preventing the use of potentially contaminated groundwater.

11.1.3 Quality Assurance

The UGTA Quality Assurance Plan (QAP) (NNSA/NFO 2015b) provides the overall quality assurance requirements and general quality practices that are applied to UGTA drilling, laboratory analyses, and modeling. The UGTA QAP complies with DOE Order DOE O 414.1D, "Quality Assurance;" Guidance for Quality Assurance Project Plans for Modeling (U.S. Environmental Protection Agency [EPA] 2002); and Guidance on the Development, Evaluation, and Application of Environmental Models (EPA 2009). UGTA work is conducted under the UGTA QAP in conjunction with other UGTA participants' quality assurance programs. In 2016, quality assurance activities included conducting oversight assessments, identifying findings and completing corrective actions, and evaluating laboratory performance. These activities were described in an annual quality assurance report which was converted from a fiscal year to a calendar year report in 2016 (covering activities from October 1, 2015 through December 31, 2016) (U.S. Department of Energy, Environmental Management Nevada Program 2017). Future calendar year reports will be issued in April. In addition, UGTA documents and models undergo thorough preemptive reviews throughout the investigation and model evaluation stages of the CAU closure process as well an independent formal peer review at the end of the investigation stage. Chapter 14 discusses the quality assurance and quality control procedures used for collecting and analyzing groundwater samples.

11.1.4 Other Activities and Studies

Compiling, evaluating, and updating various databases (e.g., chemistry, water level, hydraulic properties, hydro-stratigraphy) continued in 2016 as an ongoing effort. In 2016, The USGS continued their water-level monitoring program and also continued work on revising their regional model of groundwater flow within the Death Valley regional flow system. Water levels, and other pertinent NNSS information and data sets can be accessed through the USGS/U.S. Department of Energy Cooperative Studies in Nevada website at http://nevada.usgs.gov/doe_nv/.

11.1.5 UGTA Publications

All UGTA-related reports and publications that were completed in 2016 and published by June 2017 are listed in Table 11-1. Some of the published technical reports can be obtained from DOE's Office of Scientific and Technical Information (OSTI) at http://www.osti.gov/bridge.

Table 11-1. UGTA publications published in 2016 or prior to June 2017

Report	Reference
An Update of the Death Valley Regional Groundwater Flow System Transient Model, Nevada and California	Belcher et al. 2017
Nevada National Security Site Underground Radionuclide Inventory, 1951-1992: Accounting for Radionuclide Decay through September 30, 2012	Finnegan et al. 2016
Applications of the Advanced Simulation Capability for Environmental Management (ASCEM)	Freshley et al. 2017
Delineation of the Pahute Mesa–Oasis Valley Groundwater Basin, Nevada	Fenelon et al. 2016
Hydraulic Characterization of Volcanic Rocks in Pahute Mesa Using an Integrated Analysis of 16 Multiple-	Garcia et al. 2017
A Suite of Programs for Extracting Transmissivity from MODFLOW Models	Halford 2016
Laboratory Experiments to Evaluate Matrix Diffusion of Dissolved Organic Carbon Carbon-14 in Southern Nevada Fractured-rock Aquifers.	Hershey and Fereday 2016
Yucca Flat/Climax Mine Model Evaluation Planning – Expert Elicitation	Kwicklis 2016
2015 Annual Report Timber Mountain Environmental Monitoring Station	Lyles et al. 2016
Application of Monte Carlo Methods to Perform Uncertainty and Sensitivity Analysis on Inverse Water-Rock Reactions with NETPATH	McGraw and Hershey 2016

Table 11-1. UGTA publications published in 2016 or prior to June 2017 (continued)

Report	Reference
Testing the Suitability of Geologic Frameworks for Extrapolating Hydraulic Properties Across Regional Scales	Mirus et al. 2016
Pahute Mesa Well Development and Testing Analyses for Well ER-20-11, Nevada National Security Site, Nye County, Nevada Rev. 0	Navarro 2016a
Response to External Peer Review Team Report for Corrective Action Unit97: Yucca Flat/Climax Mine, Nevada National Security Site, Nye County, Nevada, Rev. 1	Navarro 2016b
UGTA Chemistry Database User's Manual	Navarro 2016c
Underground Test Area (UGTA) Closure Report for Corrective Action Unit 98: Frenchman Flat, Nevada National Security Site, Nevada, Rev. 1	NNSA/NFO 2016a
Underground Test Area Fiscal Year 2015 Annual Quality Assurance Report Nevada National Security Site, Nevada	NNSA/NFO 2016b
Hydrophysical Evaluation of Wells TW-B, TW-7, UE-6d, U-2gg PSE 3A, U-10L 1, and UE-6e in Yucca Flat	Pohlmann et al. 2017
Stress Field Inversions of Earthquake Focal Mechanisms and Influence of Regional Stress on Fault Permeability at Pahute Mesa, Nevada National Security Site	Reeves et al. 2016
Investigating the Influence of Regional Stress on Fault and Fracture Permeability at Pahute Mesa, Nevada National Security Site	Reeves et al. 2017
A Few Thoughts on the E-Tunnel Discharge at Rainier Mesa, Nevada National Security Site	Tompson 2016
Implementing an Alternative Modeling Strategy for Closure of the Rainier Mesa Corrective Action Unit at the Nevada National Security Site	Tompson and Rehfeldt 2016
Mineralogical and Geochemical Data Report for Samples of Lava and Tuff Cuttings from Well ER-20-12	WoldeGabriel et al. 2016
Evaluating Groundwater Interbasin Flow Using Multiple Models and Multiple Types of Data	Ye et al. 2016

11.2 Industrial Sites

NNSA/NFO has identified 1,865 Industrial Sites CASs on and off the NNSS for which they are responsible for characterization and closure under the FFACO. Closure strategies include removal of debris, excavation of soil, decontamination and decommissioning of facilities, and closure-in-place with subsequent monitoring. The contaminants of concern include hazardous chemicals/materials, unexploded ordnance, and low-level radiological materials. "Clean closures" are those where pollutants, hazardous wastes, and solid wastes have been removed and properly disposed, and where verification that all contaminants have been removed has been conducted, all in accordance with corrective action plans approved under the FFACO. Closure-in-place entails the stabilization or isolation of pollutants, hazardous wastes, and solid wastes, with or without partial treatment, removal activities, and/or post-closure monitoring, in accordance with corrective actions plans approved under the FFACO. Radioactive materials removed from sites were either disposed as low-level waste (LLW) or mixed low-level waste (MLLW) at the Area 5 Radioactive Waste Management Site (RWMS) (see Section 10.1). Solid waste (e.g., demolition debris) containing asbestos was disposed of onsite at the Area 9 U10c Solid Waste Landfill. Hazardous waste (HW) removed from the CASs was shipped to approved offsite treatment and disposal facilities or recycled. Beyond remediation, the Industrial Sites Activity ensures that long-term monitoring programs are in place to protect the safety of the public and the environment.

Since the mid-1990s, a total of 1,853 Industrial Sites CASs have been evaluated, characterized, and closed. Over 950 of these sites were clean closures and 80 have been closures-in-place while the remainder have been a combination of state approved closures involving simple "housekeeping" cleanup, no further actions, or no further actions except administrative controls to restrict access. A major focus of Industrial Sites closures has included the decontamination and decommissioning (D&D) of facilities with no active mission and in which contamination exists. To date, seven of the eight facilities identified as D&D sites have been closed under the FFACO with state approval. They include the Pluto Disassembly; Reactor Maintenance, Assembly, and Disassembly (RMAD), Test Cell A; Test Cell C; Super Kukla; Junior Hot Cell, and the EPA Farm. Major Industrial Sites efforts have also involved the safe removal, treatment, and disposal of unexploded ordnance at sites on the TTR. Large volumes of remediation wastes have been disposed on the NNSS since the mid-1990s, while cleanups conducted on the TTR have utilized the TTR landfill for approved disposal.

Only 12 Industrial Sites CASs from three CAUs remain to be closed. The three CAUs are CAU 114, Area 25 Engine Maintenance, Assembly, and Disassembly (EMAD) Facility (the eighth remaining D&D facility); CAU 572, Test Cell C Ancillary Buildings and Structures; and CAU 575, Area 15 Miscellaneous sites. Their closure will occur prior to the end of the NNSS Environmental Management Activity, which is currently planned for 2030. In 2016, field work was completed at CAU 575, although no Industrial Sites CASs were closed.

11.3 Soils

NNSA/NFO has identified a total of 148 Soils CASs on and off the NNSS for which they are/were responsible for characterization and closure under the FFACO. This total includes six new Soils CASs that were identified and added in 2016. Corrective actions range from removal of soil to closure-in-place with restricted access controls. Historical research and the preparation of summary reports have been completed for all 148 CASs. In 2016, four Soils CASs from two CAUs were closed (Table 11-2), and work was conducted towards closure at 25 CASs in 6 CAUs (Table 11-3). The closure of Double Tracks in 2016 represents the first approved closure of a plutonium dispersion site on the NTTR, and it was remediated to meet clean closure criteria under land use scenarios provided by the USAF.

The total number of Soils CASs closed and approved by the state by the end of 2016 was 123; 25 Soils CASs remain to be formally closed. Closure of CASs on the TTR and NTTR require negotiation with the State of Nevada and coordination with the U.S. Department of Defense. The anticipated date for Soils closure is FY 2027.

Table 11-2. Soils Sites closed in 2016

CAU	CAU Description	Number of CASs	Corrective Actions	Wastes Generated
411	Double Tracks Plutonium Dispersion (NTTR)	1	Clean closure[(a)]	LLW, Sanitary
412	Clean Slate I Plutonium Dispersion (TTR)	1	Clean closure	LLW, Sanitary
541	Small Boy	2	No further action	LLW, Sanitary

(a) Clean closure is the removal of pollutants, contaminants, and waste at a CAS in accordance with Corrective Action Plans.

Table 11-3. Other Soils Sites where work was conducted in 2016

CAU	CAU Description	Number of CASs	Activity	Wastes Generated
413	Clean Slate II Plutonium Dispersion (TTR)	1	Investigation of nature and extent of contamination	LLW, Sanitary
414	Clean Slate III Plutonium Dispersion (TTR)	1	Preliminary investigation and waste disposition	LLW, Sanitary
415	Project 57 No. 1 Plutonium Dispersion (NTTR)	1	Preliminary investigation	LLW
568	Area 3 Plutonium Dispersion Sites	14	Investigation of nature and extent of contamination	LLW, MLLW, Hazardous, Sanitary
573	Alpha Contaminated Sites	2	Preliminary investigation	LLW
576	Miscellaneous Radiological Sites and Debris	6	Corrective action investigation	LLW

11.3.1 Monitoring Activities at Soils CAUs

NNSA/NFO monitors airborne radiation and meteorological parameters on the TTR to determine if there is wind transport of man-made radionuclides from the contaminated Clean Slate I, II, and III Plutonium Dispersion CAUs (CAUs 412, 413, and 414, respectively). In 2008, NNSA/NFO established air monitoring stations at Clean Slate III and the Range Operations Center. In 2011, a third air monitoring station was installed at Clean Slate I. The design of these stations is similar to that used in the Community Environmental Monitoring Program (CEMP) (see Chapter 7, Section 7.1). These monitoring efforts are not required under the FFACO. In 2016, no man-made radionuclides were detected in any of the air samples collected from these stations; only naturally occurring radionuclides were identified. Sandia National Laboratories reports this monitoring in the TTR annual environmental report, which is posted at http://www.sandia.gov/news/publications/environmental/index.html.

NNSA/NFO also monitors meteorological and surface runoff data from two Soils CAUs on the NNSS: Smoky Contamination Area (CAU 550) in Area 8 and the Area11 Plutonium Valley Dispersion Sites (CAU 366). In 2011, one meteorological station and a flume to measure channelized runoff were installed at CAU 550, and two meteorological stations and an instrument station to collect surface water runoff and transported suspended and bedload sediments were installed at CAU 366. These stations are similar in design and function to those used in the CEMP with the exception of not including air filter monitoring or pressurized ion chambers. The equipment at both sites collect data to develop an understanding of meteorological conditions that contribute to contaminated soil transport. These monitoring efforts are not required under the FFACO, but are conducted to aid in developing closure designs and post-closure monitoring requirements.

During FY 2016 (October 1, 2015 – September 30, 2016), data from the CAU 550 meteorological station, the flume, and visual observations of sediment transport were summarized, evaluated, and reported (Mizell et al., 2017). No surface water flow was measured at the flume in the monitored channel during any precipitation events at CAU 550; therefore, no measurable water-borne transport of radionuclide-contaminated soils occurred. In FY 2016, air monitoring data collected at CAU 366 identified wind speed conditions that resulted in increased dust transport and, thus, the potential re-suspension of contaminated soils. Several precipitation events were recorded within Plutonium Valley but none produced significant runoff. Therefore, no suspended sediment or bedload transport sediment samples at CAU 366 were collected (Nikolich et al., 2017).

11.4 Post-Closure Monitoring and Inspections

All nine of the historical waste management units on the NNSS identified for closure under the Resource Conservation and Recovery Act (RCRA) have been closed (Table 11-4). The NNSS RCRA Part B Permit prescribes post-closure monitoring requirements for six of these sites (Table 11-4). CAUs 110 and 111 require ***vadose zone*** (see Glossary, Appendix B) monitoring (VZM) of the engineered covers over the craters/waste pits. The covers were designed to limit infiltration into the disposal units and are monitored using time-domain reflectometry soil water content sensors buried at various depths in the waste covers to provide water content profile data. The data are used to demonstrate whether the covers are performing as expected. The covers were vegetated with native plants and are monitored routinely for revegetation success. Various revegetation techniques have been studied and implemented on the covers in attempts to produce sustainable native plant communities (see Chapter 13, Section 13.4, Habitat Restoration Program).

Table 11-4. Historical RCRA closure sites and their post-closure monitoring requirements

CAU	Remediation Site	2016 Post-closure Requirements
90	Area 2 Bitcutter Containment	Annual site inspection
91	Area 3 U-3fi Injection Well	Annual site inspection
92	Area 6 Decon Pond Facility	Semi-annual site inspection Inspection if precipitation >1.0 inch/24-hour period
93	Area 6 Steam Cleaning Effluent Ponds	None
94	Area 23 Building 650 Leachfield	None
109	Area 2 U-2bu Crater	None
110	Area 3 Waste Management Division (WMD) U-3ax/bl Crater	Quarterly[b] site inspection VZM of the engineered cover caps Biennial subsidence survey Annual vegetation survey
111	Area 5 WMD Retired Mixed Waste Pits	Quarterly site inspection Inspection if precipitation >0.5 inches/24-hour period Annual subsidence survey Annual vegetation survey Quarterly TLD readings Tritium air analyses Gamma-emitting and isotopic radionuclide air analyses Annual measurements of radon flux Groundwater monitoring of Wells UE5 PW-1, -2, and -3 VZM of the engineered cover caps
112	Area 23 Hazardous Waste Trenches	Quarterly[a] site inspection

In 2016, VZM results for CAUs 110 and 111 indicated that surface water is not migrating into buried wastes and that the covers are functioning as designed (NSTec 2017a). For CAU 111, external radiation measurements from thermoluminescent dosimeters (TLDs), air and groundwater sample analyses for radionuclides, and radon flux measurements indicate that the closure covers are performing within expectations and parameter assumptions of performance assessment models, and there is no impact on the surrounding environment (NSTec 2017a; 2017b). One report for all RCRA closure sites monitored in 2016 was submitted to NDEP in March 2017 (NNSA/NFO 2017a). In April 2016, NDEP performed a Compliance Evaluation Inspection of CAUs 90, 91, 92, 110, 111, and 112, and documented that NNSA/NFO was managing them in compliance with the NNSS Part B Permit.

Post-closure inspections are also required for many of the closed remediation sites managed under the FFACO that are not included in the RCRA Part B Permit (non-RCRA CASs). In 2016, NNSA/NFO conducted visual inspections at 166 closed non-RCRA CASs managed under the FFACO. Several CASs that do not require inspections were inspected as a best-management practice to ensure that the signs are intact. A 2016 annual inspection report for non-RCRA post-closure sites on the NNSS was prepared and submitted to NDEP in May 2017 (NNSA/NFO 2017b). A 2016 annual inspection report for post-closure sites on the TTR was prepared and submitted to NDEP in March 2017 (NNSA/NFO 2017c).

11.5 Restoration Progress under the FFACO

In 2016, NNSA/NFO met all of the 2016 FFACO milestones (Table 11-5), and closed 14 CASs. Figure 11-6 depicts the progress made since 1996 in the remediation of all historically contaminated sites managed under the FFACO. A total of 2,129 of the 3,039 CASs have been closed; they include 142 sites that have been closed by the DOE Office of Legacy Management, the Defense Threat Reduction Agency, or other owners. Of the remaining 910 CASs yet to be closed under the FFACO (905 of which are the responsibility of NNSA/NFO), 868 (91%) of them are UGTA CASs, which will be closed in place with monitoring in perpetuity. The public can view an interactive map that shows all CASs on the NNSS, NTTR, and TTR at the following NNSS Remediation Sites website: http://nnssremediation.dri.edu/. The website identifies all CASs that have been closed and those that are still open.

Table 11-5. FFACO milestones for 2016 (sorted by due date, in ascending order)

CAU	CAU Name	# of CASs	Milestone	Due Date	Date Submitted	Date NDEP Approved
DOE Soil Sites						
573	Alpha Contaminated Sites	2	Corrective Action Decision Document/ Corrective Action Plan (CADD/CAP)	4/27/16	2/16/16	3/16/16
568	Area 3 Plutonium Dispersion Sites	14	Corrective Action Plan (CAP)	5/20/16	5/10/16	6/8/16
411	Double Tracks Plutonium Dispersion (NTTR)	1	Closure Report (CR)	7/18/16	6/16/16	7/15/16
413	Clean Slate II Plutonium Dispersion (TTR)	1	Corrective Action Investigation Plan (CAIP)	7/29/16	4/26/16	5/19/16
412	Clean Slate I Plutonium Dispersion (TTR)	1	CR	9/15/16	9/6/16	10/4/16
541	Small Boy	2	CADD/CR	9/30/16	8/9/16	9/6/16
576	Miscellaneous Radiological Sites and Debris	6	CAIP	12/21/16	12/19/16	1/19/17
414	Clean Slate III Plutonium Dispersion (TTR)	1	CAIP, Revision 1	4/28/17	10/3/16	11/4/16
DOE UGTA Sites						
99	Rainier Mesa/Shoshone Mountain	66	Phase I Data Completion Presentation #1	8/31/16	8/30/16	9/15/16
99	Rainier Mesa/Shoshone Mountain	66	Completion Selection Criteria for External Peer Review Panel	9/30/16	8/30/16	11/7/16
101	Central Pahute Mesa	64	Phase II Data Completion Presentation #2	9/30/16	9/20/16	9/26/16
102	Western Pahute Mesa	18	Phase II Data Completion Presentation #2	9/30/16	9/20/16	9/26/16
97	Yucca Flat/Climax Mine	720	Model Evaluation Well Drilling Presentation #1	9/30/16	9/22/16	9/26/16

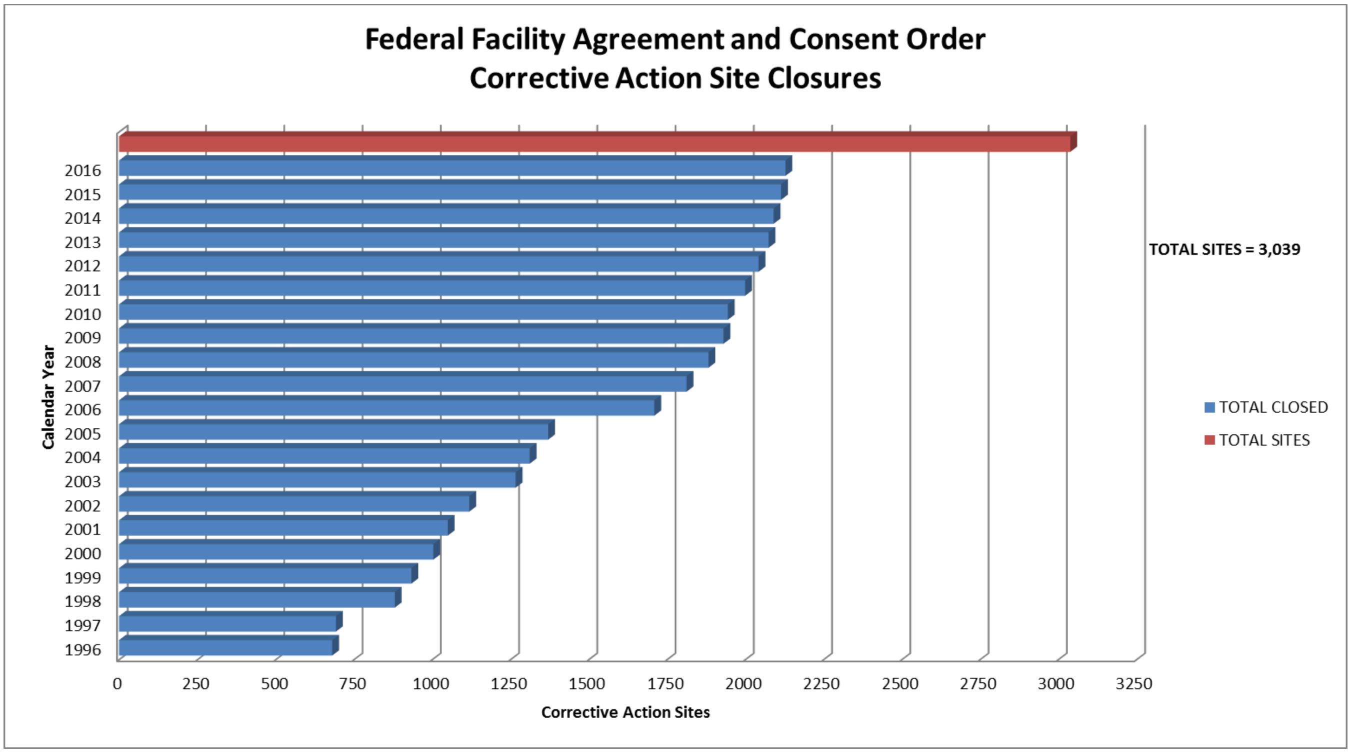

Figure 11-6. Annual cumulative totals of FFACO CAS closures

11.6 EM Public Outreach

On July 16, 2016, NNSA/NFO held the Seventh Annual Groundwater Open House for the public in Nevada at the Amargosa Community Center. Each year, NNSA/NFO conducts an open house to share current information on UGTA groundwater monitoring activities. A series of 26 posters was prepared for the July open house. The posters present an overview of the groundwater monitoring program, the current sampling results for tritium and other radionuclides, the status of model development for each CAU model area, and the various investigation and decision/action stage activities that are planned for each CAU. Attendees of the open house, in addition to the public, included representatives from NNSA/NFO, the State of Nevada, NSTec, N-I, DRI, USGS, Nye County, and members of the NSSAB. Links to the posters presented at the 2016 public meeting can be found at the NNSA/NFO Groundwater Open House web page.

Throughout calendar year 2016, seven NSSAB meetings were held, which were all open to the public and announced by NNSA/NFO on their NSSAB web page. The NSSAB is a part of the Environmental Management Site-Specific Advisory Board, a stakeholder board that provides the Assistant Secretary for Environmental Management and designees with independent advice, information, and recommendations on issues affecting the EM program at various DOE/NNSA sites. Among those issues are clean-up standards and environmental restoration, waste management and disposition, and clean-up science and technology activities.

The 2016 NSSAB public meetings covered a wide range of topics, which included the status of and, as applicable, NSSAB recommendations for the following items:

- Frenchman Flat Longterm Monitoring Plan
- Radioactive Waste Acceptance Program (RWAP) assessment process
- Path to closure for the Rainier Mesa/Shoshone Mountain CAU
- NNSS storm impacts to closed FFACO sites
- Development of recommendations for the prioritization of FY 2018 EM activities at the NNSS

- RWAP facility evaluation improvement opportunities
- Proposed changes to long-term monitoring at closed TTR sites
- Revegetation of Area 5 closed mixed waste cells
- Air monitoring stations at the TTR
- Assessing potential exposure to the public from LLW truck transportation to the NNSS
- EM communication improvement opportunities
- Path to closure for the Clean Slate II site on the TTR

Educational briefings about environmental restoration at the Central Nevada Test Area; the joint USAF and DOE retrieval, transport, and disposal of strontium-90 radioisotope thermoelectric generators at the NNSS in 2015; DOE's Motor Carrier Evaluation Program for commercial carriers of hazardous materials and waste; the hydrogeologic concepts related to contaminant transport; and the fundamental principles of radiation were also presented at the meetings. The meeting agendas, handouts, and minutes for all of the 2016 NSSAB meetings can be found under the Meetings/Minutes tab of the NSSAB web page.

In 2016, at the recommendation of the NSSAB, NNSA/NFO developed a new outreach video, posted on YouTube, which provides the public with a better understanding of what EM is doing to ensure public protection of groundwater affected by historic underground nuclear test.

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Chapter 12: Historic Preservation and Cultural Resources Management

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The cultural landscape of the Nevada National Security Site (NNSS) contains archaeological sites, buildings, structures, and places of importance to American Indians and interested persons. U.S. Department of Energy (DOE) Order DOE O 436.1, "Departmental Sustainability," requires the development and maintenance of policies and directives for the conservation and preservation of these cultural resources. The Cultural Resources Management Program (CRMP) at the NNSS was established by the U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO). The program is implemented by the Desert Research Institute (DRI) to aid in the conservation and preservation of cultural resources that may be impacted by NNSA/NFO activities and projects. As such, activities and projects on the NNSS comply with applicable federal and state regulations for the protection and management of cultural resources eligible to the National Register of Historic Places (NRHP). The CRMP is designed to meet the specific goals as shown below.

Cultural Resources Management Program Goals
Ensure compliance with all federal and state regulations pertaining to cultural resources on the NNSS.
Inventory and manage cultural resources on the NNSS.
Provide information that can be used to evaluate the potential impacts of proposed projects and programs to cultural resources on the NNSS and, when necessary, mitigate adverse effects.
Curate archaeological collections and records in accordance with Title 36 Code of Federal Regulations (CFR) Part 79, "Curation of Federally-Owned and Administered Archeological Collections."
Conduct American Indian consultations related to places and items of importance to the Consolidated Group of Tribes and Organizations having ties to the NNSS.

In order to achieve the program goals and meet federal and state requirements, the CRMP is multifaceted and contains the following major components: (1) archival research, inventories, and historical evaluations; (2) curation of archaeological collections; and (3) the American Indian Consultation Program. Guidance for the CRMP work is provided in the *Cultural Resources Management Plan for the Nevada Test Site* (Drollinger and Beck 2010). DRI historic preservation personnel and archaeologists, who meet the qualification standards set by the Secretary of the Interior, carry out these activities. The archaeological efforts are permitted under the Archaeological Resources Protection Act (ARPA).

A brief description of the CRMP components and the 2016 accomplishments are provided below. The methods to conduct cultural resources inventories and historical evaluations have been summarized in the *Nevada Test Site Environmental Report 2003* (Bechtel Nevada 2004). Additional information is available in the document *Nevada National Security Site Environmental Report 2016 Attachment A: Site Description*, which is a separate file on the compact disc version of this report and is also accessible on the NNSA/NFO web page at http://www.nnss.gov/pages/resources/library/NNSSER.html. Attachment A, Section A.5 summarizes the known human occupation and use of the NNSS from the Paleo-Indian Period, about 11,000 years ago, to the mining and ranching period of the 20th century, and just before NNSS lands were initially withdrawn for federal use by the Atomic Energy Commission.

12.1 Cultural Resources Inventories and Historical Evaluations

Cultural resources inventories are field surveys conducted at the NNSS to meet the requirements of the National Historic Preservation Act (NHPA) and the ARPA. The inventories are completed prior to proposed projects that may disturb or otherwise alter the environment and adversely affect cultural resources eligible to the NRHP. Historical evaluations are completed to evaluate historic buildings and structures for eligibility to the NRHP. The types of information resulting from the inventories and historical evaluations include the following:

- Number of cultural resources inventories conducted
- Location of each project
- Number of acres surveyed at each project location
- Number and types of cultural resources identified at each project location
- Number of cultural resources determined eligible to the NRHP
- Recommendations related to cultural resources requiring mitigation to address an adverse effect
- Final report on results

In 2016, DRI conducted cultural resources inventories and historical evaluations for 13 projects in 9 different areas of the NNSS (Table 12-1). A total of 900 acres were inventoried, 66 cultural resources identified and recorded, and, of these, 20 were determined eligible to the NRHP. One project added the Hamilton atmospheric test area to the already-determined-eligible Frenchman Flat Historic District. Two projects were a carryover from the previous year, and one was started in 2016 and finished in early 2017. The cultural resources include sites, buildings, structures, and isolated features. Consultation with the Nevada State Historic Preservation Office (SHPO) is conducted in accordance with the NHPA for undertakings that could affect historic properties. Consultation with SHPO is in progress to identify mitigation measures for the adverse effects of abandoning the Control Point 1 (CP 1) building and associated resources, as well as for the demolition of the Mercury Bowling Alley. Other eligible cultural resources were avoided by project modifications. The cleanup project for the Hamilton atmospheric test area had no adverse effect on the Frenchman Flat Historic District.

Table 12-1. Cultural resources inventories and historical evaluation projects conducted in 2016

Project	NNSS Area	Project Area (acres)	Cultural Resources	NRHP Eligible	Reference
Control Point 1 Building	6	2	9	8	Reno et al. 2016
Wildland Fire Training Area[(a)]	23	43.3	1	0	Menocal 2016a
Hamilton Test Debris Pile Cleanup[(a)]	5	1.4	1	1	King 2016
RWMC Expansion	5	521	3	0	Drollinger 2016a
LLNL Field Experiment	2	104	11	3	Keach 2016a
Mercury Bowling Alley	23	4.5	2	1	Reno and King 2016
Pit Backfill	27	0.92	1	0	Holz 2016a
UNESE Drill Hole	12	30.3	10	1	Menocal et al. 2017a
Performance Optimized Data Center	6	4.3	0	0	Keach 2016b
DOE Point Roundabout	12	0.38	0	0	Drollinger 2016b
Dense Plasma Focus Facility	11	68	2	0	Keach 2017
DAG Test Pad	2	23.1	3	0	Drollinger 2017
Frey 2[(b)]	3,7	96.8	23	6	Menocal et al. 2017b
Total		**900**	**66**	**20**	

(a) Project started in 2015 and finished in 2016.
(b) Project started in late 2016 and finished in early 2017.

12.2 Evaluations of Historic Buildings

In 2016, a Section 106 evaluation in accordance with the NHPA was conducted for the CP-1 Building and associated resources in Area 6 (Figure 12-1). The secured control point area was the primary command and control center for the NNSS during the nuclear testing era. Some of the operations of the control point consisted of the timing and firing of nuclear tests, air operations, security, communications, weather monitoring, and radiation safety. During nuclear tests, communications from CP-1 were established to receive and pass instructions or information between the various testing operations; Washington, D.C.; the national laboratories; and aircraft overhead monitoring the tests. At one time, the security control center, a weather station, and the radiation safety headquarters were located in CP-1. The building also contained a cafeteria, a dining area, bunk rooms, and the War Room used for observing and monitoring the tests. Initial construction of the building began in 1951, just after the first tests in Frenchman Flat, and was expanded over the years to finally contain 126 rooms with a main floor, basements, and a mezzanine overlooking the War Room. The architectural style is referred to as Brutalist or Heroic, characterized by simplicity and a pragmatic design typical of Cold War and other industrial buildings. As a precaution against blast and radiation effects, CP-1 was constructed of reinforced structural concrete, including the walls, floors, and roof, and had few exterior decorative elements, such as windows. Mostly due to maintenance and repair costs to upgrade the building and a mission change for the NNSS, CP-1 and its associated resources are no longer used and have been decommissioned to be abandoned in place.

Figure 12-1. Control Point Building CP-1

Another NHPA Section 106 evaluation was conducted for Building 23-517, the Mercury Bowling Alley in Area 23 (Figure 12-2). The Bowling Alley was an important recreational building at the NNSS town of Mercury during the nuclear weapons testing era. Planned as part of the recreational facilities in 1962, the eight-lane bowling alley with a full service snack bar opened in 1964. An Olympic-sized swimming pool and pool house were constructed on adjacent property. The Mid-Century Modern one-story, rectangular bowling alley with concrete masonry block walls stands out due to its flamboyant accordion roof and matching front porch. These elements are an example of Googie architecture; the Bowling Alley is the only structure with such features on the NNSS. The pool house, now demolished, was also built in this style. After testing ended in 1992, the number of workers at the NNSS substantially decreased, eliminating the need for most recreational facilities. Demolition of the abandoned bowling alley has been proposed to prepare the area for new facilities to meet the changing role of the NNSS as part of national security.

Figure 12-2. Mercury Bowling Alley

12.3 Other Cultural Resources Projects

Prior to each proposed project inventory, cultural resources records at DRI and the Nevada Cultural Resource Information System are consulted to identify previous cultural resource inventories and NRHP-eligible cultural resources within or near the project area. This aids in determining a proposed project's potential to affect cultural resources and whether cultural resources inventories are required or not. In addition to the projects in Table 12-1, which required cultural resources inventories and evaluations, reviews also included 26 proposed projects that were in areas already inventoried for cultural resources. Therefore, additional cultural resources inventories were not required. No reports were prepared for these 26 projects.

Other projects and activities by DRI resulting in reports are listed below and referenced in Table 12-2.

- A preliminary assessment for six Corrective Action Sites' potential effects on cultural resources for Corrective Action Unit 576
- A summary of Phase 1 of the Tribal Revegetation Project for the Radioactive Waste Management Complex in Area 5
- The timeline summary of cultural resources work conducted for the Apple 2 houses in Area 1
- Cultural resources historic preservation and management contributions to this NNSS Environmental Report during 2015
- The annual report for tasks completed regarding the NNSS artifact collection and records in the NNSA/NFO curation facility at the DRI Southern Nevada Sciences Center
- NNSS cultural resources monitoring

Cultural resources monitoring entailed revisiting a sample of cultural resources eligible to the NRHP, reporting their current conditions, and determining if they maintain integrity and are still eligible. Eleven cultural resources were monitored during 2016. Ten of the cultural resources still maintain integrity and eligibility, while site 26NY15513 no longer exists. A final 2016 project still in the planning stages is the demolition phase for the Mercury Redevelopment Project in Area 23. To date, a cultural resources inventory has not been conducted for this project.

Table 12-2. Other 2016 cultural resources projects and reports

Project	Reference
CAU 576 Preliminary Assessment	King and Keach 2016
Tribal Revegetation Project	Spoon and Barcalow 2016
Apple 2 Timeline	Goldenberg 2016
NNSSER 2015 Contributions	Beck et al. 2016
NNSA/NFO Annual Curation Report	Menocal 2016b
Site 26NY15513 Monitoring	Holz 2016b
NNSS Cultural Resources Monitoring	Menocal and Keach 2016

12.4 Curation

The NHPA requires that archaeological collections and associated records be maintained at professional standards. The specific requirements are delineated in 36 CFR 79. The NNSS Archaeological Collection currently contains approximately 467,000 artifacts and is curated in accordance with 36 CFR 79. Curation requirements include:

- Maintaining an inventory catalog of the items in the NNSS collection.
- Packaging the NNSS collection in materials that meet archival standards (e.g., acid-free boxes).
- Maintaining the NNSS collection and records in a secure facility with environmental controls.
- Following established procedures for the NNSS collection and curation facility.
- Complying with the Native American Graves Protection and Repatriation Act (NAGPRA).

During 2016, the artifact catalog and accession records databases were maintained and updated for ethnographic baskets, cradleboards, weaving tools, and plant samples (Menocal 2016b). Most of these items are on display in the Native American Ethnographic exhibit case at the National Atomic Testing Museum (NATM). Two items previously on display have been returned to the archived collection. The loan agreement between the NNSA/NFO and the NATM for the ethnographic display, in effect until 2018, has been revised to reflect this change. Two other ethnographic display items (cradleboards) from the Yucca Mountain Project have also been added to the catalog and incorporated into the NNSA/NFO permanent collection in custom archival boxes.

The curation facility received a favorable review after a General Services Administration inspection. The loan agreement between the NNSA/NFO and the NATM for the McGuffin artifact collection was renewed for one year. Cultural resources project files from FY 2010 and FY 2011, and copies of cultural resources reports and forms from FY 2016, were archived into the records room. Digital media within the archived project files were backed up on the curation external hard drive and on a secure DRI network drive. Photographs from multiple projects from FY 2000 and FY 2011 were digitized and backed up. Documents relevant to the American Indian Consultation Program have been organized and archived in the records room.

During the 1990s, the NNSA/NFO completed the required inventory and summary of NNSS cultural materials accessioned into the NNSS Archaeological Collection and distributed the inventory list and summary to the recognized American Indian tribes affiliated with the NNSS lands. NAGPRA consultations with the tribes followed, and all artifacts the tribes requested were repatriated to them by 2002. Required NAGPRA consultations are to be repeated periodically for new additions to the NNSS collection.

12.5 American Indian Consultation Program

The NNSA/NFO administers an American Indian Consultation Program (AICP) involving 16 culturally affiliated tribes with cultural and historic ties to the NNSS. The AICP began in 1991 and operates in accordance with directive DOE O 144.1, "American Indian Tribal Government Interaction Policy." The policy identifies guiding principles and a framework for interacting with American Indian and Alaska Native Tribal Governments.

Participating American Indian tribes work together through the Consolidated Group of Tribes and Organizations (CGTO) comprised of Southern Paiute, Western Shoshone, and Owens Valley Paiute-Shoshone. The CGTO selects a Spokesperson who is responsible for representing the group and interfacing with DOE during regularly scheduled meetings. The CGTO and its Spokesperson are viewed as mechanisms for conveying tribal perspectives and developing recommendations relating to topics of interest.

The 16 tribes are listed in NNSS environmental reports (e.g., National Security Technologies, LLC, 2008) and in *Final Site-Wide Environmental Impact Statement for the Continued Operation of the Department of Energy/National Nuclear Security Administration Nevada National Security Site and Off-Site Locations in the State of Nevada* (NNSA/NSO 2013). A history of this program is contained in *American Indians and the Nevada Test Site, A Model of Research and Consultation* (Stoffle et al. 2001). The goals of the program are to:

- Provide a government-to-government forum for the CGTO to interface directly with NNSA/NFO management on activities associated with DOE activities.
- Provide the CGTO with opportunities to actively participate and help guide decisions that involve culturally significant places, resources, and locations on the NNSS.
- Involve the CGTO in the management, curation, display, and protection of American Indian artifacts originating from the NNSS.
- Enable tribal representatives of the CGTO to engage in religious and traditional activities within the boundaries of the NNSS.
- Provide opportunities for CGTO subgroups to participate in the review and evaluation of program documents on an interim basis between regularly scheduled meetings.
- Include the CGTO in the development of tribal text in the agency's National Environmental Policy Act (NEPA) documents.

- Work in collaboration with the CGTO Spokesperson to develop approaches for expanding tribal involvement in NNSA/NFO activities on the NNSS.

In 2016, NNSA/NFO appointed a new AICP Manager to oversee the program and interact with the CGTO Spokesperson. Under the new appointment, the AICP Manager expanded tribal involvement and initiated a formal review process for proposed projects associated with NNSS activities. The process incorporates systematic reviews prior to project implementation with involvement from the CGTO Spokesperson and/or tribal representatives.

The NNSA/NFO involved tribal representatives and DRI archaeologists in the evaluation of the UNESE Drill Hole project in Area 12. Tribal representatives identified approaches for avoiding or minimizing disturbance to culturally sensitive resources, which were incorporated into the final design. This method further reinforces the importance of tribal interactions in DOE activities and is responsive to CGTO recommendations in tandem with NEPA and DOE O 144.1.

In 2016, NNSA/NFO reappointed the CGTO Spokesperson to serve as a designated liaison to the Nevada Site Specific Advisory Board (NSSAB). The appointment requires attendance at regularly scheduled meetings and sharing tribal perspectives relating to planned activities considered by NSSAB and associated with NNSA/NFO undertakings.

During the year, tribal representatives visited the NNSS to examine areas related to the original NAGPRA consultations (Pub. L. 101-601, 25 USC 3001 et seq., 104 Stat. 3048). In 1994 and 1999, NNSA/NFO supported tribal interactions with the CGTO in compliance with NAGPRA to facilitate discussions with tribal representatives to examine artifacts originating from the NNSS. These two separate historical consultations culminated with the repatriation of tribally recommended artifacts to the CGTO (see Section 12.4).). NNSA/NFO continues to facilitate interactions relating to cultural resources in accordance with NAGPRA to promote positive relations with culturally affiliated tribes (Arnold 2016).

Since the inception of the AICP in 1991, NNSA/NFO conducts Tribal Update Meetings with the CGTO to share information and receive guidance relating to NFO activities. During the reporting period, NNSA/NFO initiated planning efforts to host the next meeting to sustain tribal interactions in accordance with DOE O 144.1.

In 2016, NNSA/NFO continued supporting a tribal revegetation project integrating traditional ecological knowledge (TEK) to help restore vegetation within the area referred to as the “92-Acre Site” located at the Radioactive Waste Management Complex in Area 5. The collaborative project held a meeting with six designated tribal representatives along with three tribal elders to directly interface with DOE and provide guidance relating to culturally appropriate approaches for revegetation. Ecologists from Portland State University and DRI, along with the CGTO Spokesperson, facilitated the interactions, blending TEK with scientific methods. This multi-year project reaffirms the commitment between the CGTO and NNSA/NFO.

NNSA/NFO provides ongoing updates relating to the CGTO and NNSS projects through a series of DOE-sponsored groups, meetings, and activities. One primary example is the State Tribal Government Working Group (STGWG) sponsored by the DOE Office of Environmental Management (DOE EM). STGWG comprises representatives from various state governments, the CGTO, and ten other designated tribes from New Mexico, Idaho, Washington, Oregon, and New York engaged in DOE activities. STGWG meetings were held in Buffalo, New York, on May 3–5, 2016, and again in New Orleans, Louisiana, on November 16–18, 2016. STGWG meetings are an important forum for sharing information of mutual interest and engaging in discussions with DOE leadership and colleagues. Discussion topics focus primarily on DOE EM activities with involvement from the DOE Office of Legacy Management to examine methods for enhancing communications and expanding interactions between tribes and DOE.

Another NNSA/NFO initiative is involvement in the National Transportation Stakeholders Forum (NTSF) hosted by the DOE Office of Nuclear Energy and DOE EM. NNSA/NFO representatives, along with the CGTO Spokesperson, regularly participate in NTSF interactions and attend related meetings. In 2016, the annual NTSF conference was held on June 8–9, 2016, in Orlando, Florida. The meetings provided an opportunity to discuss topics of mutual interest among participants from the DOE, Nuclear Regulatory Commission, Federal Railroad Administration, Tribes, States, and among academia and industry representatives.

In 2016, NNSA/NFO did not receive any requests from culturally affiliated tribes to access the NNSS for ceremonial or traditional use. CGTO interests focused on expanding traditional management activities and conducting ethnographic studies to document TEK relating to land use and cultural resource protection and preservation.

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Chapter 13: Ecological Monitoring

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The Ecological Monitoring and Compliance (EMAC) Program provides ecological monitoring and biological compliance support for activities and programs conducted at the Nevada National Security Site (NNSS). The major sub-programs and tasks within EMAC include (1) the Desert Tortoise Compliance Program, (2) biological surveys at proposed project/activity sites, (3) important species and ecosystem monitoring, (4) the Habitat Restoration Program, and (5) wildland fire hazard assessment. Brief descriptions of these sub-programs and their 2016 accomplishments are provided in this chapter. Detailed information may be found in the most recent annual EMAC report (Hall et al. 2017). EMAC annual reports are available at http://www.nnss.gov/pages/resources/library/EMAC.html. The reader is also directed to *Attachment A: Site Description*, a separate file on the compact disc of this report, where the ecology of the NNSS is described.

Ecological Monitoring and Compliance Program Goals
Ensure compliance with all state and federal regulations and stakeholder commitments pertaining to NNSS flora, fauna, wetlands, and sensitive vegetation and wildlife habitats (see Table 2-1).
Delineate NNSS ecosystems.
Provide ecological information that can be used to evaluate the potential impacts of proposed projects and programs on NNSS ecosystems and important plant and animal species.

13.1 Desert Tortoise Compliance Program

The desert tortoise, which inhabits the southern one-third of the NNSS (Figure 13-1), is federally protected as a threatened species under the Endangered Species Act. Activities conducted in desert tortoise habitat on the NNSS must comply with the terms and conditions of a Biological Opinion (Opinion) issued to the U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO) by the U.S. Fish and Wildlife Service (FWS) (FWS 2009). The Opinion is effectively a permit to conduct activities in desert tortoise habitat in a specific manner. It authorizes the ***incidental take*** (see Glossary, Appendix B) of tortoises that may occur during the activities, which, without the Opinion, would be illegal and subject to civil or criminal penalties.

The Opinion states that proposed NNSS activities are not likely to jeopardize the continued existence of the Mojave population of the species and that no critical habitat would be destroyed or adversely modified. It sets compliance limits for the acres of tortoise habitat that can be disturbed, the number of accidentally injured and killed tortoises, and the number of captured, displaced, or relocated tortoises (Table 13-1). It also establishes mitigation requirements for habitat loss. The Desert Tortoise Compliance Program was developed to implement the Opinion's terms and conditions, document compliance actions taken, and assist NNSA/NFO in FWS consultations.

13.1.1 Surveys and Compliance Documentation

In 2016, biologists conducted surveys for six projects that were within the distribution range of the desert tortoise on the NNSS. At the project sites, no desert tortoises were injured or killed, nor were any found, captured, or displaced from the project sites. One of the projects, originally initiated in 2011, disturbed 0.35 acres of tortoise habitat in 2016. The other activities occurred on previously disturbed sites. Mitigation fees to compensate for the disturbance of the 0.35 acres of desert tortoise habitat were paid in 2011. No compliance limits of the Opinion were exceeded (Table 13-1). In 2016, one desert tortoise was accidentally killed by a vehicle on a paved road, and 17 were moved out of harm's way off of roads.

In January 2017, NNSA/NFO submitted a report to the FWS Southern Nevada Field Office that summarizes tortoise compliance activities conducted on the NNSS from January 1 through December 31, 2016.

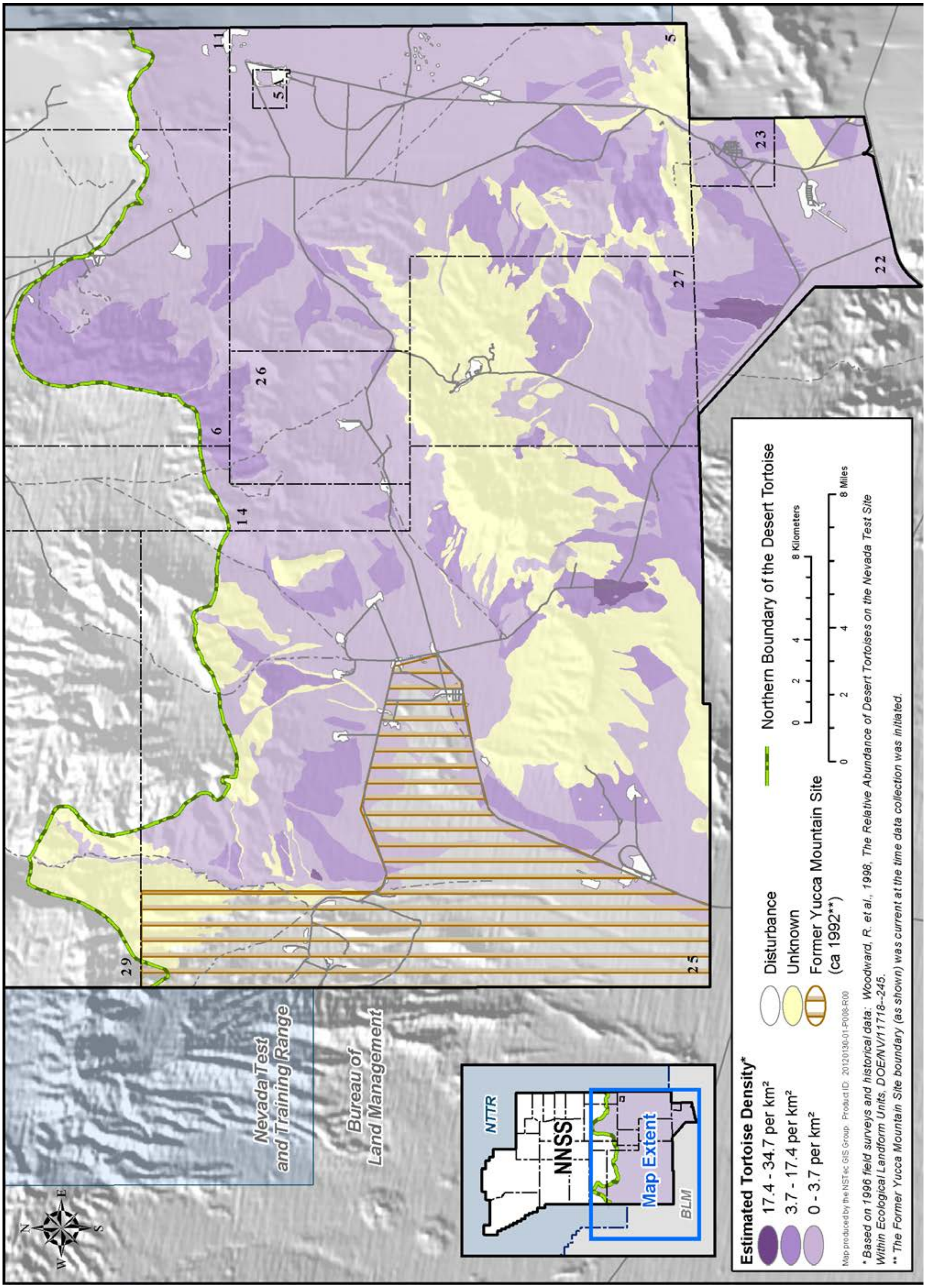

Figure 13-1. Desert tortoise distribution and abundance on the NNSS

Table 13-1. Annual totals (2016), cumulative totals (2009–2016), and compliance limits for take of acres and tortoises

Program/Activity	Acres Impacted Annual Total	Acres Impacted Cumulative Total	Acres Impacted Permit Limit	Tortoises Killed or Injured Annual Total	Tortoises Killed or Injured Cumulative Total	Tortoises Killed or Injured Permit Limit	Other Incidental Take[(a)] Annual Total	Other Incidental Take[(a)] Cumulative Total	Other Incidental Take[(a)] Permit Limit
Defense	0	5.61	500	0	0	1	0	0	10
Waste Management	0	0	100	0	0	1	0	0	2
Environmental Restoration	0	0	10	0	0	1	0	0	2
Nondefense Research and Development	0	0	1,500	0	0	2	0	0	35
Work for Others	0.35	32.84	500	0	0	1	0	0	10
Infrastructure Development	0	8.43	100	0	0	1	0	0	10
Vehicle Traffic on Roads	-	-	-	1	10	15[(b)]	17	112	125
Totals	0.35	46.88	2,710	1	10	22	17	112	194

(a) The number of desert tortoises that a qualified biologist can take by capture, displacement, relocation, or disruption of behavior if desert tortoises are found in harm's way within a project area or on a heavily trafficked road.
(b) No more than 4 desert tortoises killed during any calendar year and 15 during the term of the Opinion (2009–2019).

13.1.2 Desert Tortoise Conservation Projects

Two desert tortoise projects on the NNSS, approved by the FWS, are being conducted by NNSS biologists. They include a study of tortoise movement patterns of up to 30 resident, adult tortoises found along paved NNSS roads and a translocation study of 60 juvenile tortoises released from captivity in Area 22 in 2012. Prior to their release, the 60 juvenile tortoises were in the care of the San Diego Zoo Institute for Conservation Research (ICR) at the Desert Tortoise Conservation Center (DTCC) located near Las Vegas, Nevada. The translocation study continues to be a collaboration between the ICR, FWS and NNSS staff. NNSS biologists use radiotelemetry to document the location of the study animals and collect a variety of habitat and ecological data. In November 2013, the FWS approved NNSS biologists to conduct/support these studies in lieu of paying mitigation fees for habitat loss for NNSS projects that were not under the Work for Others Program (see Table 13-1, first column).

The roadside movements study reached its maximum limit of 30 study animals in 2015, therefore no new tortoises were added to the study in 2016. The study requires each study animal be monitored for three active seasons; March through October. In 2016, 20 study animals continued to be monitored. This amount was decreased to 13 by the end of 2016 when 7 tortoises reached the end of their monitoring and their transmitters were removed. The processing and analysis of data from the Global Positioning Unit data loggers affixed to the tortoises is ongoing and will help NNSS and FWS understand how the animals utilize roads on the NNSS.

Of the 60 juvenile tortoises released in 2012, 27 remained alive and were monitored in 2016. Study animals were tracked via radio telemetry by NNSS biologists, and annual health assessments were performed on the animals. One tortoise was found dead, most likely due to predation, and another tortoise thought to be dead since 2013 was found alive. This study will continue for the next several years and will continue to provide valuable data for future translocations conducted by FWS that help augment wild populations of the desert tortoise.

13.2 Biological Surveys at Proposed Project Sites

Biological surveys are performed at proposed project sites where land disturbance will occur or where significant impacts to plants and animals might occur (e.g., during the demolition of structures that may contain bird nests or the release of toxic chemicals into habitat of protected species). The goal is to minimize the adverse effects of land disturbance and other impacts on important plants and animals (see Section 13.3), their associated habitat, and important biological resources. Important biological resources include such things as cover sites, nest/burrow sites, roost sites, wetlands, or water sources that are vital to important species.

During 2016, biologists surveyed a total of 388 acres for 16 projects on or near the NNSS, 7 of which were on lands previously disturbed (e.g., road shoulders, existing well pads, old building sites). The 16 projects combined have the potential to disturb 52 acres. Important species and biological resources found included 13 predator burrows, Joshua trees (*Yucca brevifolia*), four species of cacti, and numerous sightings of birds and mammals. Biologists provided to project managers written summary reports of all survey findings and mitigation recommendations, which are summarized by project in Hall et al. (2017). No important species or important biological resources were known to be harmed by project activities in 2016, although accidental bird mortalities occurred (Table 13-2).

13.3 Important Species and Ecosystem Monitoring

NNSA/NFO strives to protect and conserve sensitive plant and animal species found on the NNSS and to minimize cumulative impacts to those species as a result of NNSA/NFO activities. Important species known to occur on the NNSS include 19 sensitive plants, 1 mollusk, 2 reptiles, 237 birds, and 28 mammals. They are identified in Tables A-10 and A-11 of *Attachment A: Site Description* (see file on the compact disc of this document). They are classified as important due to their sensitive, protected, and/or regulatory status with state or federal agencies, and they are evaluated for inclusion in long-term monitoring activities on the NNSS. NNSA/NFO has produced numerous documents reporting the occurrence, distribution, and susceptibility to threats for predominately sensitive species on the NNSS (Wills and Ostler 2001).

Ecosystem monitoring includes monitoring a wide variety of terrestrial and aquatic habitats and species not classified, as in the text above, as "important." Such monitoring over time can identify impacts of climate and other environmental changes on the NNSS that are unrelated to NNSS project activities. In 1996, biologists began mapping plant communities and wildlife habitat on the NNSS within field mapping units called ecological landform units (ELUs). ELUs are landforms with similar vegetation, soil, slope, and hydrology. Boundaries of ELUs were defined using aerial photographs, satellite imagery, and field confirmation. ELU mapping resulted in the identification of 10 vegetation alliances and 20 vegetation associations on the NNSS (Ostler et al. 2000).

Field monitoring activities in 2016 related to important NNSS plants and animals and to ecosystem monitoring are listed in Table 13-2. A description of the methods and a more detailed presentation of the results of these activities are reported in Hall et al. (2017).

Table 13-2. Activities conducted in 2016 for important species and ecosystem monitoring on the NNSS

Sensitive Plants (see Table A-10 of *Attachment A: Site Description*)

- The list of known sensitive plants on the NNSS was reviewed. The cactus species *Sclerocactus polyancistrus* was added to the list because it had been added to the Nevada Natural Heritage Program's "At-Risk Plant and Animal Tracking List," although it is relatively common on the NNSS. No field surveys were conducted in 2016 for sensitive plants, although some new populations of two sensitive plant species were opportunistically found and documented during the conduct of other field work.

Reptiles

- No trapping or roadkill surveys were conducted in 2016. Opportunistic observations were documented and 2 snake specimens (1 red racer [*Masticophis flagellum*], 1 king snake [*Masticophis flagellum*]) were collected and given to the Nevada Department of Wildlife (NDOW) for future genetic analysis.

Migratory Birds (protected under the Migratory Bird Treaty Act)

- Biologists rescued and released 3 grounded birds: 1 common loon (*Gavia immer*), 1 juvenile barn owl (*Tyto alba*), and 1 juvenile poorwill (*Phalaenoptilus nuttallii*).
- Eleven bird mortalities were documented, 7 of which were due to human activities: 1 golden eagle (*Aquila chrysaetos)*, 3 great-horned owls (*Bubo virginianus*), and 2 red-tailed hawks (*Buteo jamaicensis*) were electrocuted; and 1 turkey vulture (*Cathartes aura*) collided with a vehicle. Two red-tailed hawks, 1 horned lark (*Eremophila alpestris*), and 1 northern saw-whet owl (*Aegolius acadicus*) were found dead of unknown causes.
- The NSTec Power Group installed bird guards, protective covers, and other retrofits on 13 NNSS power poles where golden eagles had been previously electrocuted. Biologists prepared a draft NNSA/NFO Avian Protection Plan, which was submitted to the FWS for review.
- Two winter raptor survey routes were sampled in January and February; 25 raptors representing 5 species were observed. Data were shared with the U.S. Army Corps of Engineers for their nationwide mid-winter bald eagle survey and with NDOW for their statewide monitoring effort.

Table 13-2. Activities conducted in 2016 for important species and ecosystem monitoring on the NNSS (continued)

Wild Horses (*Equus caballus*) (protected under the Wild Free Roaming Horses and Burros Act)

- Annual horse monitoring has been conducted from 1980–2014 to determine abundance, foal survival, and population distribution on the NNSS. No horse surveys were conducted in 2016 due to limited resources. However, opportunistic sightings were noted and motion-activated cameras at water sources were used. Camp 17 Pond and Gold Meadows Spring continue to be important summer water sources for NNSS horses.

Mule Deer (*Odocoileus hemionus*) (managed as a game mammal by NDOW)

- Mule deer surveys were conducted on Pahute and Rainier mesas, and the average number of deer counted was 25 deer/night. The observed buck/doe ratio was 74 bucks/100 does, the second lowest ratio measured on the NNSS. The observed fawn/doe ratio was 40 fawns/100 does, the third highest measured on the NNSS.

Desert Bighorn Sheep (*Ovis canadensis nelsoni*) (managed as a game mammal by NDOW)

- A total of 15 desert bighorn sheep were captured on or near the NNSS during November 2016. Thirteen (6 ewes and 7 rams) of these were radio-collared to track their movements over the next 2 years. Blood samples and nasal swabs were also taken for genetic and disease testing. A ram that was captured on the NNSS in 2015 was legally harvested by a hunter in 2016 in the hills north of Bare Mountain.

Sensitive Bats (see Table A-11 of *Attachment A: Site Description*)

- The recording of bat vocalizations at Camp 17 Pond was discontinued indefinitely. Bat monitoring in 2016 was restricted to documenting roost sites in buildings.
- NNSS biologists responded to seven reports of bats in NNSS buildings. Four bats were captured and released away from populated areas, 1 was found dead and removed, and 2 were left undisturbed.

Mountain Lions (*Puma concolor*) (managed as a game mammal by NDOW)

- A collaborative effort with U.S. Geological Survey (USGS) scientists Dr. Erin Boydston and Dr. Kathy Longshore continued in 2016 to investigate mountain lion distribution and abundance on the NNSS using remote, motion-activated cameras. Cameras collected a total of 70 photographs/video clips of mountain lions from 9 of 28 camera sites, and 3 visual sightings by workers/biologists were recorded (Figure 13-3). A minimum of 5 lions (3 adult males, 1 adult female, and 1 subadult) inhabited the NNSS during 2016 based on photographic data.
- A collaborative effort with Kathy Longshore and Brian Jansen of the USGS continued in 2016 to investigate the movements, habitat use, and food habits of mountain lions on the NNSS using radio-collared individuals. No radio-collared individuals studied in previous years had functioning collars. In July and August 2016, 2 adult males were trapped on the NNSS, radio-collared, and tracked. Their kill sites were visited and all observed prey were mule deer. Preferred lion habitat on the NNSS is rugged, mountainous, typically forested areas in the northern and western portions of the NNSS (Figure 13-2).

Natural and Man-made Water Sources

- Ten natural water sources, 1 well pond, 5 wildlife water troughs, and 3 well sumps which periodically retain tritium contaminated groundwater discharged from monitoring wells (see Chapter 5, Section 5.1.3.7.3) were monitored with motion-activated cameras to document wildlife use. Tritium contaminated well sumps are monitored to identify which species are being exposed and which may provide an exposure pathway to offsite hunters who may consume them. Mule deer, which can move off site and be harvested by hunters, were photographed at all three of the well sumps monitored.

Long-Term Vegetation Monitoring Plots

- Permanent plots established by NNSS biologists in all major vegetation associations on the NNSS are monitored to document baseline conditions and possible long-term changes due to climate change or other impacts. Between July and November 2016, plant cover and density were measured in 12 plots established in 2008 in the pinyon pine (*Pinus monophylla*)–big sagebrush (*Artemisia tridentata*) vegetation association, and 2 new paired plots were added and sampled to compare burned versus unburned areas. Burned plots had higher total plant cover due to invasive cheatgrass, and unburned plots had higher perennial plant densities.

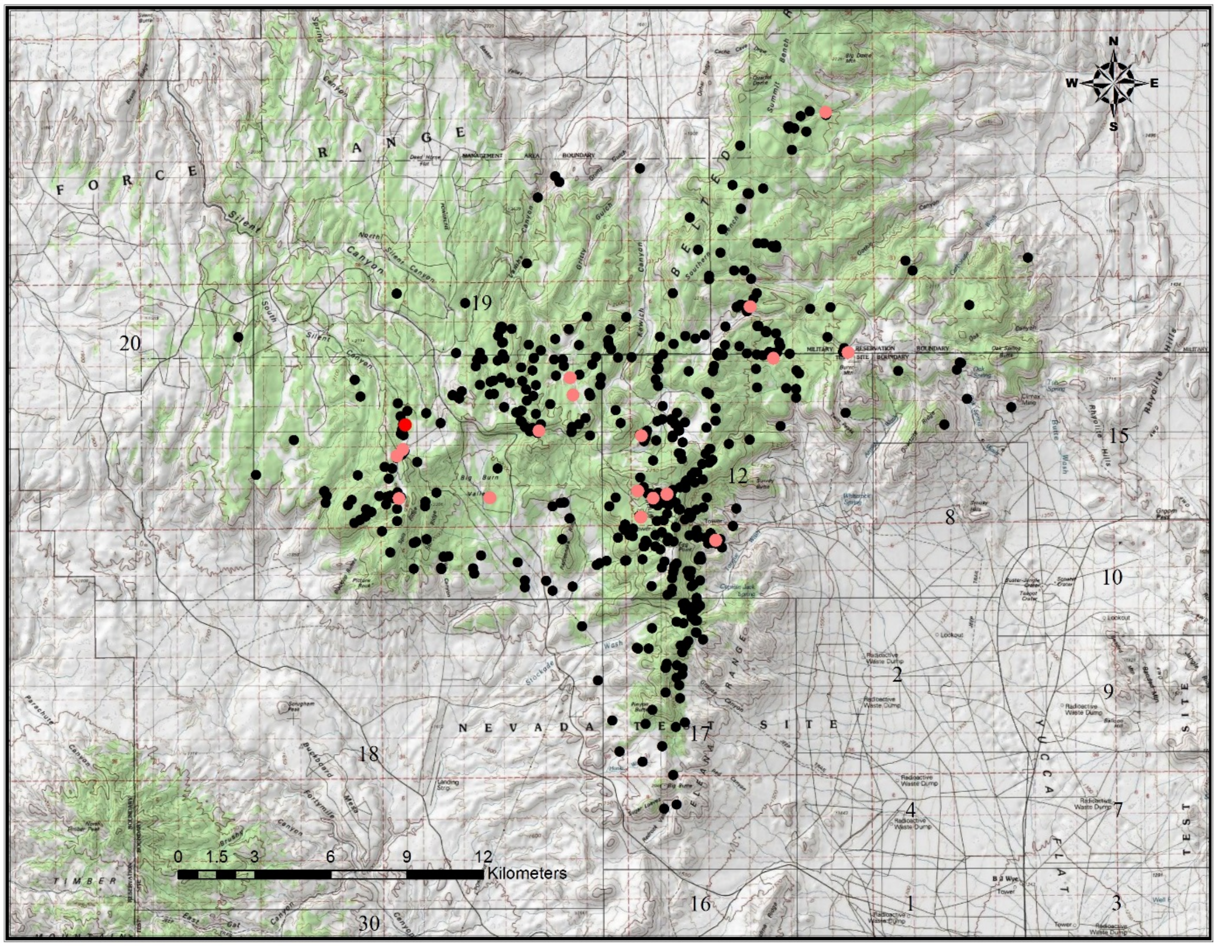

Figure 13-2. Locations of one male radio-collared mountain lion from August 3, 2016 to January 1, 2017 (black dots), mule deer kill locations (pink dots), and one scavenged mule deer site (red dot).

13.4 Habitat Restoration Program

The Habitat Restoration Program revegetates disturbances and evaluates previous revegetation efforts. Sites that have been revegetated are periodically sampled, and the information obtained is used to develop site-specific revegetation plans for future restoration efforts on the NNSS. Revegetation supports the intent of Executive Order EO 13112, "Invasive Species," to prevent the introduction and spread of non-native species and restore native species to disturbed sites. Revegetation also may qualify as mitigation for the loss of desert tortoise habitat under the current Opinion. NNSA/NFO revegetation projects include lands disturbed in desert tortoise habitat; wildland fire sites; abandoned industrial or nuclear test support sites classified into Corrective Action Units (CAUs) that are remediated by Environmental Management (EM) Operations; and EM soil closure covers (or cover caps) over closed waste disposal pits. Sites that have been revegetated are periodically sampled as needed to monitor success or identify further needed actions. All monitoring information is used to develop site-specific revegetation plans for future restoration efforts on the NNSS. Sites at which revegetation has occurred in past years are listed below (the year each was revegetated is shown in parentheses). Field sampling and revegetation efforts performed in 2016 are discussed below.

- Double Tracks (CAU 411), Tonopah Test Range (TTR) (1996)
- Bomblet Pit and Five Points Landfill (CAU 400), TTR (1997)
- Cactus Spring Waste Trenches (CAU 426), TTR (1997)
- Roller Coaster Lagoons and Trench (CAU 404), TTR (1997)
- U3ax/bl Closure Cover (CAU 110), Area 3, NNSS (2000)

- Egg Point Fire, Area 12, NNSS (2002)
- Roller Coaster RadSafe Area (CAU 407), TTR (2004)
- NTS Waterline Replacement, Area 6, NNSS (2005)
- CP Hill Waterline, Area 6, NNSS (2009)
- 92 Acre Site, Area 5 RWMC (CAU 111), NNSS (2011)

Activities conducted in 2016 included visual inspection of the vegetation at the U3ax/bl Closure Cover in Area 3 (see Chapter 10, Figure 10-2) and quantitative assessments of vegetation at four sites on the TTR: Bomblet Pit, Five Points Landfill, Roller Coaster Lagoons, and Roller Coaster Radsafe Area. The visual assessment of U3ax/bl's vegetative cover indicated that it continues to show signs of a stable plant community capable of removing water from the soil profile through evapotranspiration.

The four TTR sites were inspected on June 14-15, 2016. Plant cover and density estimates were made, wildlife usage was noted, and erosion conditions were evaluated. Species richness was calculated from the density data. Sampling methods and sampling data are described in Hall et al. (2017).

The staging area at Five Points Landfill has successfully revegetated and the plant community appears to be viable and persistent. The reseeded area is located in a low-lying area that collects runoff from precipitation events which can cause plant mortality. This area should be monitored periodically and perhaps seeded with species better adapted to inundation. The goals of revegetation at the Bomblet Pit have been accomplished and total plant cover and density exceeded the success standards. One concern is the abundance of saltlover (*Halogeton glomeratus*) on the revegetated area. A viable native plant community has established on both the staging area and cover cap at the Roller Coaster Lagoons and Trench. However, total plant cover and perennial plant density on the staging area is below the success standards. Success standards were exceeded for total plant cover and total plant density at the Roller Coaster Radsafe Area. The abundance of saltlover at this site is somewhat concerning and should be monitored over time to ensure the persistence of the perennial plant community.

13.5 Wildland Fire Hazard Assessment

A Wildland Fire Management Plan is maintained, which requires protection of site resources from wildland and operational fires. An annual vegetation survey to determine wildland fire hazards is conducted on the NNSS each spring. Survey findings are submitted to the NNSS Fire Marshal and summarized in the annual EMAC report (Hall et al. 2017). In April and May 2016, NNSS biologists visited 104 roadside sampling stations to assess a fuel index that can range from 0 to 10 (lowest to highest risk of wildfires). The mean combined fuels index (which includes both fine [non-woody] and woody fuels) for all sampling stations was 5.10, the fourth highest ranking since 2004 when index values were initiated (the highest since 2004 was 5.64 in 2005). Results from the wildland fuel surveys showed a higher than average risk of wildland fire due to increased fuel loads that was the result of consistent winter precipitation. Average precipitation during December 2015–April, 2016, when it most influences plant growth and thus the availability of fine fuels for wildland fires, was 4.28 inches, just above the average of 4.12 inches for this period over the last 30 years. Two wildland fires occurred on the NNSS in 2016, each less than 1 acre in size, and were extinguished quickly.

13.6 References

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Chapter 14: Quality Assurance Program

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Required Criteria of a Quality Program
• Quality assurance program • Personnel training and qualification • Quality improvement process • Documents and records • Established work processes • Established standards for design and verification • Established procurement requirements • Inspection and acceptance testing • Management assessment • Independent assessment

The environmental monitoring work conducted for the U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO) is performed in accordance with the Quality Assurance Program (QAP) established by the current Management and Operations (M&O) contractor, National Security Technologies, LLC (NSTec), and with the Underground Test Area (UGTA) QAP implemented by Navarro Research and Engineering, Inc. (Navarro). Both QAPs describe the methods used to ensure that quality is integrated into the monitoring work. Both QAPs comply with Title 10 Code of Federal Regulations (CFR) Part 830, Subpart A, “Quality Assurance Requirements,” and with U.S. Department of Energy (DOE) Order DOE O 414.1D, “Quality Assurance.” The 10 criteria of a quality program specified by these regulations are shown in the box above. The QAPs require a graded approach to quality for determining the level of rigor that effectively provides assurance of performance and conformance to requirements.

The Data Quality Objective (DQO) process developed by the U.S. Environmental Protection Agency (EPA) is generally used to provide the quality assurance (QA) structure for designing, implementing, and improving upon environmental monitoring efforts when environmental sampling and analysis are involved. Sampling and Analysis Plans are developed prior to performing an activity to ensure complete understanding of the data-use objectives. Personnel are trained and qualified in accordance with company- and task-specific requirements. Access to sampling locations is coordinated with organizations conducting work at or having authority over those locations in order to avoid conflicts in activities and to communicate hazards to better ensure successful execution of the work and protection of the safety and health of sampling personnel. Sample collection activities adhere to organization instructions and/or procedures that are designed to ensure that samples are representative and data are reliable and defensible. Sample shipments on site and to offsite laboratories are conducted in accordance with U.S. Department of Transportation and International Air Transport Association regulations, as applicable. Quality control (QC) in the analytical laboratories is maintained through adherence to standard operating procedures that are based on methodologies developed by nationally recognized organizations such as the EPA, DOE, and ASTM International. Key quality-affecting procedural areas cover sample collection, preparation, instrument calibration, instrument performance checking, testing for precision and accuracy, obtaining a measurement, and laboratory data review. Data users perform reviews as required by the project-specific objectives before the data are used to support decision making.

The key elements of the environmental monitoring process work flow are listed below. Each element is designed to ensure that applicable QA requirements are implemented. A discussion of these elements follows.

- A **Sampling and Analysis Plan** (SAP) is developed using the EPA DQO process to ensure that clear goals and objectives are established for the environmental monitoring activity. The SAP is implemented in accordance with EPA, DOE, and other requirements addressing environmental, safety, and health concerns.
- **Environmental Sampling** is performed in accordance with the SAP and site work controls to ensure defensibility of the resulting data products and protection of the workers and the environment.
- **Laboratory Analyses** are performed to ensure that the resultant data meet DOE, NSTec (as the current M&O contractor), and UGTA regulation-defined requirements.

- **Data Review** is done to ensure that the SAP DQOs have been met, and thereby determine whether the data are suitable for their intended purpose.
- **Assessments** are employed to ensure that monitoring operations are conducted according to procedure and that analytical data quality requirements are met in order to identify nonconforming items, investigate causal factors, implement corrective actions, and monitor for corrective action effectiveness.

14.1 Sampling and Analysis Plan

Sampling is specifically mandated to demonstrate compliance with a variety of requirements, including federal and state regulations and DOE orders and standards. Developing the SAP using the DQO approach ensures that those requirements are considered in the planning stage. The following statistical concepts and controls are vital in designing and evaluating the system design and implementation.

14.1.1 Precision

Precision is the degree to which a set of observations or measurements of the same property, obtained under similar conditions, conform to themselves. Precision is a data quality indicator and is usually expressed as standard deviation, variance, or range, in either absolute or relative terms (DOE 2013).

In practice, precision is determined by comparing the results obtained from performing analyses on split or duplicate samples taken at the same time from the same location or locations very close to one another, maintaining sampling and analytical conditions as nearly identical as possible.

14.1.2 Accuracy

Accuracy refers to the degree of agreement between an observed value and an accepted reference value. Accuracy includes a combination of random error (precision) and systematic error (bias) components that are due to sampling and analytical operations. Accuracy is a data quality indicator (DOE 2013). Accuracy is monitored by performing measurements and evaluating results of control samples containing known quantities of the analytes of interest.

14.1.3 Representativeness

Representativeness is the degree to which measured analytical concentrations represent concentrations in the medium being sampled (Stanley and Verner 1985).

At each point in the sampling and analysis process, samples of the medium of interest are obtained. The challenge is to ensure that each sample maintains the character of the larger population being sampled. From a field sample collection standpoint, representativeness is managed through sampling plan design and execution. Sampling locations are/have been determined historically by consensus and/or agreement with authorities, in many cases, or are determined based on the properties of the operation being monitored (such as environmental remediation). Representativeness related to laboratory operations concerns the ability to appropriately subsample and characterize for analytes of interest. For example, in order to ensure representative characterization of a heterogeneous matrix (soil, sludge, solids, etc.), the sampling and/or analysis process should evaluate whether homogenization or segregation should be employed prior to sampling or analysis. Water samples are generally considered homogeneous unless observation suggests otherwise. Each air monitoring station's continuous operation at a fixed location results in representatively sampling the ambient atmosphere. Field sample duplicate analyses are additional controls allowing evaluation of representativeness and heterogeneity; these are employed for air monitoring and direct radiation monitoring measurements. Generally monitoring measurements are compared with historical measurements at the same location.

14.1.4 Comparability

Comparability refers to "the confidence with which one data set can be compared to another" (Stanley and Verner 1985). Comparability from an overall monitoring perspective is ensured by consistent execution of the sampling design concerning sample collection and handling, laboratory analyses, and data review. This is ensured through adherence to established procedures and standardized methodologies. Ongoing data evaluation compares data collected at the same locations from sampling events conducted over multiple years and produced by numerous laboratories to detect any anomalies that might occur.

14.2 Environmental Sampling

Environmental samples are collected in support of various environmental programs. Each program executes the field sampling activities in accordance with the SAP to ensure usability and defensibility of the resulting data. The key elements supporting the quality and defensibility of the sampling process and products include the following:

- Training and qualification
- Procedures and methods
- Field documentation
- Inspection and acceptance testing

14.2.1 Training and Qualification

The environmental programs ensure that personnel are properly trained and qualified prior to doing the work. In addition to procedure-specific and task-specific qualifications for performing work, training addresses environment, safety, and health aspects to ensure protection of the workers, the public, and the environment. Recurrent training is also conducted as appropriate to maintain proficiency.

14.2.2 Procedures and Methods

Sampling is conducted in accordance with established procedures to ensure consistent execution and continuous comparability of the environmental data. Descriptions of the analytical methods to be used are also consulted in order to ensure that, as methods are revised, sample collection is performed appropriately and that viable samples are obtained.

14.2.3 Field Documentation

Field documentation is generated for each sample collection activity. This may include chain of custody documentation, sampling procedures, analytical methods, equipment and data logs, maps, Safety Data Sheets, and other materials needed to support the safe and successful execution and defense of the sampling effort. Chain-of-custody practices are employed from point of generation through disposal (cradle-to-grave); these are critical to the defensibility of the decisions made as a result of the sampling and analysis. Sampling data and documentation are stored and archived so they are readily retrievable for use at a later date. In many cases the data are managed in electronic data management systems. Routine assessments or surveillances are performed to ensure that sampling activities are performed in accordance with applicable requirements. Deficiencies are noted, causal factors are determined, corrective actions are implemented, and follow-up assessments are performed to ensure effective resolution. This data management approach ensures the quality and defensibility of the decisions made using analytical environmental data.

14.2.4 Inspection and Acceptance Testing

Sample collection data are reviewed for appropriateness, accuracy, and fit with historical measurements. In the case of groundwater sampling, water quality parameters are monitored during purging. Stabilization of these parameters generally indicates that the water is representative of the aquifer, at which time sample collection may begin. After a sampling activity is complete, data are reviewed to ensure the samples were collected in accordance with the SAP. Samples are further inspected to ensure that their integrity has not been compromised, either physically (leaks, tears, breakage, custody seals) or administratively (labeled incorrectly) and that they are valid for supporting the intended analyses. If concerns are raised at any point during collection, the data user, in consideration of data usability, is consulted for direction on proceeding with or canceling the subsequent analyses.

14.3 Laboratory Analyses

Samples are transported to a laboratory for analysis. Several DOE contractor organizations maintain measurement capabilities that may be used to support planning or decision-making activities. However, unless specifically authorized by NNSA/NFO or the regulator, data used for demonstrating regulatory compliance are generated by a DOE- and NSTec-qualified laboratory whose services have been obtained through subcontracts. Ensuring the quality of procured laboratory services is accomplished through focus on three specific areas: (1) procurement, (2) initial and continuing assessment, and (3) data evaluation.

14.3.1 Procurement

Laboratory services are procured through subcontracts in accordance with the Competition in Contracting Act, the Federal Acquisition Regulations, the DOE Acquisition Regulations, contractor terms and conditions for subcontracting, and other relevant policies and procedures. The analytical services technical basis is codified in the DOE Quality Systems for Analytical Services (QSAS) (DOE 2013). The QSAS is based on the National Environmental Laboratory Accreditation Conference Chapter 5, "Quality Systems," as implemented in 2005, based on International Organization for Standardization Standard ISO 17025, "General Requirements for the Competence of Testing and Calibration Laboratories." Subcontracted laboratories must be assessed to be in compliance with the QSAS and are routinely audited under the DOE Consolidated Audit Program (DOECAP).

A request for proposal (RFP) is posted to the government website, laboratory responses are evaluated, and subcontracts awarded. The RFP cites the QSAS and DOECAP participation as base requirements and addresses site-specific conditions. Multiple laboratories may receive a subcontract through one RFP.

The laboratories are primarily those providing a wide range of analytical services to DOE. Other services can be subcontracted by the laboratory (i.e., lower-tier subcontractor) or contracted directly from a vendor. In either case, requirements are established for the specific services provided.

The subcontract places numerous requirements on the laboratory, including the following:

- Maintaining the following documents:
  - A Quality Assurance Plan and/or Manual describing the laboratory's policies and approach to the implementation of QA requirements
  - An Environment, Safety, and Health Plan
  - A Waste Management Plan
  - Procedures pertinent to subcontract scope
- The ability to generate data deliverables, both hard copy reports and electronic files
- Responding to all data quality questions in a timely manner
- Mandatory participation in proficiency testing programs
- Maintaining specific licenses, accreditations, and certifications
- Conducting internal audits of laboratory operations as well as audits of vendors
- Allowing external audits by DOECAP and NNSA/NFO contractors and providing copies of other audits considered by NSTec to be comparable and applicable

14.3.2 Initial and Continuing Assessment

An initial assessment is made during the RFP process, including a pre-award audit. If an acceptable audit has not been performed within the past year, NSTec or Navarro will consider performing an audit (or participating in a DOECAP audit) of those laboratories awarded the contract. Neither contractor will initiate work with a laboratory without authorized approval from those NSTec or Navarro personnel responsible for ensuring vendor acceptability.

A continuing assessment consists of the ongoing monitoring of a laboratory's performance against contract terms and conditions, of which the technical specifications are a part. Tasks supporting continuing assessment are listed below:

- Conducting regular audits or participating in evaluation of DOECAP audit products
- Monitoring for continued successful participation in proficiency testing programs such as:
  - National Institute of Standards and Technology Radiochemistry Intercomparison Program
  - Studies that support certification by the State of Nevada or appropriate regulatory authority for analyses performed in support of routine monitoring
- Routine ongoing monitoring of the laboratory's adherence to the quality requirements

14.3.3 Data Evaluation

Data products are routinely evaluated for compliance with contract terms and specifications. This primarily involves review of the data against the specified analytical method to determine the laboratory's ability to adhere to the QA/QC requirements, as well as an evaluation of the data against the DQOs. This activity is discussed in further detail in Section 14.4. Any discrepancies are documented and resolved with the laboratory, and ongoing assessment tracks the recurrence and efficacy of corrective actions.

14.4 Data Review

A systematic approach to thoroughly evaluating the data products generated from an environmental monitoring effort is essential for understanding and sustaining the quality of data collected under the program. This allows the programs to determine whether the DQOs established in the planning phase were achieved and whether the monitoring design performed as intended or requires review.

Because decisions are based on environmental data, and the effectiveness of operations is measured at least in part by environmental data, reliable, accurate, and defensible records are essential. Detailed records that must be kept include temporal, spatial, numerical, geotechnical, chemical, and radiological data as well as all sampling, analytical, and data review procedures used. Failure to maintain these records in a secure but accessible form may result in exposure to legal challenges and the inability to respond to demands or requests from regulators and other interested organizations.

An electronic data management system is a key tool used by many programs for achieving standardization and integrity in managing environmental data. The primary objective is to store and manage in an easily and efficiently retrievable form unclassified environmental data that are directly or indirectly tied to monitoring events. This may include information on monitoring system construction (groundwater wells, ambient air monitoring), and analytical, geotechnical, and field parameters at the Nevada National Security Site. Database integrity and security are enforced through the assignment of varying database access privileges commensurate with an employee's database responsibilities.

14.4.1 Data Verification

Data verification is defined as a subcontract compliance and completeness review to ensure that all laboratory data and sample documentation are present and complete. Additional critical sampling and analysis process information is also reviewed at this stage, which may include, but is not limited to, sample preservation and temperature, defensible chain-of-custody documentation and integrity, and analytical hold-time compliance. Data verification also ensures that electronic data products correctly represent the sampling and/or analyses performed, and includes evaluation of QC sample results.

14.4.2 Data Validation

Data validation supplements verification and is a more thorough process of analytical data review to better determine if the data meet the analytical and project requirements. Data validation ensures that the reported results correctly represent the sampling and analyses performed, determines the validity of the reported results, and assigns data qualifiers (or "flags"), if required.

14.4.3 Data Quality Assessment (DQA)

DQA is a scientific and statistical evaluation to determine if the data obtained from environmental operations are of the right type, quality, and quantity to support their intended use. The DQA includes reviewing data for accuracy, representativeness, and fit with historical measurements to ensure that the data will support their intended uses.

14.5 Assessments

The overall effectiveness of the environmental program is determined through routine surveillance and assessments of work execution as well as review of program requirements. Deficiencies are identified, causal factors are investigated, corrective actions are developed and implemented, and follow-on monitoring is performed to ensure effective resolution. The assessments discussed below are broken down into general programmatic and focused measurement data areas.

14.5.1 Programmatic

Assessments and audits under this category include evaluations of work planning, execution, and performance activities. Personnel independent of the work activity perform the assessments to evaluate compliance with established requirements and report on deficiencies identified. Organizations responsible for the activity are required to develop and implement corrective actions, with the concurrence of the deficiency originator or recognized subject matter expert. NNSA/NFO contractors maintain companywide issues tracking systems to manage assessments, findings, and corrective actions.

14.5.2 Measurement Data

This type of assessment includes routine evaluation of data generated from analyses of QC and other samples. QC sample data are used to monitor the analytical control on a given batch of samples and are indicators over time of potential biases in laboratory performance. Discussions of the 2016 results for field duplicates, laboratory control samples, blank analyses, matrix spikes, and proficiency testing programs are provided, and summary tables are included below.

14.5.2.1 Field Duplicates

Samples obtained at nearly the same locations and times as initial samples are termed field duplicates. These are used to evaluate the overall precision of the measurement process, including small-scale heterogeneity in the medium (air, water, or direct radiation) being sampled as well as analytical and sample preparation variation. The absolute relative percent difference (RPD) compares the absolute difference of initial and field duplicate measurements with the average of the two measurements (Table 14-1, footnote c); it is computed only from pairs for which both values are above their respective minimum detectable concentrations (MDCs). The relative error ratio (RER) compares the absolute difference of initial and field duplicate measurements to the laboratory's reported analytical uncertainty (Table 14-1, footnote d).

The average absolute RPD and average RER values for all 2016 radiological air and water duplicate pairs are shown in Table 14-1. They are similar to those seen in prior years. The higher average absolute RPDs (those greater than 25) are associated with two types of phenomena. RPDs for actinides in air, in particular, and consequently for gross alpha in air, can be elevated when one sampler of a pair intercepts a particle with high americium (Am) or plutonium (Pu), while the other sampler in the pair had a typical background value. For example, RPDs for ^{241}Am and $^{239+240}$Pu were 33.8 and 46.8 respectively. Also, higher average absolute RPDs are often associated with relatively few pairs having both values above their MDCs, as low level measurements are typically "noisier" than higher-level measurements ($^{235+236}$U in 2016, with only one pair above MDCs).

Table 14-1. Summary of field duplicate samples for 2016

Analyte	Medium	Number of Duplicate Pairs[(a)]	Number of Pairs > MDC[(b)]	Average Absolute RPD[(c)] of Pairs > MDC	Average Absolute RER[(d)] of All Pairs
Environmental Monitoring Samples					
Gross alpha	Air	52	28	18.9	0.81
Gross beta	Air	52	52	7.0	1.12
Tritium	Air	50	9	7.0	0.80
^{241}Am	Air	8	1	33.8	1.12
^{238}Pu	Air	8	0	----	1.10
$^{239+240}$Pu	Air	8	4	46.8	1.23
$^{233+234}$U	Air	5	5	6.1	0.47
$^{235+236}$U	Air	5	1	55.7	1.14
^{238}U	Air	5	5	6.4	0.48
^{7}Be[(e)]	Air	8	8	2.6	0.35
^{137}Cs	Air	8	0	----	1.39
^{40}K[(e)]	Air	8	6	18.1	0.46
Gross alpha	Water	4	2	27.4	0.70
Gross beta	Water	4	4	3.9	0.23
Tritium (standard)	Water	16	0	----	0.70
TLD	Ambient Radiation	432	NA	3.1	0.30
Underground Test Area (UGTA) Samples					
Gross alpha	Water	23	11	19.6	0.55
Gross beta	Water	23	14	23.9	0.75
Tritium (standard)	Water	33	17	9.1	0.37
Tritium (low-level)	Water	9	2	9.8	0.50

(a) Represents the number of field duplicates reported for evaluating precision.

(b) Represents the number of field duplicate–field sample pairs with both values above their MDCs. If either the field sample or duplicate was below the MDC, the RPD was not determined. This does not apply to thermoluminescent dosimeter (TLD) measurements; because TLDs virtually always detect ambient background radiation, MDCs are not computed.

(c) Represents the average absolute RPD calculated as follows:

$$Absolute\ RPD = \frac{|S - D|}{(D + S)/2} \ X \ 100$$

Where: S = Sample result
D = Duplicate result

(d) Represents the absolute RER, determined by the following equation, which is used to determine whether a sample result and the associated field duplicate result differ significantly when compared to their respective 1 sigma uncertainties (i.e., measurement standard deviation). The RER is calculated for all sample and field duplicate pairs reported without regard to the MDC.

$$Absolute\ RER = \frac{|S - D|}{\sqrt{(SD_S)^2 + (SD_D)^2}}$$

Where: S = Sample result
D = Duplicate result
SD_S Standard deviation of the sample result as reported
SD_D = Standard deviation of the duplicate result as reported

(e) ^{7}Be and ^{40}K are naturally occurring analytes included for quality assessment of the gamma spectroscopy analyses.

14.5.2.2 Laboratory Control Samples (LCSs)

An LCS is prepared from a sample matrix verified to be free from the analytes of interest, and then spiked with verified known amounts of analytes or a material containing known and verified amounts of analytes. The LCS is generally used to establish intra-laboratory or analyst-specific precision and bias or to assess the performance of all or a portion of the measurement system (DOE 2013).

The results are calculated as a percentage of the true value (i.e., percent recovery), and must fall within established control limits to be considered acceptable. If the LCS recovery falls outside control limits, evaluation for potential sample data bias is necessary. The numbers of the 2016 LCSs analyzed and within control limits are summarized in Table 14-2. There were no systemic issues identified in 2016 by LCS recovery data, and no failures that invalidated the associated sample data.

Table 14-2. Summary of LCSs for 2016

Analyte	Matrix	Number of LCS Results Reported	Number Within Control Limits	Control Limits (%)
Environmental Monitoring Samples				
Tritium	Air	71	69	75–125
^{60}Co	Air	6	6	75–125
^{137}Cs	Air	6	6	75–125
$^{239+240}$Pu	Air	22	22	75–125
^{241}Am	Air	24	24	75–125
Gross alpha	Water	15	15	75–125
Gross beta	Water	15	15	75–125
Tritium (standard)	Water	24	24	75–125
^{60}Co	Water	0	0	75–125
^{90}Sr	Water	0	0	75–125
^{137}Cs	Water	0	0	75–125
$^{239+240}$Pu	Water	0	0	75–125
^{241}Am	Water	0	0	75–125
Tritium	Soil	0	0	75–125
^{60}Co	Soil	1	1	75–125
^{90}Sr	Soil	0	0	75–125
^{137}Cs	Soil	1	1	75–125
$^{239+240}$Pu	Soil	1	1	75–125
^{241}Am	Soil	1	1	75–125
^{60}Co	Vegetation	10	10	75–125
^{90}Sr	Vegetation	11	11	75–125
^{137}Cs	Vegetation	10	10	75–125
$^{239+240}$Pu	Vegetation	14	14	75–125
^{241}Am	Vegetation	24	23	75–125
Metals	Water	179	179	80–120
Volatiles	Water	883	877	70–130
Semi volatiles	Water	1101	1101	Laboratory specific
Miscellaneous	Water	93	93	80–120
Metals	Soil	23	23	80–120
Volatiles	Soil	15	15	70–130
Semi volatiles	Soil	43	43	Laboratory specific
Miscellaneous	Soil	2	2	80–120
UGTA Samples				
Gross alpha	Water	27	24	80-120
Gross beta	Water	27	27	80-120
Tritium (standard)	Water	32	32	80-120
Tritium (low-level)	Water	5	4	80-120

14.5.2.3 Blank Analysis

In general, a blank is a sample that has not been exposed to the targeted environment and is analyzed in order to monitor "no exposure" analyte levels and contamination that might be introduced during sampling, transport, storage, or analysis. The blank is subjected to the usual analytical and measurement process to establish a baseline or background value, and is sometimes used to adjust or correct routine analytical results (DOE 2013). Blanks are processed simultaneously with and under the same conditions as samples through all steps of the analytical procedures. The following list identifies the blanks routinely used during environmental monitoring activities.

- A trip blank is a sample of analyte-free media taken from the laboratory to the sampling site and returned to the laboratory unopened. A trip blank is used to document contamination attributable to shipping and field handling procedures. This type of blank is useful in documenting contamination of volatile organics samples (DOE 2013).
- An equipment blank is a sample of analyte-free media that has been used to rinse common sampling equipment to check effectiveness of decontamination procedures (DOE 2013).
- A field blank is prepared in the field by filling a clean container with purified water (appropriate for the target analytes) and appropriate preservative, if any, for the specific sampling activity being undertaken. The field blank is used to indicate the presence of contamination due to sample collection and handling (DOE 2013).
- A method blank is a sample of a matrix similar to the associated sample batch in which no target analytes or interferences are present at concentrations that would impact the sample analyses results (DOE 2013). Method blank data are summarized in Table 14-3.

There were no systemic issues and no failures that required invalidating the associated sample data identified in 2016 by the blank data.

Table 14-3. Summary of laboratory method blank samples for 2016

Analyte	Matrix	Number of Blank Results Reported	Number of Results < MDC
Environmental Monitoring Samples			
Tritium	Air	71	71
^{7}Be	Air	6	6
^{60}Co	Air	2	2
^{137}Cs	Air	6	6
^{238}Pu	Air	12	10
$^{239+240}$Pu	Air	12	12
^{241}Am	Air	11	10
Gross alpha	Water	15	14
Gross beta	Water	15	15
Tritium (standard)	Water	23	23
^{60}Co	Water	0	0
^{90}Sr	Water	0	0
^{137}Cs	Water	0	0
^{238}Pu	Water	0	0
$^{239+240}$Pu	Water	0	0
^{241}Am	Water	0	0
Tritium	Soil	0	0
^{60}Co	Soil	1	1
^{90}Sr	Soil	0	0
^{137}Cs	Soil	1	1
^{238}Pu	Soil	1	1
$^{239+240}$Pu	Soil	1	1
^{241}Am	Soil	1	1
^{60}Co	Vegetation	6	6
^{90}Sr	Vegetation	9	8
^{137}Cs	Vegetation	10	10
^{238}Pu	Vegetation	9	7
$^{239+240}$Pu	Vegetation	9	9
^{241}Am	Vegetation	15	14
Metals	Water	183	165
Volatiles	Water	621	611
Semi volatiles	Water	541	541
Miscellaneous	Water	145	134
Metals	Soil	16	16
Volatiles	Soil	11	10
Semi volatiles	Soil	41	40
Miscellaneous	Soil	0	0

Table 14-4. Summary of laboratory method blank samples for 2016 (continued)

Analyte	Matrix	Number of Blank Results Reported	Number of Results < MDC
UGTA Samples			
Gross alpha	Water	21	20
Gross beta	Water	21	21
Tritium (standard)	Water	19	18
Tritium (low-level)	Water	5	5

14.5.2.4 Matrix Spike Analysis

A matrix spike is a sample spiked with a known concentration of analyte. This spiked sample is subjected to the same sample preparation and analysis as the original environmental sample. The matrix spike is used to indicate if the matrix (e.g., soil, water with sediment) interferes with the analytical results. Matrix spike analyses were conducted for samples in 2016, and there were no issues identified by the analysis data (Table 14-4).

Table 14-4. Summary of matrix spike samples for 2016

Analyte	Matrix	Number of Matrix Spikes Reported	Number Within Control Limits	Control Limits (%)
Environmental Monitoring Samples				
Tritium	Air	13	13	60–140
Gross alpha	Water	13	12	60–140
Gross beta	Water	13	13	60–140
Tritium	Water	19	19	60–140
UGTA Samples				
Gross alpha	Water	13	12	60-140
Gross beta	Water	13	13	60-140
Tritium (standard)	Water	11	11	60-140
Tritium (low-level)	Water	4	4	60-140

14.5.2.5 Proficiency Testing Program Participation

All contracted laboratories are required to participate in proficiency testing programs. Laboratory performance supports decisions on work distribution and may also be a basis for state certifications. Table 14-5 presents the 2016 results for the laboratory performance in the March and August studies of the Mixed Analyte Performance Evaluation Program (MAPEP) (http://www.id.energy.gov/resl/mapep/mapepreports.html) administered by the Radiological and Environmental Sciences Laboratory of the Idaho National Laboratory. Proficiency testing programs are not available for the low-level tritium analytical method. Low-level tritium proficiency was assessed by comparing commercial laboratory results to LLNL data for the same wells. The relative percent difference (RPD) was within established acceptance criteria.

Table 14-5. Summary of 2016 MAPEP reports

Analyte	Matrix	Number of Results Reported	Number within Control Limits[(a)]
Environmental Monitoring Samples			
Gross alpha	Filter	3	3
Gross beta	Filter	3	3
^{60}Co	Filter	6	6
^{137}Cs	Filter	6	6
^{238}Pu	Filter	6	6
$^{239+240}Pu$	Filter	6	6
^{241}Am	Filter	6	6
Gross alpha	Water	3	3
Gross beta	Water	3	3

Table 14-5. Summary of 2016 MAPEP reports (continued)

Analyte	Matrix	Number of Results Reported	Number within Control Limits[(a)]
Environmental Monitoring Samples (continued)			
Tritium (standard)	Water	6	6
^{60}Co	Water	6	6
^{90}Sr	Water	6	6
^{137}Cs	Water	6	6
^{238}Pu	Water	6	6
$^{239+240}Pu$	Water	6	6
^{241}Am	Water	6	5
^{60}Co	Vegetation	6	6
^{90}Sr	Vegetation	5	4
^{137}Cs	Vegetation	6	5
^{238}Pu	Vegetation	6	6
$^{239+240}Pu$	Vegetation	6	6
^{60}Co	Soil	6	6
^{90}Sr	Soil	6	6
^{137}Cs	Soil	6	6
^{238}Pu	Soil	6	6
$^{239+240}Pu$	Soil	6	6
^{241}Am	Soil	6	6
Metals	Water	110	108
Organics	Water	277	277
Metals	Soil	115	112
Organics	Soil	219	216

(a) Based upon MAPEP criteria

Table 14-6 shows the summary of inter-laboratory comparison sample results for the NSTec Radiological Health Dosimetry Group. The DOE Standard DOE-STD-1095-2011, “Department of Energy Laboratory Accreditation for External Dosimetry,” establishes the methodology for determining acceptable performance testing of dosimeter systems. It also establishes the technical basis for performance testing and the testing categories and performance criteria, which are outlined in the American National Standards Institute/Health Physics Society (ANSI/HPS) N13.11-2009, “American National Standard for Dosimetry–Personnel Dosimetry Performance–Criteria for Testing,” and in ANSI/HPS N13.32-2008, “An American National Standard, Performance Testing of Extremity Dosimeters.” The Dosimetry Group participated in the Battelle Pacific Northwest National Laboratory proficiency testing program during the course of the year.

Table 14-6. Summary of inter-laboratory comparison TLD samples (UD-802 dosimeters) for 2016

Analysis	Matrix	Number of Results Reported	Number within Control Limits[(a)]
TLD	Gamma Radiation	75	75

(a) Based upon ANSI/HPS N13.11-2009 criteria

American National Standard ANSI/HSP N13.37-2014, “Environmental Dosimetry – Criteria for System Design and Implementation,” contains guidance on conducting “blind spike” quality assurance testing. This process was followed in 2016 by having 39 Panasonic UD-814AS environmental TLDs exposed to a known radiation level (200 milliroentgens) and placing them with routine monitoring TLDs for analysis. A performance quotient for each dosimeter was calculated as follows: P = (reported exposure – true value) / true value. According to the standard, the absolute value of the mean performance quotient should not exceed 0.15. The value for 2016-tested environmental TLDs was 0.02, demonstrating good agreement between the results and the controlled exposure using the blind spike.

14.6 References

DOE, see U.S. Department of Energy.

Stanley, T. W., and S. S. Verner, 1985. The U.S. Environmental Protection Agency's Quality Assurance Program. In: Taylor, J. K., and T. W. Stanley (eds.), *Quality Assurance for Environmental Measurements,* ASTM STP-867, Philadelphia, PA.

U.S. Department of Energy, 2013. *DOE Quality Systems for Analytical Services Version 3.0*, July 2013.

Chapter 15: Quality Assurance Program for the Community Environmental Monitoring Program

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Desert Research Institute

The Community Environmental Monitoring Program (CEMP) Quality Assurance Management and Assessment Plan (QAMAP) (Desert Research Institute 2009) was followed for the collection and analysis of radiological air and water data presented in Chapter 7 of this report. The CEMP QAMAP ensures compliance with U.S. Department of Energy (DOE) Order DOE O 414.1D, "Quality Assurance," which implements a quality management system, ensuring the generation and use of quality data. This QAMAP addresses the following items previously defined in Chapter 14:

- Data Quality Objectives (DQOs)
- Sampling plan development appropriate to satisfy the DQOs
- Environmental health and safety
- Sampling plan execution
- Sample analyses
- Data review
- Continuous improvement

15.1 Data Quality Objectives (DQOs)

The DQO process is a strategic planning approach that is used to plan data collection activities. It provides a systematic process for defining the criteria that a data collection design should satisfy. These criteria include when and where samples should be collected, how many samples to collect, and the tolerable level of decision errors for the study. DQOs are unique to the specific data collection or monitoring activity, and follow similar guidelines for onsite activities where applicable as discussed in Chapter 14.

15.2 Measurement Quality Objectives (MQOs)

The MQOs are basically equivalent to DQOs for analytical processes. The MQOs provide direction to the laboratory concerning performance objectives or requirements for specific method performance characteristics. Default MQOs are established in the subcontract with the laboratory, but may be altered in order to satisfy changes in the DQOs. The MQOs for the CEMP project are described in terms of precision, accuracy, representativeness, completeness, and comparability requirements. These terms are defined and discussed in Section 14.1 for onsite activities.

15.3 Sampling Quality Assurance Program

Quality Assurance (QA) in field operations for the CEMP includes sampling assessments, surveillances, and oversight of the following supporting elements:

- The sampling plan, DQOs, and field data sheets accompanying the sample package
- Database support for field and laboratory results, including systems for long-term storage and retrieval
- A training program to ensure that qualified personnel are available to perform required tasks

Sample packages include the following items:

- Station manager checklist confirming all observable information pertinent to sample collection
- An Air Surveillance Network Sample Data Form documenting air sampler parameters, collection dates and times, and total sample volumes collected
- Chain-of-custody forms

This managed approach to sampling ensures that the sampling is traceable and enhances the value of the final data available to the project manager. The sample package also ensures that the Community Environmental Monitor (CEM) station manager (see Chapter 7 for a description of CEMs) has followed proper procedures for sample collection. The CEMP Project Manager or QA Officer routinely performs assessments of the station managers and field monitors to ensure that standard operating procedures and sampling protocols are being followed properly.

Data obtained in the course of executing field operations are entered in the documentation accompanying the sample package during sample collection and in the CEMP database along with analytical results upon their receipt and evaluation.

Completed sample packages are kept as hard copy in file archives. Analytical reports are kept as hard copy in file archives as well as on read-only compact discs by calendar year. Analytical reports and databases are protected and maintained in accordance with the Desert Research Institute's Computer Protection Program.

15.4 Laboratory QA Oversight

The CEMP QA Officer ensures that DOE O 414.1D requirements are met with respect to laboratory services through review of the vendor laboratory policies formalized in a Laboratory Quality Assurance Plan (LQAP) (Testamerica, Inc., 2012). The CEMP is assured of obtaining quality data from laboratory services through a multifaceted approach, involving specific procurement protocols, the conduct of quality assessments, and requirements for selected laboratories to have an acceptable QA program. These elements are discussed below.

15.4.1 Procurement

Laboratory services are procured through subcontracts. The subcontract establishes the technical specifications required of the laboratory and provides the basis for determining compliance with those requirements and evaluating overall performance. The subcontract is awarded on a "best value" basis as determined by pre-award audits. The prospective vendor is required to provide a review package to the CEMP QA Officer that includes the following items:

- All procedures pertinent to subcontract scope
- Environment, Safety, and Health Plan
- LQAP
- Example deliverables (hard copy and/or electronic)
- Proficiency testing (PT) results from the previous year from recognized PT programs
- Résumés
- Facility design/description
- Accreditations and certifications
- Licenses
- Audits performed by an acceptable DOE program covering comparable scope
- Past performance surveys
- Pricing

The CEMP QA Officer evaluates the review package in terms of technical capability. Vendor selection is based solely on these capabilities and not biased by pricing.

15.4.2 Initial and Continuing Assessment

An initial assessment of a laboratory is managed through the procurement process above, including a pre-award audit. Pre-award audits are conducted by the CEMP (usually by the CEMP QA Officer). The CEMP does not initiate work with a laboratory without approval of the CEMP Program Manager.

A continuing assessment of a selected laboratory involves ongoing monitoring of a laboratory's performance against the contract terms and conditions, of which technical specifications are a part. The following tasks support continuing assessment:

- Tracking schedule compliance
- Reviewing analytical data deliverables
- Monitoring the laboratory's adherence to the LQAP
- Conducting regular audits
- Monitoring for continued successful participation in approved PT programs

15.4.3 Laboratory QA Program

The laboratory policies and approach to the implementation of DOE O 414.1D must be verified in an LQAP prepared by the laboratory. The elements of an LQAP required for the CEMP are similar to those required by National Security Technologies, LLC, for onsite monitoring, and are described in Section 14.3.

15.5 Data Review

Essential components of process-based QA are data checks, verification, validation, and data quality assessment to evaluate data quality and usability.

Data Checks – Data checks are conducted to ensure accuracy and consistency of field data collection operations prior to and upon data entry into CEMP databases and data management systems.

Data Verification – Data verification is defined as a subcontract compliance and completeness review to ensure that all laboratory data and sample documentation are present and complete. Sample preservation, chain-of-custody, and other field sampling documentation shall be reviewed during the verification process. Data verification ensures that the reported results entered in CEMP databases correctly represent the sampling and/or analyses performed and includes evaluation of quality control (QC) sample results.

Data Validation – Data validation is the process of reviewing a body of analytical data to determine if it meets the data quality criteria defined in operating instructions. Data validation ensures that the reported results correctly represent the sampling and/or analyses performed, determines the validity of the reported results, and assigns data qualifiers (or "flags"), if required. The process of data validation consists of the following:

- Evaluating the quality of the data to ensure that all project requirements are met
- Determining the impact on data quality of those requirements if they are not met
- Verifying compliance with QA requirements
- Checking QC values against defined limits
- Applying qualifiers to analytical results in the CEMP databases for the purposes of defining the limitations in the use of the reviewed data

Operating instructions, procedures, applicable project-specific work plans, field sampling plans, QA plans, analytical method references, and laboratory statements of work may all be used in the process of data validation. Documentation of data validation includes checklists, qualifier assignments, and summary forms.

Data Quality Assessment (DQA) – DQA is the scientific evaluation of data to determine if the data obtained from environmental data operations are of the right type, quality, and quantity to support their intended use. DQA review is a systematic review against pre-established criteria to verify that the data are valid for their intended use.

15.6 QA Program Assessments

The overall effectiveness of the QA Program is determined through management and independent assessments as defined in the CEMP QAMAP. These assessments evaluate the plan execution workflow (sampling plan development and execution, chain-of-custody, sample receiving, shipping, subcontract laboratory analytical activities, and data review) as well as program requirements as it pertains to the organization.

15.7 2016 Sample QA Results

QA assessments were performed by the CEMP, including the laboratories responsible for sample analyses. These assessments ensure that sample collection procedures, analytical techniques, and data provided by the subcontracted laboratories comply with CEMP requirements. Data were provided by Testamerica Laboratories and the University of Nevada, Las Vegas, Radiation Services Laboratory (gross alpha/beta and gamma spectroscopy data); Mirion Technologies (thermoluminescent dosimeter [TLD] data); and the University of Miami Tritium Laboratory (tritium data). A brief discussion of the 2016 results for field duplicates, laboratory control samples, blank analyses, and inter-laboratory comparison studies is provided along with summary tables within this section. The 2016 CEMP radiological air and water monitoring data are presented in Chapter 7.

15.7.1 Field Duplicates (Precision)

A field duplicate is a sample collected, handled, and analyzed following the same procedures as the primary sample. The relative percent difference (RPD) between the field duplicate result and the corresponding field sample result is a measure of the variability in the process caused by the sampling uncertainty (matrix heterogeneity, collection variables, etc.) and measurement uncertainty (field and laboratory) used to arrive at a final result. The average absolute RPD, expressed as a percentage, was determined for the calendar year 2016 samples and is listed in Table 15-1. An RPD of zero indicates a perfect duplication of results of the duplicate pair, whereas an RPD greater than 100% generally indicates that a duplicate pair falls beyond QA requirements and is not considered valid for use in data interpretation. These samples are further evaluated to determine the reason for QA failure and if any corrective actions are required. Overall, the RPD values for all analyses indicate very good results, with only one gross beta duplicate exceeding an RPD of 100%.

Table 15-1. Summary of field duplicate samples for CEMP monitoring in 2016

Analysis	Matrix	Number of Samples Reported[(a)]	Number of Samples Reported above MDC[(b)]	Average Absolute RPD of those above MDC (%)[(c)]
Gross Alpha	Air	48	48	55.5
Gross Beta	Air	50	49	34.5
Gamma – Beryllium-7	Air	8	7	90.1
Tritium	Water	1	0	NA[(d)]
TLDs	Ambient Radiation	12	NA	3.6

(a) Represents the number of field duplicates reported for the purpose of monitoring precision. If an associated field sample was not processed, the field duplicate was not included in this table.

(b) Represents the number of field duplicate–field sample result sets reported above the minimum detectable concentration (MDC) (MDC is not applicable for TLDs). If either the field sample or its duplicate was reported below the detection limit, the precision was not determined.

(c) Reflects the average absolute RPD calculated for those field duplicates reported above the MDC.

(d) Not applicable.

The absolute RPD calculation is as follows:

$$Absolute\ RPD = \frac{|FD - FS|}{(FD + FS)/2} \ X \ 100\%$$

Where: FD = Field duplicate result
FS = Field sample result

15.7.2 Laboratory Control Samples (Accuracy)

Laboratory control samples (LCSs) (also known as matrix spikes) are performed by the subcontract laboratory to evaluate analytical accuracy, which is the degree of agreement of a measured value with the true or expected value. Samples of known concentration are analyzed using the same methods as employed for the project samples. The results are determined as the measured value divided by the true value, expressed as a percentage. To be considered valid, the results must fall within established control limits (or percentage ranges) for further analyses to be performed. The LCS results obtained for 2016 are summarized in Table 15-2. The LCS results were satisfactory, with all samples falling within control parameters for the air sample matrix.

Table 15-2. Summary of laboratory control samples (LCSs) for CEMP monitoring in 2016

Analysis	Matrix	Number of LCS Results Reported	Number Within Control Limits[(a)]
Gross Alpha	Air	29	29
Gross Beta	Air	29	29
Gamma	Air	12	12
Tritium	Water	3	3

(a) Control limits are as follows: 75% to 125% for gross alpha, 75% to 125% for gross beta, 87% to 120% for gamma (^{137}Cs, ^{60}Co, ^{241}Am), and 80% to 120% for tritium.

15.7.3 Blank Analysis

Laboratory blank sample analyses are essentially the opposite of LCSs discussed in Section 15.7.2. These samples do not contain any of the analyte of interest. Results of these analyses are expected to be "zero," or, more accurately, below the MDC of a specific procedure. Blank analysis and control samples are used to evaluate overall laboratory procedures, including sample preparation and instrument performance. The laboratory blank sample results obtained for 2016 are summarized in Table 15-3. The laboratory blank results were satisfactory with only one of the beta blank samples outside of control parameters for the air sample matrix.

Table 15-3. Summary of laboratory blank samples for CEMP monitoring in 2016

Analysis	Matrix	Number of Blank Results Reported	Number within Control Limits[(a)]
Gross Alpha	Air	37	37
Gross Beta	Air	37	36
Gamma	Air	12	12
Tritium	Water	1	1

(a) Control limit is less than the MDC.

15.7.4 Inter-laboratory Comparison Studies

Inter-laboratory comparison studies are conducted by the subcontracted laboratories to evaluate their performance relative to other laboratories providing the same service. These types of samples are commonly known as "blind" samples, in which the expected values are known only to the program conducting the study. The analyses are evaluated and, if found satisfactory, the laboratory is certified that its procedures produce reliable results. The inter-laboratory comparison sample results obtained for 2016 are summarized in Tables 15-4 and 15-5.

Table 15-4 shows the summary of inter-laboratory comparison sample results for the subcontract radiochemistry laboratories. The laboratories participated in either the QA Program administered by Environmental Research Associates (ERA) and/or the Mixed Analyte Performance Evaluation Program (MAPEP) for gross alpha, gross beta, and gamma analyses. The subcontract tritium laboratory also participated in the MAPEP program. Overall, all of the subcontractors performed very well during the year by passing all of the parameters analyzed.

Table 15-4. Summary of inter-laboratory comparison samples of the subcontract radiochemistry and tritium laboratories for CEMP monitoring in 2016

		MAPEP and ERA Results	
Analysis	**Matrix**	**Number of Results Reported**	**Number Within Control Limits[(a)]**
Gross Alpha	Air	2	2
Gross Beta	Air	2	2
Gamma	Air	4	4
Tritium	Water	2	2

(a) Control limits are determined by the individual inter-laboratory comparison study.

Table 15-5 shows the summary of the in-house performance evaluation results conducted by the subcontract dosimetry group. This internal evaluation was based on National Voluntary Laboratory Accreditation Program (NVLAP) criteria and was performed biannually. The dosimetry group performed very well during the year, passing 12 out of 12 TLDs analyzed.

Table 15-5. Summary of inter-laboratory comparison TLD samples of the subcontract dosimetry group for CEMP monitoring in 2016

Analysis	**Matrix**	**Number of Results Reported**	**Number Within Control Limits[(a)]**
TLDs	Ambient Radiation	12	12

(a) Based upon NVLAP criteria; absolute value of the bias plus one standard deviation < 0.3.

15.8 References

Desert Research Institute, 2009. *DOE NNSA/NSO Community Environmental Monitoring Program Quality Assurance Management and Assessment Plan*, July 2009.

Testamerica, Inc., 2012. *Quality Assurance Manual*. Version 8.0, February 2016.

Appendix A

Las Vegas Area Support Facilities

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Appendix A: Las Vegas Area Support Facilities

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National Security Technologies, LLC

The U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO) manages two facilities in Clark County, Nevada, that support NNSA/NFO missions on and off the Nevada National Security Site (NNSS). These are the North Las Vegas Facility (NLVF) and the Remote Sensing Laboratory–Nellis (RSL-Nellis) (Figure A-1). This appendix describes all environmental monitoring and compliance activities conducted in 2016 at these support facilities.

A.1 North Las Vegas Facility

The NLVF is a fenced complex composed of 31 buildings that house much of the NNSS project management, diagnostic development and testing, design, engineering, and procurement personnel. The 32-hectare (80-acre) facility is located along Losee Road, a short distance west of Interstate 15 (Figure A-1). The facility is buffered on the north, south, and east by general industrial zoning. The western border separates the property from fully developed, single-family residential-zoned property. The NLVF is a controlled-access facility. Environmental compliance and monitoring activities associated with this facility in 2016 included the maintenance of one air quality operating permit; one wastewater permit; one National Pollutant Discharge Elimination System (NPDES) permit; one Spill Prevention, Control, and Countermeasure (SPCC) Plan; and one hazardous materials permit (see Chapter 2, Table 2-3 for a list of all NNSA/NFO permits). NNSA/NFO also monitors tritium in air and ambient gamma-emissions to comply with federal radiation protection regulations, although this monitoring is not required by any city or state permits.

A.1.1 Air Quality and Protection

Sources of air pollutants at the NLVF are regulated by the Source 657 Minor Source Permit issued by the Clark County Department of Air Quality (DAQ) for the emission of ***criteria pollutants*** (see Glossary, Appendix B). These pollutants include particulate matter (PM), nitrogen oxide (NO_X), carbon monoxide (CO), sulfur oxides (SO_x), and volatile organic compounds (VOCs). Because the NLVF is considered a true minor source, there is no requirement to report ***hazardous air pollutants (HAPs)*** (see Glossary, Appendix B). The regulated sources of emissions at the NLVF include diesel generators, a fire pump, cooling towers, and boilers. The DAQ requires an annual emissions inventory of criteria air pollutants. The 2016 emissions inventory, which reported the estimated quantities shown in Table A-1, was submitted to the DAQ on March 13, 2017.

Table A-1. Summary of air emissions for the NLVF in 2016

	Criteria Pollutant (Tons/yr)[(a)]					
Parameter	**PM10[(b)]**	**PM2.5[(c)]**	**NO_x**	**CO**	**SO_x**	**VOC**
PTE[(d)]	1.49	0.87	20.40	4.54	0.09	0.93
Actual[(e)]	0.21	0.08	1.87	0.44	0.01	0.07
Total Emissions = 2.68 Actual, 28.32 PTE						

(a) 1 ton equals 0.91 metric tons
(b) Particulate matter equal to or less than 10 microns in diameter
(c) Particulate matter equal to or less than 2.5 microns in diameter
(d) Potential to emit (PTE) is the quantity of criteria air pollutant that facilities/pieces of equipment would emit annually if they were operated for the maximum number of hours at the maximum production rate specified in the air permit
(e) Emissions based on calculations using actual hours of operation for each piece of equipment

Clark County air regulations specify that the opacity from any emission unit may not exceed the Clean Air Act National Ambient Air Quality Standards (NAAQS) opacity limit of 20% for more than 6 consecutive minutes. The NLVF air permit requires that at least one visual emissions observation be performed each month of operating

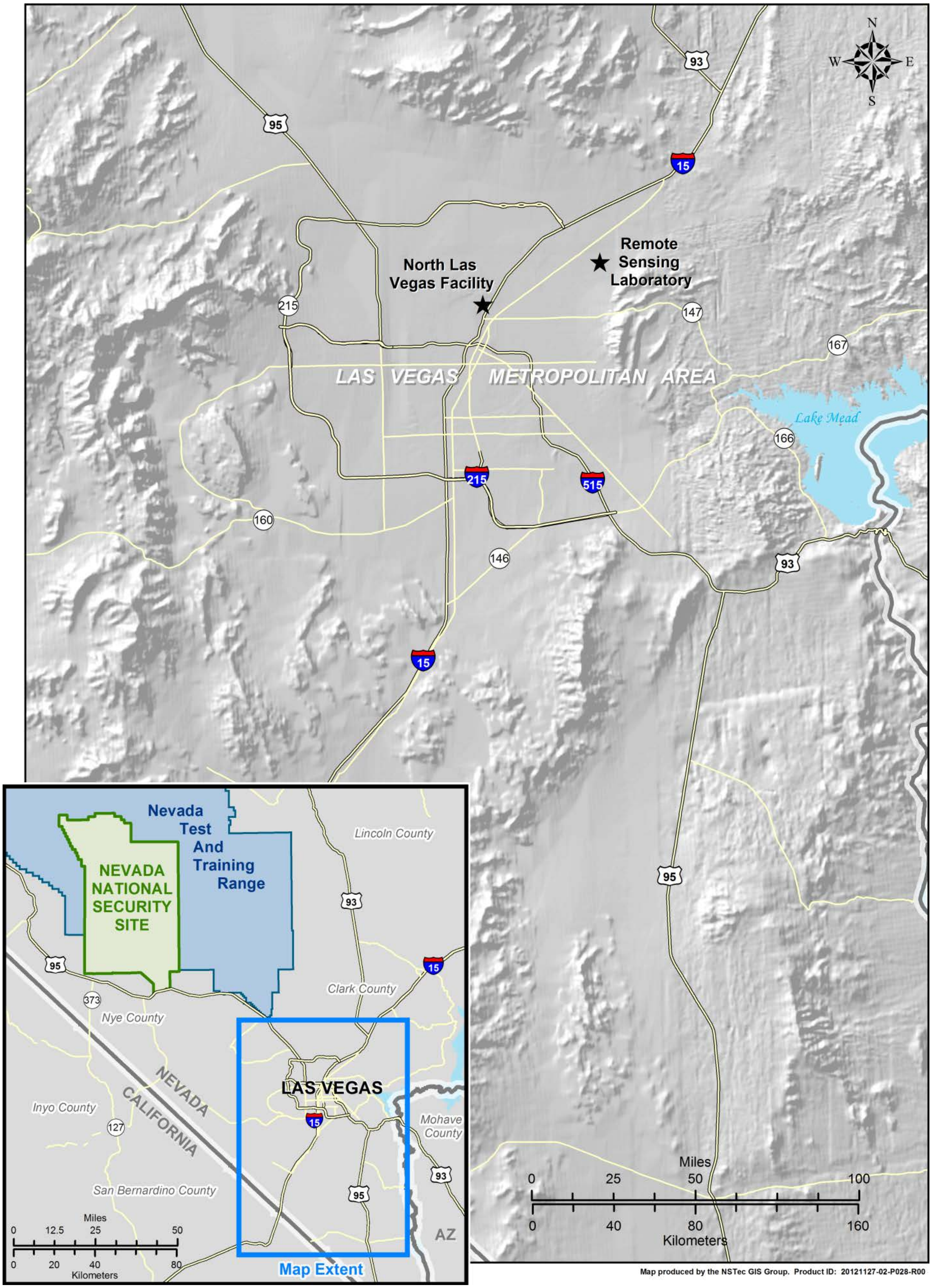

Figure A-1. Location of NNSS offsite facilities in Las Vegas and North Las Vegas

equipment, i.e., boilers, generators, emergency fire pump, emergency generator, and the cooling towers. If emissions are observed, then U.S. Environmental Protection Agency (EPA) Method 9 opacity readings are recorded by a certified visible emissions evaluator. If visible emissions appear to exceed the limit, corrective actions must be taken to minimize emissions. In 2016, two NLVF Maintenance Engineers were recertified and two new employees were certified to conduct opacity readings. In 2016, observations were taken for the boilers, generators, the fire pump, and cooling towers; emissions were below the NAAQS opacity limit of 20%.

At NLVF, a verbal notification to the City of North Las Vegas (CNLV) Fire Department is required before each fire extinguisher training session. In 2016, one hot work live fire extinguisher training session was conducted at the NLVF. Quantities of criteria air pollutants produced by the open burns during training are not required to be calculated or reported.

A.1.2 Water Quality and Protection

Water used at the NLVF is supplied by the CNLV and meets or exceeds federal drinking water standards. Water quality permits issued to NNSA/NFO include a Class II Wastewater Control Permit from the CNLV for NLVF sewer discharges and an NPDES permit from the Nevada Division of Environmental Protection (NDEP) for dewatering operations to control rising groundwater levels at the facility. Discharges of sewage and industrial wastewater from the NLVF must meet permit limits set by the CNLV. These limits support the permit limits for the Publicly Owned Treatment Works operated by the City of North Las Vegas.

A.1.2.1 Wastewater Contribution Permit MSC-833

This permit, issued in December 2013, specifies operations and maintenance practices and identifies substances which are prohibited from being discharged in NLVF wastewater. The permit requires that CNLV be notified when there are changes in discharge flow rates, deviations in operations or maintenance, spills, or other off-normal events. The permit does not require wastewater to be sampled and analyzed. In 2016, no changes, deviations, spills, or other off-normal events requiring notification occurred at the NLVF.

A.1.2.2 Storm Water No Exposure Waiver ISW-40565

This waiver was approved on July 16, 2015 and it provides a conditional exemption from the NPDES Storm Water Program and the State of Nevada Stormwater General Permit. The conditions specify that storm water discharges from the NLVF will not be exposed to industrial activities or materials. In 2016, no storm water exposures to such activities or materials occurred.

A.1.2.3 National Pollution Discharge Elimination System Permit NV0023507

An NPDES permit (NV0023507) covers the dewatering operation conducted at the NLVF (see Section A.1.2.3). Dewatering wells (NLVF-13s, -15, -16, -17) pump groundwater into a 37,854-liter (L) (10,000-gallon [gal]) storage tank (Figure A-2). The permit allows for the discharge of water from the storage tank to groundwater via percolation, when used for landscape irrigation and dust suppression, and into the Las Vegas Wash via direct discharge into the CNLV storm water drainage system. The permit defines the discharge source via percolation as "Outfall 001" and via the storm water drainage system as "Outfall 002." Water produced from the dewatering wells may also be used for purposes that do not require a groundwater discharge permit or an NPDES permit (e.g., evaporative cooling). Chemistry analyses are performed quarterly, annually, and biennially for water samples collected from the storage tank. Results of the chemistry analyses required in 2016 are presented in Table A-2. The total quantities of groundwater produced and discharged and the results of groundwater chemistry analyses are reported quarterly to NDEP's Bureau of Water Pollution Control.

In 2016, the four dewatering wells produced a total of about 9,464 L (2,500 gal) per day that were directed into the storage tank (Figure A-2). The average pumping rates varied from 2.7 liters per minute (Lpm) (0.71 gallons per minute [gpm]) at Well NLVF-17 to 0.68 Lpm (0.18 gpm) at Well NLVF-16. The average combined discharge from all four wells was about 283,906 L (75,000 gal) per month.

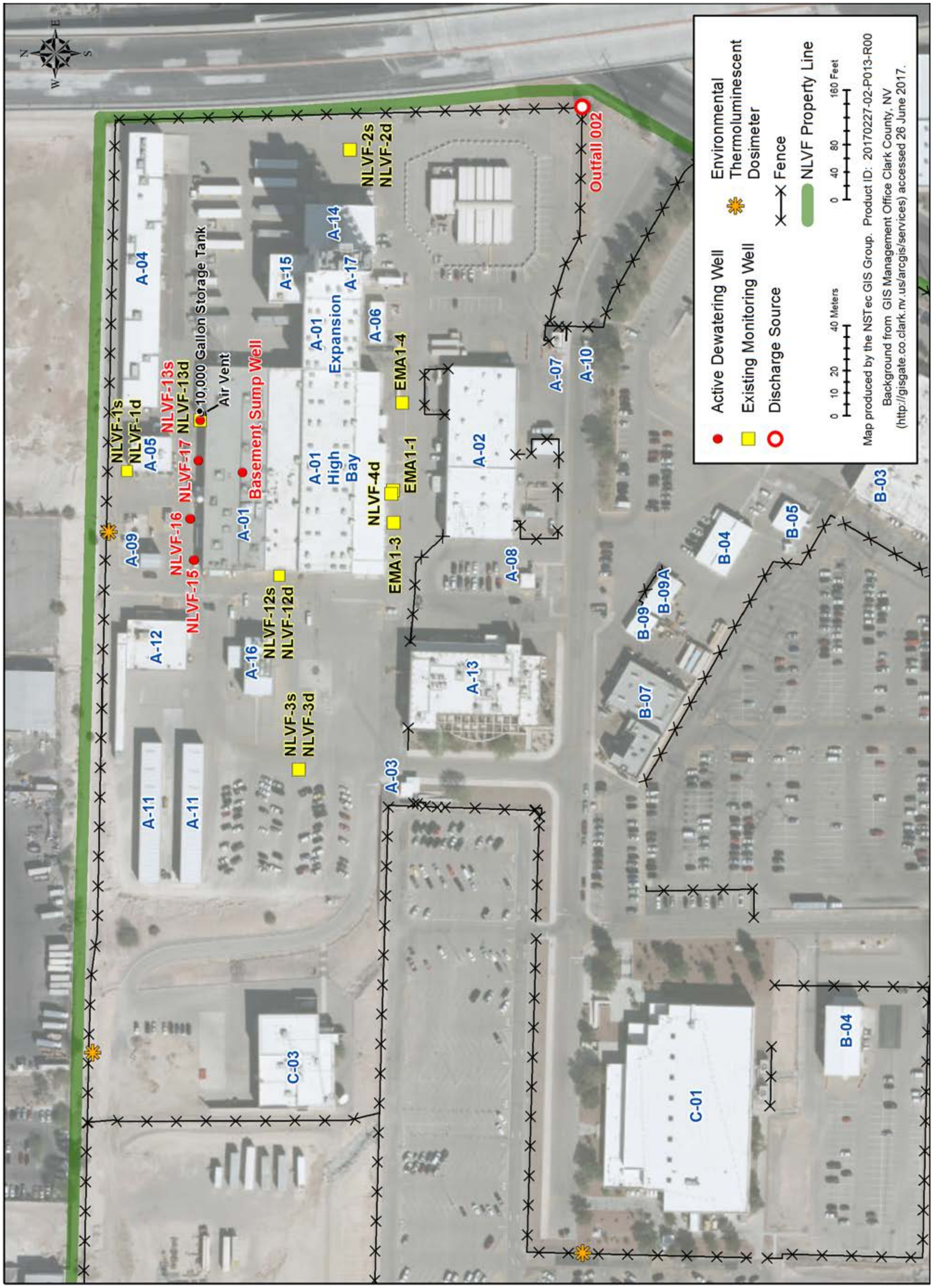

Figure A-2. Location of dewatering and monitoring wells around Building A-1

Table A-2. NLVF NPDES permit 2016 monitoring requirements and analysis results of storage tank water samples

Parameter	Monitoring Requirements Sample Frequency	Monitoring Requirements Sample Type	Permit Discharge Limits Daily Maximum	Sample Results 1st Quarter	Sample Results 2nd Quarter	Sample Results 3rd Quarter	Sample Results 4th Quarter
Daily Maximum Flow (MGD)[(a)]	Continuous	Flow Meter	0.0052	0.0024	0.0023	0.0025	0.0026
Total Petroleum Hydrocarbons[(b)] (mg/L)	Annually (4th Qtr)	Discrete	1.0	NS[(c)]	NS	NS	ND[(d)]
Total Suspended Solids (mg/L)	Quarterly	Discrete	135	4.20	0.63	0.57	0.76
Total Dissolved Solids (mg/L)	Quarterly	Discrete	1900	2040	3780	1460	360
Total Inorganic Nitrogen as N (mg/L)	Quarterly	Discrete	20	1.08	1.31	1.30	0.71
pH (Standard Units)	Quarterly	Discrete	6.5–9.0	7.92[(e)]	8.02	8.11	8.16
Tritium (picocuries per liter [pCi/L])	Annually (4th Qtr)	Discrete	MR[(f)]	NS	NS	NS	ND

(a) MGD = million gallons per day
(b) This parameter includes three analytes: diesel range organics, gasoline range organics, and oil range organics
(c) NS = not required to be sampled that quarter
(d) ND = not detected; values were less than the laboratory detection limits
(e) Sample was analyzed outside of the laboratory-specific holding time
(f) MR = monitor and report; no specified daily maximum or 30-day average limit, just the requirement that there shall be no discharge of substances that would cause a violation of state water quality standards

Discharge rates (i.e., daily maximum flows) did not exceed the NPDES permit limits (Table A-2). Quarterly and annual water samples from the holding tank had total petroleum hydrocarbons, total suspended solids, total inorganic nitrogen (as nitrogen [N]), pH, and tritium levels that were all below permit limits (Table A-2). The total dissolved solids were above the permit limit for the first and second quarters of 2016, and the exceedances were reported to NDEP. It was advised by NDEP to continue monitoring and reporting. In September 2016, NLVF-15, NLVF-16, NLVF-17, and the A-01 Basement Sump Well were redeveloped by removing silt that had built up over the years. This caused the total dissolved solids results to decrease and fall below the permit limit for the third and fourth quarters of 2016 (Table A-2). Biennial water sampling for the presence of over 100 analytes (listed in Attachment A of the permit) was last performed in 2015 (see NSTec, 2016) and is next scheduled to occur in the fourth quarter of 2017.

A.1.2.4 Groundwater Control and Dewatering Operation

During 2016, the groundwater control and dewatering project at the NLVF continued efforts to reduce the intrusion of groundwater below Building A-01. The project has transitioned from initial groundwater investigations and characterization phases in 2002 to a long-term/permanent dewatering operation project. A review of the rising groundwater situation and past efforts to understand and remediate the problem is presented in previous reports (Bechtel Nevada [BN] 2003, 2004; NSTec 2006). Groundwater monitoring for this operation includes taking periodic water-level measurements at 24 accessible wells out of the 27 NLVF monitoring wells, taking continuous water-level measurements at the A-01 Basement Sump Well, measuring the total volume of discharged groundwater, and conducting groundwater chemistry analyses in accordance with the NPDES permit. Groundwater data are assessed quarterly or as new data become available. This information is used to help characterize groundwater conditions, validate the conceptual hydrologic model, and evaluate the dewatering operation.

In 2016, about 283,906 L (75,000 gal) per month were pumped from the dewatering wells. Groundwater also continued to be pumped from the A-01 Basement Sump Well (Figure A-2), totaling about 104,099 L (27,500 gal) per month in 2016. When the A-01 Basement Sump Well pump is active, the water level directly beneath Building A-01 averages 45.2 centimeters (cm) (17.8 inches [in.]) below the basement floor, as measured in a monitoring tube installed in a nearby elevator shaft. This average water level is based on the daily measurements taken in 2016 and reflects a drop of about 66.8 cm (26.3 in.) in the local water table beneath Building A-01 since full-scale dewatering operations began in 2006. The general trend for the NLVF site-wide monitoring network shows an average rise in the water level of 1.2 meters (3.8 feet) since 2003. Although recently the water levels in many of the wells appear to be stabilizing or decreasing, the dewatering efforts must continue to counter this rising groundwater trend.

A.1.2.5 Discharge of Groundwater from Building A-01 Sump Well

During 2001, the sump well was installed in the basement of Building A-01 and used in operations to remediate tritium contamination in the basement that occurred between 1994 and 1995 (BN 2000). The discharge water, which contained tritium, was disposed of at the NNSS. The sump well was turned off after the remedial operations were completed. However, beginning in early 2003, the sump well has been used to help control the encroaching water below Building A-01. The water contains some residual tritium, and it is segregated from the uncontaminated water from the dewatering operation. The amount of tritium in the sump well water has decreased since 2003 from about 1,970 pCi/L to less than the average analytical minimum detection limit of 285 pCi/L, which is well below the Safe Drinking Water Act limit of 20,000 pCi/L. In 2016, a total of 1,253,335 L (331,096 gal) of water were pumped from the sump well and transported to the NNSS for disposal.

A.1.2.6 Oil Pollution Prevention

The NLVF has an SPCC Plan that was prepared in accordance with the Clean Water Act to minimize the potential discharge of petroleum products, animal fats and vegetable oils, and other non-petroleum oils and greases into waters of the U.S. (i.e., the Las Vegas Wash). The EPA requires SPCC Plans for non-transportation–related facilities having the potential to pollute waters of the U.S. and having an aggregate aboveground oil storage capacity of more than 4,997 L (1,320 gal). Oil storage facilities at the NLVF include 9 aboveground tanks, 18 transformers, 14 pieces of oil-filled machining equipment (e.g., lathes, elevators), and numerous 55-gal drums that are used to store new and used oils. These facilities/pieces of equipment are located within approved spill and storm water runoff containment structures. The SPCC specifies procedures for removing storm water from containment structures and identifies discharge countermeasures, disposal methods for recovered materials, and discharge reporting requirements.

In 2016, quarterly inspections of tanks, transformers, oil-filled equipment, and drums were conducted in March, May, September, and November through December. Throughout 2016, all NLVF employees who handle oil received their required annual spill prevention and management training. A small quantity (less than one gallon) of diesel fuel leaked from a commercial vehicle that had been overfilled at the NLVF. The spill was contained, cleaned up, and the residues properly disposed. No spills occurred in 2016 that met regulatory agency reporting criteria.

A.1.3 Radiation Protection

A.1.3.1 National Emission Standards for Hazardous Air Pollutants (NESHAP)

In compliance with NESHAP of the Clean Air Act, the radionuclide air emissions from the NLVF and the resultant radiological dose to the public surrounding the facility were assessed. NESHAP establishes a dose limit for the general public to be no greater than 10 millirems per year (mrem/yr) from all radioactive air emissions. Building A-01’s basement was contaminated with tritium in 1995 when a container of tritium foils was opened, emitting about 1 curie of tritium (U.S. Department of Energy, Nevada Operations Office 1996). Complete cleanup of the tritium was unsuccessful due to the tritium being absorbed into the building materials. This has resulted in a continuous but decreasing release of tritium into the basement air space, which is ventilated to the outdoors. Since 1995, a dose assessment has been performed every year for this building.

In 2016, no tritium was detected above its analytical minimum detection limit in groundwater pumped from the sump well in the basement of Building A-01 during dewatering operations. However, there is still an emission from tritium emanating from building materials in the building’s basement. This tritium emission was determined by taking two air samples from the basement (on April 13–20 and September 13–20, 2016) in order to compute average tritium emissions. A calculated annual total of 2.14 millicuries were released from the basement air that was vented to the outside. Based on this emission rate, the 2016 calculated radiation dose to the nearest member of the general public from the NLVF was very low: 0.000011 mrem/yr (NSTec 2017). The nearest public place is

100 meters (328 feet) northwest of Building A-01. This annual public dose is well below the regulatory limit of 10 mrem/yr and continues to decrease at a rate of about one-half every 4.75 years (NSTec 2017).

A.1.3.2 DOE O 458.1

U.S. Department of Energy (DOE) Order DOE O 458.1, "Radiation Protection of the Public and the Environment," specifies that the radiological dose to a member of the public from radiation from all pathways must not exceed 100 mrem/yr as a result of DOE activities. This dose limit does not include the dose contribution from natural background radiation. The Atlas A-1 Source Range Laboratory and the Building C-3 High Intensity Source Building are two NLVF facilities that use radioactive sources or where radiation-producing operations are conducted that have the potential to expose the general population or non-project personnel to direct radiation. Direct radiation monitoring is conducted using thermoluminescent dosimeters (TLDs) to monitor external gamma radiation exposure near the boundaries of these facilities. The methods of TLD use and data analyses are described in Chapter 6 of this report.

In 2016, radiation exposure was measured at two locations along perimeter fences for Buildings A-01 and C-3 and at one control location along the west fence of Building C-1 (Figure A-2). Annual exposure rates estimated from measurements at those locations are summarized in Table A-3. The radiation exposure in air measured by the TLDs is in the unit of milliroentgens per year (mR/yr), which is considered equivalent to the unit of mrem/yr for tissue. These exposures include contributions from background radiation and are similar to the TLD measurement of 100 mR/yr for total annual exposure reported by the Desert Research Institute from their Las Vegas air monitoring station (see Section 7.1.4, Table 7-3). The NLVF TLD results indicate that facility activities do not contribute a radiological dose to the surrounding public that can be distinguished from the dose due to background radiation.

Table A-3. Results of 2016 direct radiation exposure monitoring at the NLVF

Location	Number of Samples	Gamma Exposure (mR/yr) Mean	Median	Minimum	Maximum
West Fence of Building C-1 (Control)	4	97	96	93	105
North Fence of Building A-01	3	66	66	63	69
North Fence of Building C-3	4	67	66	62	70

A.1.4 Hazardous Waste Management

Hazardous wastes (HWs) generated at the NLVF include such items as non-empty aerosol cans, lead debris, and oily rags. HWs are stored temporarily in satellite accumulation areas until they are direct-shipped to approved disposal facilities. The NLVF is normally a Conditionally Exempt Small Quantity Generator; therefore, no HW permit is required by the State of Nevada. However, the Southern Nevada Health District (SNHD) issues the facility an annual permit for restricted waste management. The SNHD conducts an annual onsite audit to validate proper handling and storage of restricted wastes. SNHD personnel conducted the annual audit on November 1, 2016, and found existing restricted waste processes and procedures acceptable.

A.1.5 Hazardous Materials Control and Management

In 2016, the chemical inventory at the NLVF was updated and submitted to the state in the Nevada Combined Agency (NCA) Report on February 13, 2017. The inventory data were submitted in accordance with the requirements of the Hazardous Materials Permit 58908. For a description of the content, purpose, and federal regulatory driver behind the NCA Report, see Chapter 2, Section 2.4.4.1, Emergency Planning and Community Right-to-Know Act. No accidental or unplanned release of an extremely hazardous substance (EHS) occurred at the NLVF in 2016. Also, the quantities of toxic chemicals kept at the NLVF that are used annually did not exceed the specified reporting thresholds (see Chapter 2, Table 2-5 concerning Toxic Chemical Release Inventory, Form R).

A.2 Remote Sensing Laboratory–Nellis

RSL-Nellis is approximately 13.7 kilometers (km) (8.5 miles [mi]) northeast of the Las Vegas city center, and approximately 11.3 km (7 mi) northeast of the NLVF. It occupies six facilities on approximately 14 secured hectares (35 acres) at the Nellis Air Force Base. The six NNSA/NFO facilities were constructed on property owned by the U.S. Air Force (USAF). There is a Memorandum of Agreement between the USAF and NNSA/NFO whereby the land belongs to the USAF but is under lease to the NNSA/NFO. The facilities are owned by NNSA/NFO. RSL-Nellis provides emergency response resources for weapons-of-mass-destruction incidents. The laboratory also designs and conducts field tests of counterterrorism/intelligence technologies, and has the capability to assess environmental and facility conditions using complex radiation measurements and multi-spectral imaging technologies.

Environmental compliance and monitoring activities at RSL-Nellis in 2016 included maintenance of an air quality permit, a waste management permit for underground storage tanks, and a hazardous materials permit (see Chapter 2, Table 2-3 for a list of all NNSA/NFO permits). Sealed radiation sources are used for calibration at RSL-Nellis, but the public has no access to any area that may have elevated gamma radiation emitted by the sources. Therefore, no environmental TLD monitoring is conducted. However, dosimetry monitoring is performed to ensure protection of personnel who work within the facility.

A.2.1 Air Quality and Protection

Sources of air pollutants at RSL-Nellis are regulated by the Minor Source Permit 348 issued by the Clark County DAQ for the emission of criteria pollutants, which was revised in December 2015. The regulated sources of emissions at RSL-Nellis include an aluminum sander, an abrasive blaster, spray paint booth, generators, a fire pump, cooling towers, and boilers. In 2016, one emergency generator was removed from the permit. The 2016 emissions inventory of criteria air pollutants was submitted to the DAQ on March 13, 2017, and is shown in Table A-4.

Clark County Air Quality Regulations specify that the opacity from any emission unit may not exceed the Clean Air Act NAAQS opacity limit of 20% for more than 6 consecutive minutes. The RSL-Nellis air permit requires that equipment be observed each day it is operated. If visible emissions are observed, then EPA Method 9 opacity readings are recorded by a certified visible emissions evaluator. If visible emissions appear to exceed the limit, corrective actions must be taken to minimize emissions. In 2016, two RSL-Nellis Maintenance Engineers were recertified and two more were certified to conduct opacity readings. Observations were taken for the permitted emission units. Emissions for all equipment were well below the Clean Air Act NAAQS opacity limit of 20%.

Table A-4. Summary of air emissions for RSL-Nellis in 2016

	Criteria Pollutant (Tons/yr)[(a)]					
Parameter	**PM10[(b)]**	**PM2.5[(c)]**	**NO_x**	**CO**	**SO_x**	**VOC**
PTE[(d)]	1.23	0.85	13.55	5.49	0.66	1.58
Actual[(e)]	0.31	0.13	2.23	1.12	0.07	0.16
Total Emissions = 4.02 Actual, 23.36 PTE						

(a) 1 ton equals 0.91 metric tons
(b) Particulate matter equal to or less than 10 microns in diameter
(c) Particulate matter equal to or less than 2.5 microns in diameter
(d) Potential to emit: The quantity of criteria air pollutant that facilities/pieces of equipment would emit annually if they were operated for the maximum number of hours at the maximum production rate specified in the air permit
(e) Emissions based on calculations using actual hours of operation for each piece of equipment

A.2.2 Water Quality and Protection

Water used at RSL-Nellis is supplied by the CNLV and meets or exceeds federal drinking water standards. The Clark County Water Reclamation District (CCWRD) determined that a discharge permit is not necessary for RSL-Nellis since no industrial wastewaters were being discharged. Instead, an annual submission of a Zero

Discharge Form verifying that no industrial wastewater was discharged to the sanitary sewer system is required. A Zero Discharge Certification for 2016 was submitted to CCWRD on January 18, 2017. There were no regulatory inspections of RSL-Nellis by the CCWRD in 2016, and no findings or corrective actions for the facility were identified by internal assessments.

A.2.2.1 Oil Pollution Prevention

An SPCC Plan is in place for RSL-Nellis. Similar to the NLVF (see Section A.1.3), the SPCC Plan is required because the facility has an aggregate aboveground oil storage capacity of more than 4,997 L (1,320 gal) and spills could potentially enter the Las Vegas Wash. Oil storage facilities at RSL-Nellis include nine aboveground tanks, four transformers, and two pieces of oil-filled machining equipment (e.g., elevators). These facilities and pieces of equipment are located within approved spill and storm water runoff containment structures. The SPCC specifies procedures for removing storm water from containment structures and identifies discharge countermeasures, disposal methods for recovered materials, and discharge reporting requirements.

In 2016, quarterly inspections of tanks, transformers, and oil-filled equipment were conducted in March, May, September, and December. All RSL-Nellis employees who handle oil received their required annual spill prevention and management training. There was one small spill at RSL in 2016; approximately 0.25 gallons of aviation fuel spilled on asphalt due to a cracked fuel line. No spills occurred in 2016 that met regulatory agency reporting criteria.

A.2.3 Underground Storage Tank (UST) Management

The SNHD has oversight authority of USTs in Clark County. The UST program at RSL-Nellis consists of three fully regulated tanks (one for unleaded gasoline, one for diesel fuel, and one for used oil), one deferred tank (in accordance with Title 40 Code of Federal Regulations Part 280.10[d]) for emergency power generation, and three excluded tanks. They are managed under the RSL-Nellis Waste Management Permit PR0064276 issued by SNHD. The active tanks are inspected annually by SNHD. In December, 2016, SNHD inspected the fully regulated and deferred USTs at RSL-Nellis. No deficiencies were noted.

A.2.4 Hazardous Materials Control and Management

In 2016, the chemical inventory at RSL-Nellis was updated and submitted to the state in the NCA Report on February 13, 2017 in accordance with the requirements of the Hazardous Materials Permit 58910 (see Chapter 2, Section 2.4.4.1 for a description of the content, purpose, and federal regulatory driver behind the NCA Report). No accidental or unplanned release of an EHS occurred at RSL-Nellis in 2016. Also, no annual usage quantities of toxic chemicals kept at RSL-Nellis exceeded specified thresholds (see Chapter 2, Section 2.4.4.1, Table 2-5 concerning Toxic Chemical Release Inventory, Form R).

A.3 References

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Appendix B: Glossary of Terms

A **Absorbed dose:** the amount of energy absorbed by an object or person per unit mass. It reflects the amount of energy that ionizing radiation sources deposit in materials through which they pass, and is measured in units of radiation-absorbed dose (rad). The related international system unit is the gray (Gy), where 1 Gy is equivalent to 100 rad.

Actinide: any of the series of 15 metallic elements from actinium (atomic number 89) to lawrencium (atomic number 103) in the periodic table. They are all radioactive, the heavier members being extremely unstable and not of natural occurrence. The actinides mentioned in this document include uranium, plutonium, and americium.

Alpha particle: a positively charged particle emitted from the nucleus of an atom having mass and charge equal to those of a helium nucleus (two protons and two neutrons), usually emitted by transuranic elements (elements with atomic numbers greater than 92 [the atomic number of uranium], all of which are unstable and decay radioactively into other elements).

Alpha radioactivity: ionizing radiation consisting of alpha particles, emitted by some substances undergoing radioactive decay.

Analyte: the specific component measured in a chemical analysis.

Aquifer: a saturated layer of rock or soil below the ground surface that can supply usable quantities of groundwater to wells and springs and be a source of water for domestic, agricultural, and industrial uses.

Area 5 Radioactive Waste Management Complex (RWMC): the complex in Area 5 of the Nevada National Security Site at which low-level waste (LLW) and mixed low-level waste (MLLW) may be received, examined, packaged, stored, or disposed. Limited quantities of onsite-generated transuranic waste (TRU) are also stored temporarily at the RWMC. The RWMC is composed of the Area 5 Radioactive Waste Management Site (RWMS) and the Waste Examination Facility (WEF) and supporting administrative buildings, parking areas, and utilities. The operational units of the Area 5 RWMS include active, inactive, and closed LLW and MLLW cells and a Real Time Radiography Building. The operational units of the WEF include the TRU Pad, TRU Pad Cover Building, TRU Loading Operations Area, WEF Yard, WEF Drum Holding Pad, Sprung Instant Structure, and the Visual Examination and Repackaging Building.

Atom: the smallest particle of an element capable of entering into a chemical reaction.

Atomic number: the number of protons in the nucleus of an atom, which determines the chemical properties of an element and its place in the periodic table.

B **Background:** as used in this report, background is the term for the amounts of chemical constituents or radioactivity in the environment that are not caused by Nevada National Security Site operations. In the broader context outside this report, background radiation refers to radiation arising from natural sources always present in the environment, including solar and cosmic radiation from outer space and naturally radioactive elements in the atmosphere, the ground, building materials, and the human body.

Becquerel (Bq): the International System of Units unit of activity of a radionuclide, equal to the activity of a radionuclide having one spontaneous nuclear transition per second.

Beta particle: a negatively charged particle emitted from the nucleus of an atom, having charge, mass, and other properties of an electron, emitted from fission products such as cesium-137.

Beta radioactivity: ionizing radiation consisting of beta particles emitted in the radioactive decay of an atomic nucleus.

Biological oxygen demand (BOD): a measure of the amount of dissolved oxygen that microorganisms need to break down organic matter in water; used as an indicator of water quality.

C **CAP88-PC:** a computer code required by the U.S. Environmental Protection Agency for modeling air emissions of radionuclides.

Closure-in-place: the stabilization or isolation of pollutants, hazardous wastes, and solid wastes, with or without partial treatment, removal activities, and/or post-closure monitoring. Closures-in-place of legacy contamination sites on and off the Nevada National Security Site, which are managed by the U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office, are attained in accordance with approved corrective action plans outlined in the 1996 Federal Facility Agreement and Consent Order (as amended) between the U.S. Department of Energy, the U.S. Department of Defense, and the State of Nevada.

Code of Federal Regulations (CFR): a codification of all regulations promulgated by federal government agencies.

Collective population dose: the sum of the total effective dose equivalents of all individuals within a defined population. The unit of collective population dose is person-rem or person-sievert. Collective population dose may also be referred to as "collective effective dose equivalent" or simply "population dose."

Committed dose equivalent: the dose equivalent to a tissue or organ over a 50-year period after an intake of a radionuclide into the body. Committed dose equivalent is expressed in units of rem or sievert.

Committed effective dose equivalent (CEDE): the sum of the committed dose equivalents to various tissues in the body, each multiplied by an appropriate weighting factor representing the relative vulnerability of different parts of the body to radiation. Committed effective dose equivalent is expressed in units of rem or sievert.

Community water system: as defined in Nevada Revised Statute 445A.808, it is a public water system that has at least 15 service connections used by year-round residents of the area served by the system; or regularly serves at least 25 year-round residents of the area served by the system.

Compliance Level (CL): the Clean Air Act National Emission Standards for Hazardous Air Pollutants Concentration Level for Environmental Compliance. The CL value represents the annual average concentration that would result in a dose of 10 millirem per year, which is the federal dose limit to the public from all radioactive air emissions.

Composite analysis (CA): an analysis of the risks posed by all wastes disposed in a low level radioactive waste disposal facility and by all other sources of residual contamination that may interact with the disposal site. CAs, along with performance assessments (PAs), are conducted for the Area 3 and Area 5 Radioactive Waste Management Sites on the Nevada National Security Site to assess and predict their long-term performance.

Confining unit: a geologic unit of relatively low permeability that impedes the vertical movement of groundwater.

Contaminant Boundary: a type of boundary developed for an Underground Test Area (UGTA) corrective action unit (CAU). It is a forecast perimeter and a lower hydrostratigraphic unit boundary that delineates the potential extent of radionuclide-contaminated groundwater from underground testing for 1,000 years. Contaminated groundwater is defined as water exceeding the radiological standards of the Safe Drinking Water Act (SDWA). The forecasted contamination is a volume, which is projected upward to the ground surface to define a two-dimensional contaminant boundary perimeter. Simulation modeling of the transport of radiological contaminants in groundwater is usually used to forecast the locations of the contaminant boundaries within the next 1,000 years. CAU-specific contaminant boundaries are approved by the Nevada Division of Environmental Protection.

Continuous release: defined by the U.S Environmental Protection Agency as a release that occurs without interruption or abatement, or that is routine, anticipated, intermittent, and incidental to normal operation or treatment process.

Criteria pollutants: those air pollutants designated by the U.S. Environmental Protection Agency as potentially harmful and for which National Ambient Air Quality Standards under the Clean Air Act have been established to protect the public health and welfare. These pollutants include sulfur dioxide (SO_2), nitrogen oxides (NO_X), carbon monoxide (CO), ozone, lead, and particulate matter equal to or less than 10 microns in diameter (PM10). The State of Nevada, through an air quality permit, establishes emission limits on the Nevada National Security Site for SO_2, NO_X, CO, PM10, and volatile organic compounds (VOCs). Ozone is not regulated by the permit as an emission, as it is formed in part from NO_X and VOCs. Lead is considered a hazardous air pollutant (HAP) as well as a criteria pollutant, and lead emissions on the Nevada National Security Site are reported as part of the total HAP emissions. Lead emissions above a specified threshold are also reported under Section 313 of the Emergency Planning and Community Right-to-Know Act.

Critical Level (L_C): the counts of radioactivity (or concentration level of a radionuclide) in a sample that must be exceeded before there is a specified level of confidence (typically 95 or 99 percent) that the sample contains radioactive material above the background; called the Critical Level (L_C) or the decision level.

Critical receptor sampler: a type of radiological air monitoring station on the NNSS that samples air particulates and water vapor for the purpose of assessing dose to the public from airborne radionuclides originating from past or current NNSS activities and documenting if the assessed dose exceeds the DOE public dose limit of 10 millirems per year from inhalation. The U.S. Environmental Protection Agency has approved a sampling network of six such stations on the NNSS. The critical receptor is assumed to be an individual who resides at the station location. Air sample analysis results for each station identify whether this hypothetical individual would be exposed to airborne radionuclides that would exceed the DOE public dose limit. It is assumed that if air sampling results at these six locations on the NNSS indicate doses below the public limit, then the public who reside off the NNSS at greater distances from the NNSS sources of airborne radionuclides, then the offsite public dose is even less.

Curie (Ci): a unit of measurement of radioactivity, defined as the amount of radioactive material in which the decay rate is 3.7×10^{10} (37 billion) disintegrations per second; one Ci is approximately equal to the decay rate of one gram of pure radium.

D

Daughter nuclide: a nuclide formed by the radioactive decay of another nuclide, which is called the parent.

Decision level: the counts of radioactivity (or concentration level of a radionuclide) in a sample that must be exceeded before there is a specified level of confidence (typically 95 or 99 percent) that the sample contains radioactive material above the background; also known as the Critical Level (L_C).

Depleted uranium: uranium having a lower proportion of the isotope ^{235}U than is found in naturally occurring uranium. The masses of the three uranium isotopes with atomic weights 238, 235, and 234 occur in depleted uranium in the weight-percentages 99.8, 0.2, and 5×10^{-4}, respectively.

Derived Concentration Standard (DCS): concentration of a given radionuclide in either water or air that results in a member of the public receiving 100 millirem (1 millisievert) effective dose following continuous exposure for one year via each of the following pathways: ingestion of water, submersion in air, and inhalation. They replace the Derived Concentration Guides previously published by the U.S. Department of Energy (DOE) in 1993 in DOE Order DOE O 5400.5. Since 1993, the radiation protection framework on which DCSs are based has evolved with more sophisticated biokinetic and dosimetric information provided by the International Commission on Radiological Protection (ICRP), thus enabling consideration of age and gender. DOE-STD-1196-2011 establishes DCS values that reflect the current state of knowledge and practice in radiation protection. These DCSs are based on age-specific effective dose coefficients, revised gender specific physiological parameters for the Reference Man (ICRP 2002), and the latest information on the energies and intensities of radiation emitted by radionuclides (ICRP 2008).

Designated pollutant: any pollutant regulated by the Clean Air Act's New Source Performance Standards that is not a criteria pollutant. Examples of these are acid mist, fluorides, hydrogen sulfide in acid gas, and total reduced sulfur.

Diffuse source: an area source from which radioactive air emissions are continuously distributed over a given area or emanate from a number of points randomly distributed over the area (generally, all sources other than point sources). Diffuse sources are not actively ventilated or exhausted. Diffuse sources include: emissions from large areas of contaminated soil, resuspension of dust deposited on open fields, ponds and uncontrolled releases from openings in a structure.

Dose: the energy imparted to matter by ionizing radiation; the unit of absorbed dose is the rad, equal to 0.01 joules per kilogram for irradiated material in any medium.

Dose equivalent: a measure of the biological damage to living tissue as a result of radiation exposure. Also known as the "biological dose," the dose equivalent is calculated as the product of absorbed dose in tissue multiplied by a quality factor and then sometimes multiplied by other necessary modifying factors at the location of interest. The dose equivalent is expressed numerically in rems or sieverts (Sv).

Dosimeter: a portable detection device for measuring the total accumulated exposure to ionizing radiation.

Dosimetry: the theory and application of the principles and techniques of measuring and recording radiation doses.

E

Effective dose equivalent (EDE): an estimate of the total risk of potential effects from radiation exposure; it is the summation of the products of the dose equivalent and weighting factor for each tissue. The weighting factor is the decimal fraction of the risk arising from irradiation of a selected tissue to the total risk when the whole body is irradiated uniformly to the same dose equivalent. These factors permit dose equivalents from non-uniform exposure of the body to be expressed in terms of an EDE that is numerically equal to the dose from a uniform exposure of the whole body that entails the same risk as the internal exposure. The EDE includes the committed effective dose equivalent from internal deposition of radionuclides and the EDE caused by penetrating radiation from sources external to the body, and is expressed in units of rem or sievert.

Energy Savings Performance Contract (ESPC): a type of Energy Performance Contract (EPC). EPCs are alternative financing mechanisms authorized by the U.S. Congress designed to accelerate investment in cost effective energy conservation measures in existing federal buildings. Another type of EPC is a Utility Energy Service Contract. ESPCs allow federal agencies to accomplish energy savings projects without up-front capital costs and without special Congressional appropriations. The contract is a partnership between a federal agency and an energy service company (ESCO). The ESCO conducts a comprehensive energy audit for the federal facility and identifies improvements to save energy. In consultation with the federal agency, the ESCO designs and constructs a project that meets the agency's needs and arranges the necessary financing. The ESCO guarantees that the improvements will generate energy cost savings sufficient to pay for the project over the term of the contract. After the contract ends, all additional cost savings accrue to the agency. The savings must be guaranteed and the federal agencies may enter into a multiyear contract for a period not to exceed 25 years.

ESPC ENABLE: a program provided through DOE's Federal Energy Management Program (FEMP) that provides a standardized and streamlined process for small, federal facilities to install targeted, energy conservation measures (ECMs) in 6 months or less. Projects are administered through the General Services Administration (GSA) Federal Supply Schedule 84, Special Identification Number (SIN) 246-53 using a set of pre-established procurement and technical tools. The program allows sites an opportunity to implement specific ECMs pertaining to lighting, water, simple heating, ventilation, and air conditioning (HVAC) controls, HVAC system replacement, and solar photovoltaics.

Exposure: the absorption of ionizing radiation or ingestion of a radioisotope. Acute exposure is a large exposure received over a short period of time. Chronic exposure is exposure received over a long period of time, such as during a lifetime.

F **Federal citation:** a reference to a federal law identified by its Public Law (Pub. L) or United States Code (USC) abbreviation, or a reference to the implementing regulation of a federal law identified by its Code of Federal Regulations (CFR) abbreviation. CFR citations are used in this report unless none have been written, in which case, USC citations are used. If a public law has yet to be incorporated into the USC, then its public law (Pub. L) citation is used.

When a bill is signed by the President and becomes a new public law, it is assigned a law number, legal statutory citation, and prepared for publication as a slip law. Citations for public laws include the abbreviation, Pub. L., the Congress number, and the number of the law. At the end of each session of Congress, the slip laws are compiled into bound volumes called the Statutes at Large, which present a chronological arrangement of the laws in the order that they have been enacted.

Every 6 years, public laws are incorporated into the USC, which is a codification of all general and permanent laws of the United States. They are assigned a USC number which reflects their relationship to similar laws or laws that govern similar programs. A supplement to the USC is published during each interim year until the next comprehensive volume is published. The USC is arranged by subject matter, and it shows the present status of laws with amendments already incorporated in the text that have been amended on one or more occasions.

Implementing regulations for federal laws are written by the government agencies responsible for the subject matter of the laws and explain in detail how the laws are to be carried out. For example, the United States Environmental Protection Agency writes the regulations concerning water pollution control which are found in Title 40 of the CFR, while the U. S. Fish and Wildlife Service writes the regulations concerning endangered species protection found in Title 50 of the CFR.

Federal Register: a document published daily by the federal government containing notification of government agency actions, including notification of U.S. Environmental Protection Agency and U.S. Department of Energy decisions concerning permit applications and rule-making.

G **Gamma radiation:** high-energy, short-wavelength, ionizing, electromagnetic radiation emitted from the nucleus of an atom, frequently accompanying the emission of alpha or beta particles. It consists of photons in the highest observed range of photon energy. Gamma radiation (or gamma rays) easily pass through the human body but can be almost completely blocked by about 40 inches of concrete, 40 feet of water, or a few inches of lead.

Gray (Gy): the International System of Units unit of measure for absorbed dose; the quantity of energy imparted by ionizing radiation to a unit mass of matter, such as tissue. One gray equals 100 rads, or 1 joule per kilogram.

Gross alpha: the measure of radioactivity caused by all radionuclides present in a sample that emit alpha particles. Gross alpha measurements reflect alpha activity from all sources, including those that occur naturally. Gross measurements are used as a method to screen samples for relative levels of radioactivity.

Gross beta: the measure of radioactivity caused by all radionuclides present in a sample that emit beta particles. Gross beta measurements reflect beta activity from all sources, including those that occur naturally. Gross measurements are used as a method to screen samples for relative levels of radioactivity.

H **Half-life:** the time required for one-half of the radioactive atoms in a given amount of material to decay; for example, after one half-life, half of the atoms will have decayed; after two half-lives, three-fourths; after three half-lives, seven-eighths; and so on, exponentially.

Hazardous air pollutant (HAP): a toxic air pollutant that is known or suspected to cause cancer or other serious health effects, such as reproductive effects or birth defects, or adverse environmental effects. The U.S. Environmental Protection Agency has set emission standards for 22 of the 187 designated HAPs. Examples of toxic air pollutants include benzene, which is found in gasoline; perchloroethylene, which is emitted from some dry cleaning facilities; and methylene chloride, which is used as a solvent and paint stripper by a number of industries. Examples of other listed HAPs include dioxin, asbestos, toluene, and metals such as cadmium, mercury, chromium, and lead compounds.

Hazardous waste (HW): hazardous wastes exhibit any of the following characteristics: ignitability, corrosivity, reactivity, or Extraction Procedure toxicity (yielding excessive levels of toxic constituents in a leaching test), but other wastes that do not necessarily exhibit these characteristics have been determined to be hazardous by the U.S. Environmental Protection Agency (EPA). Although the legal definition of hazardous waste is complex, according to the EPA, the term generally refers to any waste that, if managed improperly, could pose a threat to human health and the environment.

High-efficiency particulate air (HEPA) filter: a disposable, extended-media, dry-type filter used to capture particulates in an air stream; HEPA collection efficiencies are at least 99.97 percent for 0.3-micrometer diameter particles.

I **Incidental take:** as per the Endangered Species Act (ESA), 'take' means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct of a listed species under the ESA. An incidental take is a take that results from activities that are otherwise lawful.

International System of Units (SI): an international system of physical units that includes meter (length), kilogram (mass), kelvin (temperature), becquerel (radioactivity), gray (radioactive dose), and sievert (dose equivalent). The abbreviation, SI, comes from the French term Système International d'Unités.

Ion: (1) an atom that has too many or too few electrons, causing it to have an electrical charge, and therefore, be chemically active. (2) An electron that is not associated (in orbit) with a nucleus.

Ionizing radiation: a form of radiation, which includes alpha particles, beta particles, gamma rays, x-rays, neutrons, high-speed electrons, high-speed protons, and other particles capable of producing ions. Compared to non-ionizing radiation, such as radio- or microwaves, or visible, infrared, or ultraviolet light, ionizing radiation is considerably more energetic. When ionizing radiation passes through material such as air, water, or living tissue, it deposits enough energy to produce ions by breaking molecular bonds and displace (or remove) electrons from atoms or molecules. This electron displacement may lead to changes in living cells. Given this ability, ionizing radiation has a number of beneficial uses, including treating cancer or sterilizing medical equipment. However, ionizing radiation is potentially harmful if not used correctly, and high doses may result in severe skin or tissue damage.

Isotopes: each of two or more forms of the same element that contain equal numbers of protons but different numbers of neutrons in their nuclei, and hence differ in relative atomic mass but not in chemical properties; in particular, a radioactive form of an element. For example, carbon-12 (^{12}C), the most common form of carbon, has six protons and six neutrons, whereas carbon-14 (^{14}C), the radioactive isotope of carbon, has six protons and eight neutrons.

L **L_C:** see Critical Level (L_C).

Less than detection limits: a phrase indicating that a chemical constituent or radionuclide was either not present in a sample, or is present in such a small concentration that it cannot be measured as significantly different from zero by a laboratory's analytical procedure and, therefore, is not identified at the lowest level of sensitivity.

Low-level waste (LLW): defined by U.S. Department of Energy Manual DOE M 435.1-1, "Radioactive Waste Management Manual," as radioactive waste that is not high-level radioactive waste, spent nuclear fuel, transuranic waste, byproduct material (as defined in section 11e.(2) of the Atomic Energy Act of 1954, as amended), or naturally occurring radioactive material.

Lower limit of detection: the smallest concentration or amount of analyte that can be detected in a sample at a 95-percent confidence level; also known as minimum detectable concentration.

Lysimeter: an instrument for measuring the water percolating through soils and determining the dissolved materials.

M **Maximally exposed individual (MEI):** a hypothetical member of the public at a fixed location who, over an entire year, receives the maximum effective dose equivalent (summed over all pathways) from a given source of radionuclide releases to air. Generally, the MEI is different for each source at a site.

Maximum contaminant level (MCL): the highest level of a contaminant in drinking water that is allowed by U.S. Environmental Protection Agency regulation.

Minimum detectable concentration (MDC): also known as the lower limit of detection, the smallest amount of radioactive material in a sample that can be quantitatively distinguished from background radiation in the sample with 95 percent confidence.

Mixed low-level waste (MLLW): waste containing both radioactive and hazardous components. It is defined by U.S. Department of Energy Manual DOE M 435.1-1, “Radioactive Waste Management Manual,” as low-level waste determined to contain both source, special nuclear, or byproduct material subject to the Atomic Energy Act of 1954, as amended, and a hazardous component subject to the Resource Conservation and Recovery Act (RCRA), as amended.

N **Non-community water system:** as defined in Nevada Revised Statute 445A.828, it is a public water system that is not a community water system.

Nuclide: any species of atom that exists for a measurable length of time. A nuclide can be distinguished by its atomic mass, atomic number, and energy state.

O **Ozone Depleting Substances (ODS):** substances regulated by the EPA in the U.S. as Class I or Class II controlled substances. Class I substances have a higher ozone depletion potential (0.2 or higher) and have been completely phased out in the U.S. With a few exceptions, this means no one can produce or import Class I substances. Class I ODS include halons, chlorofluorocarbons (CFCs), methyl chloroform, carbon tetrachloride, and methyl bromide. Class II substances have an ozone depletion potential less than 0.2 and are all hydrochlorofluorocarbons (HCFCs). HCFCs were developed as transitional substitutes for many Class I substances. New production and import of most HCFCs will be phased out by 2020. The most common HCFC in use today is HCFC-22 or R-22, a refrigerant still used in existing air conditioners and refrigeration equipment.

P **Performance assessment (PA):** a systematic analysis of the potential risks posed by a waste disposal facility to the public and to the environment from disposed low level radioactive waste. PAs are conducted, along with composite analyses (CAs), for the Area 3 and Area 5 Radioactive Waste Management Sites on the Nevada National Security Site to assess and predict their long-term performance.

Piezometer: an instrument for measuring the pressure of a liquid or gas, or something related to pressure (such as the compressibility of liquid). Piezometers are often placed in boreholes to monitor the pressure or depth of groundwater.

Plowshare Program: the program established by the United States Atomic Energy Commission (AEC), now the Department of Energy (DOE), as a research and development activity to explore the technical and economic feasibility of using nuclear explosives for industrial applications. The reasoning was that the relatively inexpensive energy available from nuclear explosions could prove useful for a wide variety of peaceful purposes. The Plowshare Program began in 1958 and continued through 1975. Between December 1961 and May 1973, the U.S. conducted 27 Plowshare nuclear explosive tests comprising 35 individual detonations. *Source:* https://www.osti.gov/opennet/reports/plowshar.pdf

Point source: a single well-defined point (origin) of an airborne release, such as a stack or vent or other functionally equivalent structure. Point sources are actively ventilated or exhausted. Point-source monitoring is monitoring emissions from a stack or vent.

Polychlorinated biphenyls (PCBs): a chemical belonging to the broad family of man-made organic chemicals known as chlorinated hydrocarbons. PCBs were domestically manufactured from 1929 until their manufacture was banned by the U.S. Congress in 1979. They have a range of toxicity and vary in consistency from thin, light-colored liquids to yellow or black waxy solids. Due to their non-flammability, chemical stability, high boiling point, and electrical insulating properties, PCBs were used in hundreds of industrial and commercial applications including electrical, heat transfer, and hydraulic equipment; as plasticizers in paints, plastics, and rubber products; in pigments, dyes, and carbonless copy paper; and many other industrial applications. PCBs can persist in the environment and accumulate in the food chain. PCBs' are classified as persistent organic pollutants. Their production was banned by the Stockholm Convention on Persistent Organic Pollutants in 2001. The International Research Agency on Cancer (IRAC), rendered PCBs as definite carcinogens in humans. According to the U.S. Environmental Protection Agency, PCBs cause cancer in animals and are probable human carcinogens.

Potential to emit (PTE): the quantity of a criteria air pollutant that each facility/piece of equipment would emit annually if it were operated for the maximum number of hours at the maximum production rate specified under its applicable air permit.

Private water system: a water system that is not a public water system, as defined in Nevada Revised Statute 445A.235, and is not regulated under State of Nevada permits.

Public water system (PWS): as defined in Nevada Revised Statute 445A.235, it is a system, regardless of ownership, that provides the public with water for human consumption through pipes or other constructed conveyances, if the system has 15 or more service connections, as defined in NRS 445A.843, or regularly serves 25 or more persons. The three PWSs on the NNSS are permitted by the State of Nevada as non-community water systems.

Q **Quality assurance (QA):** a system of activities whose purpose is to provide the assurance that standards of quality are attained with a stated level of confidence.

Quality control (QC): procedures used to verify that prescribed standards of performance are attained.

Quality factor: the factor by which the absorbed dose (rad) is multiplied to obtain a quantity that expresses (on a common scale for all ionizing radiation) the biological damage to exposed persons, usually used because some types of radiation, such as alpha particles, are biologically more damaging than others. Quality factors for alpha, beta, and gamma radiation are in the ratio 20:1:1.

R **Rad:** one of the two units used to measure the amount of radiation absorbed by an object or person, known as the "absorbed dose," which reflects the amount of energy that radioactive sources deposit in materials through which they pass. The radiation-absorbed dose (rad) is the amount of energy (from any type of ionizing radiation) deposited in any medium (e.g., water, tissue, air). An absorbed dose of 1 rad means that 1 gram of material absorbed 100 ergs of energy (a small but measurable amount) as a result of exposure to radiation. The related international system unit is the gray (Gy), where 1 Gy is equivalent to 100 rad.

Radioactive decay: the spontaneous transformation of one radionuclide into a different nuclide (which may or may not be radioactive), or de-excitation to a lower energy state of the nucleus by emission of nuclear radiation, primarily alpha or beta particles, or gamma rays (photons).

Radioactivity: the spontaneous emission of nuclear radiation, generally alpha or beta particles, or gamma rays, from the nucleus of an unstable isotope.

Radioisotope: same as radionuclide.

Radionuclide: may also be called a radioactive nuclide, radioisotope, or radioactive isotope. It is an atom that has excess nuclear energy, making it unstable. This excess energy can either create and emit from the nucleus new radiation (gamma radiation) or a new particle (alpha particle or beta particle), or transfer this excess energy to one of its electrons, causing it to be ejected (conversion electron). During this process, the radionuclide is said to undergo radioactive decay.

Regulatory Boundary: a type of boundary developed for an Underground Test Area (UGTA) corrective action unit (CAU). It is established by negotiation between the U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO) and the Nevada Division of Environmental Protection (NDEP) during the CAU closure process based upon negotiated CAU-specific objectives to provide protection for the public and the environment from the effects of migration of radioactive contaminants. If radionuclides above the agreed-upon levels reach this boundary, NNSA/NFO is required to submit a plan for NDEP approval that will identify how the CAU-specific regulatory boundary objectives will be met.

Rem: one of the two standard units used to measure the dose equivalent (or effective dose), which combines the amount of energy (from any type of ionizing radiation that is deposited in human tissue), along with the medical effects of the given type of radiation. For beta and gamma radiation, the dose equivalent is the same as the absorbed dose. By contrast, the dose equivalent is larger than the absorbed dose for alpha and neutron radiation, because these types of radiation are more damaging to the human body. Thus, the dose equivalent (in rems) is equal to the absorbed dose (in rads) multiplied by the quality factor of the type of radiation [see Title 10, Section 20.1004, of the *Code of Federal Regulations* (10 CFR 20.1004), "Units of Radiation Dose"]. The related international system unit is the sievert (Sv), where 100 rem is equivalent to 1 Sv.

Roentgen (R): a unit of measurement used to express radiation exposure in terms of the amount of ionization produced in a volume of air. It is the amount of gamma or x-rays required to produce ions resulting in a charge of 0.000258 coulombs/kilogram of air under standard conditions. Named after Wilhelm Roentgen, the German scientist who discovered x-rays in 1895.

S

Sanitary waste: most simply, waste generated by routine operations that is not regulated as hazardous or radioactive by state or federal agencies.

Saturated zone: a zone below the earth's surface below which all pore spaces between rocks or soil are completely filled with water.

Sievert (Sv): the International System of Units unit of radiation dose equivalent and effective dose equivalent, that is the product of the absorbed dose (gray), quality factor, distribution factor, and other necessary modifying factors; 1 Sv equals 100 rem.

Source term: the amount of a specific pollutant emitted or discharged to a particular medium, such as the air or water, from a particular source.

Subcritical experiment: an experiment using high explosives and nuclear weapon materials (including special nuclear materials like plutonium) to gain data used to maintain the nuclear stockpile without conducting nuclear explosions banned by the Comprehensive Nuclear Test Ban Treaty.

T

Thermoluminescent dosimeter (TLD): a device used to measure external beta or gamma radiation levels, and which contains a material that, after exposure to beta or gamma radiation, emits light when processed and heated.

Total effective dose equivalent (TEDE): The sum of the external exposures and the committed effective dose equivalent (CEDE) for internal exposures.

Transuranic (TRU) waste: material contaminated with alpha-emitting transuranium nuclides, which have an atomic number greater than 92 (e.g., ^{239}Pu), half-lives longer than 20 years, and are present in concentrations greater than 100 nanocuries per gram of waste. Mixed TRU waste contains hazardous waste also.

Tritium: a radioactive form of hydrogen that is produced naturally in the upper atmosphere when cosmic rays strike nitrogen molecules in the air. Although tritium can be a gas, its most common form is in water, because, like non-radioactive hydrogen, tritium reacts with oxygen to form water. Tritium replaces one of the stable hydrogens in the water molecule, H_2O, and is called tritiated water (HTO). Like H_2O, tritiated water is colorless and odorless. Naturally-occurring tritium is found in very small or trace amounts in the environment as HTO, which easily disperses in the atmosphere, water bodies, soil, and rock. Tritium is also produced during nuclear weapons explosions, as a by-product in nuclear reactors producing electricity, and in special production reactors, where the isotope lithium-6 is bombarded to produce tritium. In the mid-1950s and early 1960s, tritium was widely dispersed during the above-ground testing of nuclear weapons. The quantity of tritium in the atmosphere from weapons testing peaked in 1963 and has been decreasing ever since. Tritium is a contaminant of groundwater in select areas of the NNSS as a result of historical underground nuclear testing and is the contaminant of concern being monitored in NNSS groundwater samples. Tritium decays at a half-life of 12.3 years by emitting a low-energy beta particle. In 1976, EPA established a dose-based drinking water standard of 4 mrem per year and set a maximum contaminant level for drinking water of 20,000 picocuries per liter (pCi/L) for tritium, the level assumed to yield a dose of 4 mrem per year. One year of drinking water with this amount of contamination would produce approximately the same dose of radiation you would get during a single commercial flight between Los Angeles and New York City.

U **Uncertainty:** the parameter associated with a sample measurement that characterizes the range of the measurement that could reasonably be attributed to the sample. Used in this report, the uncertainty value is established at ± 2 standard deviations.

United States Code (USC): a codification of all general and permanent laws of the United States. Laws in the USC are grouped into various Titles, Chapters, and Sections by topic. For example, the citation 16 USC 1531-1544 is for Title 16 (Conservation), Sections 1531-1544 (in Chapter 35) which comprise the law called the Endangered Species Act.

Unsaturated zone: that portion of the subsurface in which the pores are only partially filled with water and the direction of water flow is vertical; also referred to as the vadose zone.

Use-Restriction (UR) Boundary: a type of boundary developed for an Underground Test Area (UGTA) corrective action unit (CAU). It delineates an area expected to require institutional controls to restrict access to potentially contaminated groundwater. A UR boundary is established by negotiation between the U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO) and the Nevada Division of Environmental Protection. It is based primarily on ***contaminant boundary*** (see Glossary definition) forecasts. A UR boundary is established to protect site workers from inadvertently contacting, or site activities from affecting, the flow paths of contaminated groundwater. NNSA/NFO, and any future land manager, must maintain all official CAU-specific UR boundary records.

V **Vadose zone:** the partially saturated or unsaturated region above the water table that does not yield water to wells; also referred to as the unsaturated zone.

W **Water table:** the underground boundary between saturated and unsaturated soils or rock. It is the point beneath the surface of the ground at which natural groundwater is found. It is the upper surface of a saturation zone where the body of groundwater (i.e., aquifer) is not confined by an overlying impermeable formation. In the situation where an aquifer does have an overlying confining formation, the aquifer has no water table.

Weighting factor: a tissue-specific value used to calculate dose equivalents that represents the fraction of the total health risk resulting from uniform, whole-body irradiation that could be contributed to that particular tissue. The weighting factors used in this report are recommended by the International Commission on Radiological Protection.

Appendix C: Acronyms and Abbreviations

ac	acre(s)
Ac	actinium
ACHP	Advisory Council on Historic Preservation
ACM	asbestos-containing material
AEA	Atomic Energy Act
AEC	Atomic Energy Commission
AFV	alternative fuel vehicle
AICP	American Indian Consultation Program
ALARA	as low as reasonably achievable
Am	americium
ANSI/HPS	American National Standards Institute/Health Physics Society
APP	affirmative procurement program
ARL	Army Research Laboratory
ARL/SORD	Air Resources Laboratory, Special Operations and Research Division
ARPA	Archaeological Resources Protection Act
ASCEM	Advanced Simulation Capability for Environmental Management
ASER	Annual Site Environmental Report
ASN	Air Surveillance Network
B	Background
BCG	Biota Concentration Guide
Be	beryllium
BEEF	Big Explosives Experimental Facility
BFF	Bureau of Federal Facilities
BGEPA	Bald and Golden Eagle Protection Act
bgs	below ground surface
BLM	Bureau of Land Management
BN	Bechtel Nevada
BO	Biological Opinion
BOD_5	5-day biological oxygen demand
Bq	becquerel
BREN	Bare Reactor Experiment–Nevada
BSDW	Bureau of Safe Drinking Water
BTU	British thermal unit
C	carbon (except in Chapter 6 where it denotes “control”)
CA	Composite Analysis
CAA	Clean Air Act
CADD	Corrective Action Decision Document
CAI	Corrective Action Investigation
CAIP	Corrective Action Investigation Plan
CAP	Corrective Action Plan
CAPP	Chemical Accident Prevention Program
CAP88-PC	Clean Air Package 1988
CAS	Corrective Action Site
CAU	Corrective Action Unit
CCDAQ	Clark County Department of Air Quality
CCWRD	Clark County Water Reclamation District
CEDE	committed effective dose equivalent
CEI	Compliance Evaluation Inspection
CEM	Community Environmental Monitor
CEMP	Community Environmental Monitoring Program
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFC	chlorofluorocarbon
CFR	Code of Federal Regulations
CGTO	Consolidated Group of Tribes and Organizations
Ci	curie(s)
CL	compliance level (used in text for the Clean Air Act National Emission Standards for Hazardous Pollutants Concentration Level for Environmental Compliance)
cm	centimeter(s)
cm^2	square centimeter(s)
CNLV	City of North Las Vegas
Co	cobalt
CO	carbon monoxide
COC	contaminant of concern
COPC	contaminant of potential concern
CR	Closure Report
CRM	Cultural Resources Management
CRMP	Cultural Resources Management Program
Cs	cesium
CV	coefficient of variation

CWA	Clean Water Act
CX	Categorical Exclusion
CY	calendar year
DAF	Device Assembly Facility
DAG	Dry Alluvium Geology
DAQ	Department of Air Quality (Clark County)
DCS	Derived Concentration Standard
D&D	decontamination and decommissioning
DNWR	Desert National Wildlife Refuge
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOECOE	Department of Energy Common Operating Environment
DOECAP	U.S. Department of Energy Consolidated Audit Program
DOE/NV	U.S. Department of Energy, Nevada Operations Office
DOI	U.S. Department of Interior
DPF	Dense Plasma Focus
dpm	disintegrations per minute
DQA	Data Quality Assessment
DQO	Data Quality Objective
DRI	Desert Research Institute
DTCC	Desert Tortoise Conservation Center
DSA	Documented Safety Analysis
DU	depleted uranium
E1	Environmental 1
E2	Environmental 2
EA	Environmental Assessment
E&EM	Ecological and Environmental Monitoring
ECM	energy conservation measure
EDE	effective dose equivalent
EHS	extremely hazardous substance
EIS	Environmental Impact Statement
EISA	Energy Independence and Security Act of 2007
ELU	ecological landform units
EM	Environmental Management
EMAC	Ecological Monitoring and Compliance
EMAD	Engine Maintenance, Assembly, and Disassembly
EMC	Energy Management Council
EMP	Energy Management Program
EMS	Environmental Management System
EO	Executive Order
EODU	Explosive Ordnance Disposal Unit
EP	Environmental Programs
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
EPEAT	Electronic Product Environmental Assessment Tool
EPP	Environmentally Preferable Product
ER	Environmental Restoration
ERA	Environmental Research Associates
ESA	Endangered Species Act
ESCO	energy service company
ESPC	Energy Savings Performance Contract
ETDS	E-Tunnel Waste Water Disposal System
Eu	europium
EWDP	Early Warning Drill Program
EWG	Environmental Working Group
EWO	Environmental Waste Operations
F&I	Facility and Infrastructure
FD	field duplicate
FEMP	Federal Energy Management Program
FFACO	Federal Facility Agreement and Consent Order
FFCA	Federal Facility Compliance Act
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
ft	foot or feet
ft^2	square feet
ft^3	cubic feet
FS	U.S. Forest Service
FWS	U.S. Fish and Wildlife Service
FY	fiscal year
g	gram(s)
gal	gallon(s)
gal/ft^2	gallons used per square foot
GCD	Greater Confinement Disposal
gCO_2e/mile	grams of carbon dioxide equivalents per mile
GHG	greenhouse gas
GIS	Geographic Information System
gpm	gallon(s) per minute
GP	Guiding Principle

GSA	General Services Administration
gsf	gross square feet
Gy	gray(s)
Gy/d	gray(s) per day
^{3}H	tritium
ha	hectare(s)
HAP	hazardous air pollutant
HCFC	hydrochlorofluorocarbon
HENRE	High-Energy Neutron Reactions Experiment
HEPA	high-efficiency particulate air
HEST	High Explosives Simulation Test
HMA	Herd Management Area
HPSB	High Performance Sustainable Building
HQ	Headquarters
HTO	tritiated water
HVAC	heating, ventilation, and air conditioning
HW	hazardous waste
HWAA	Hazardous Waste Accumulation Area
HWSU	Hazardous Waste Storage Unit
I	iodine
IAEA	International Atomic Energy Agency
ICR	San Diego Zoo Institute for Conservation Research
ID	identification number
IL	investigation level
ILA	industrial, landscaping, and agricultural
in.	inch(es)
IOC	inorganic chemical
ISMS	Integrated Safety Management System
ISO	International Organization for Standardization
ISWG	Interagency Sustainability Working Group
IT	International Technology Corporation
JASPER	Joint Actinide Shock Physics Experimental Research
JIT	Just-In-Time
K	potassium
kg	kilogram(s)
kg/d	kilogram(s) per day
km	kilometer(s)
km^2	square kilometer(s)
L	liter(s)
LANL	Los Alamos National Laboratory
lb	pound(s)
L_C	Critical Level (synonymous with Decision Level)
LCA	lower carbonate aquifer
LCS	laboratory control sample
L/d	liter(s) per day
LED	light emitting diode
LEED	Leadership in Energy and Environmental Design
LEPC	Local Emergency Planning Commission
LLNL	Lawrence Livermore National Laboratory
LLW	low-level waste
Lpm	liter(s) per minute
LoC	Level of Concern
log	logarithmic
LQAP	Laboratory Quality Assurance Plan
LRQA	Lloyd's Register Quality Assurance
m	meter(s)
m^2	square meter(s)
m^3	cubic meter(s)
M&O	Management and Operating
MAPEP	Mixed Analyte Performance Evaluation Program
MBTA	Migratory Bird Treaty Act
mCi	millicurie(s)
MCL	maximum contaminant level
MDC	minimum detectable concentration
MEI	maximally exposed individual
MET	meteorological
MGD	million gallons per day
mg/L	milligram(s) per liter
mGy/d	milligray(s) per day
mi	mile(s)
mi^2	square mile(s)
mL	milliliter
MLLW	mixed low-level waste
mm	millimeter(s)
mmhos/cm	millimhos per centimeter
Mod.	Modification
MQO	Measurement Quality Objectives
MR	monitor and report
mR	milliroentgen(s)
mR/d	milliroentgen(s) per day

mR/yr	milliroentgen(s) per year
mrad	millirad(s)
mrem	millirem(s)
mrem/yr	millirem(s) per year
MSDS	Material Safety Data Sheet
mSv	millisievert(s)
mSv/yr	millisievert(s) per year
$mTCO_2e$	metric ton(s) of carbon dioxide equivalent
mton	metric ton(s)
MTRU	mixed transuranic
MWDU	Mixed Waste Disposal Unit
MWSU	Mixed Waste Storage Unit
µCi/mL	microcurie(s) per milliliter
µg/L	microgram(s) per liter
µR/hr	microroentgen(s) per hour
µS/cm	microseimen(s) per centimeter
N	nitrogen
NAAQS	National Ambient Air Quality Standards
NAC	Nevada Administrative Code
NAGPRA	Native American Graves Protection and Repatriation Act
NATM	National Atomic Testing Museum
NCA	Nevada Combined Agency
NC-GWE	Nye County Groundwater Evaluation
NCRP	National Council on Radiation Protection
NDEP	Nevada Division of Environmental Protection
NDOA	Nevada Department of Agriculture
NDOF	Nevada Department of Forestry
NDOW	Nevada Department of Wildlife
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NFS	Nuclear Fuel Services
NHPA	National Historic Preservation Act
N-I	Navarro-Intera, LLC
NLVF	North Las Vegas Facility
NNES	Navarro Nevada Environmental Services, LLC
NNHP	Nevada Natural Heritage Program
NNSA	U.S. Department of Energy, National Nuclear Security Administration
NNSA/NFO	U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office
NNSA/NSO	U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office
NNSA/SFO	U.S. Department of Energy, National Nuclear Security Administration Sandia Field Office
NNSS	Nevada National Security Site
NNSSER	Nevada National Security Site Environmental Report
NO_x	nitrogen oxides
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPTEC	Nonproliferation Test and Evaluation Complex
NRC	Non-Radiological Classified
NRCH	Non-Radiological Classified Hazardous
NREL	National Renewable Energy Laboratory
NRHP	National Register of Historic Places
NRS	Nevada Revised Statutes
NSHPO	Nevada State Historic Preservation Office
NSPS	New Source Performance Standards
NSSAB	Nevada Site Specific Advisory Board
NSSER	Nevada National Security Site Environmental Report
NSTec	National Security Technologies, LLC
NTS	Nevada Test Site
NTSER	Nevada Test Site Environmental Report
NTSF	National Transportation Stakeholders Forum
NTTR	Nevada Test and Training Range
NVLAP	National Voluntary Laboratory Accreditation Program
ODS	ozone-depleting substance
ORPS	Occurrence Reporting and Processing System
OSHA	Occupational Safety and Health Administration
OSTI	Office of Scientific and Technical Information

oz	ounce(s)
P2/WM	pollution prevention/waste minimization
PA	Performance Assessment
PAAA	Price-Anderson Amendments Act
Pb	lead
PCB	polychlorinated biphenyl
pCi	picocurie(s)
pCi/g	picocurie(s) per gram
pCi/L	picocurie(s) per liter
pCi/mL	picocurie(s) per milliliter
PEV	plug-in electric vehicle
PI	prediction interval
PIC	pressurized ion chamber
PLall	prediction limit for all enriched tritium measurements
PM	particulate matter
PM10	particulate matter equal to or less than 10 microns in diameter
PMOV	Pahute Mesa-Oasis Valley
POE	point of entry
PT	proficiency testing
PTE	potential to emit
Pu	plutonium
PUE	Power Utilization Effectiveness
PV	photovoltaic
PWS	public water system
QA	quality assurance
QAP	Quality Assurance Program
QAMAP	Quality Assurance Management and Assessment Plan
QAPP	Quality Assurance Program Plan
QC	quality control
QPID	Quality and Performance Improvement Division
QSAS	Quality Systems for Analytical Services
R	roentgen(s)
Ra	radium
rad	radiation absorbed dose (a unit of measure)
rad/d	rad(s) per day
RC	Radiological Control
RCRA	Resource Conservation and Recovery Act
RCT	Radiological Control Technician
rem	roentgen equivalent man
RER	relative error ratio
RFP	request for proposal
RIDP	Radionuclide Inventory and Distribution Program
RMAD	Reactor Maintenance, Assembly, and Disassembly
RNCTEC	Radiological/Nuclear Countermeasures Test and Evaluation Complex
ROTC	Record of Technical Change
RPD	relative percent difference
RREMP	Routine Radiological Environmental Monitoring Plan
RSL	Remote Sensing Laboratory
RTR	Real-Time Radiography
RW	Radioactive Waste
RWAP	Radioactive Waste Acceptance Program
RWMC	Radioactive Waste Management Complex
RWMS	Radioactive Waste Management Site
SA	Supplement Analysis
SAA	Satellite Accumulation Area
SAD	surface area disturbance
SAFER	Streamlined Approach for Environmental Restoration
SAP	Sampling and Analysis Plan
SARA	Superfund Amendments and Reauthorization Act
SC	specific conductance
SD	standard deviation
SDWA	Safe Drinking Water Act
SE	standard error of the mean
SER	Safety Evaluation Report
SERC	State Emergency Response Commissioner
SF_6	Sulfur hexafluoride
SHPO	State Historic Preservation Office
SI	International System of Units
SIS	Sprung Instant Structure
SMCL	Secondary maximum Contaminant Level
SNHD	Southern Nevada Health District
SNJV	Stoller-Navarro Joint Venture
SNL	Sandia National Laboratories
SOC	synthetic organic chemical

SORD	Special Operations and Research Division
SO_2	sulfur dioxide
SPCC	Spill Prevention, Control, and Countermeasure
SPO	Sustainability Performance Office
Sr	strontium
SSC	structures, systems, and components
SSP	Site Sustainability Plan
SSPP	Strategic Sustainability Performance Plan
STGWG	State Tribal Government Working Group
S.U.	standard unit(s) (for measuring pH)
Sv	sievert(s)
SWEIS	Site-Wide Environmental Impact Statement
SWO	Solid Waste Operations
T½	half-life
Tc	technetium
TDS	total dissolved solids
TEDE	total effective dose equivalent
TEK	traditional ecological knowledge
Th	thorium
TLD	thermoluminescent dosimeter
TOC	total organic carbon
TOX	total organic halides
TPCB	Transuranic Pad Cover Building
TPH	total petroleum hydrocarbons
TRI	Toxic Release Inventory
TRU	transuranic
TSaMP	Tritium Sampling and Monitoring Program
TSCA	Toxic Substances Control Act
TSR	Technical Safety Requirements
TSS	total suspended solids
TTR	Tonopah Test Range
U	uranium
UESC	Utility Energy Service Contract
UGT	underground test
UGTA	Underground Test Area
UIC	underground injection control
UNESE	Underground Nuclear Event Signatures Experiment Forensics
UR	use restriction
U.S.	United States
USACE	U.S. Army Corps of Engineers
USAF	U.S. Air Force
USC	United States Code
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
UST	underground storage tank
VERB	Visual Examination and Repackaging Building
VOC	volatile organic compound
VZM	vadose zone monitoring
WAC	Waste Acceptance Criteria
WDP	water delivery point
WEF	Waste Examination Facility
WIPP	Waste Isolation Pilot Plant
WMD	Waste Management Division
WO	Waste Operations
WW	water well
yr	year(s)

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Back cover photos:

Desert dandelions *(Malacothrix glabrata)* in bloom on the NNSS

Bobcat *(Lynx rufus)* in Fortymile Canyon, Area 25 (photo taken by Derek Hall)

Bighorn sheep rams *(Ovis canadensis nelsoni)* in Mercury Pass, Area 23 (photo taken by Derek Hall)

Pocket gopher *(Thomomys bottae)* at Rounded Ridge, Area 10 (photo taken by Derek Hall)

NNSA
National Nuclear Security Administration

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