DOE/NV/11718--1080

Nevada Test Site Environmental Report 2004

Bechtel Nevada
Strengthening national security through engineering and operational excellence

National Nuclear Security Administration

DOE/NV/11718--1080

Nevada Test Site Environmental Report 2004

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October 2005

Work Performed Under
Contract No. DE-AC08-96NV11718

Prepared for:
U. S. Department of Energy
National Nuclear Security Administration
Nevada Site Office

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Acknowledgements

Environmental Technical Services (ETS) of Bechtel Nevada (BN) is responsible for production of this document. Environmental monitoring and compliance data were gathered through the combined efforts of several BN organizations in addition to ETS: Environmental Services, Radioactive Waste Operations, Solid Waste Operations, Environmental Restoration, Ecological Services, Radiological Control, Occupational Safety & Health, and Contractor Assurance & Compliance. The Water Resources and Cultural Resources divisions of the Desert Research Institute (DRI) contributed data for offsite water and air monitoring and cultural resource protection. My sincere thanks go to each of the authors and contributors from these organizations that are listed below. Your generous help and perseverance during the writing and review phases were greatly appreciated.

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ETS Support Staff

The following individuals within ETS are responsible year-in and year-out for the numerous tasks that are integral to the collection, quality assurance, and quality control of much of the environmental data reported in this NTSER. These are the “behind the scenes” folks. Thank you all for your efforts in the following areas.

Administration of the Bechtel Environmental Integrated Data Management System (BEIDMS) for Routine Radiological Environmental Monitoring Program (RREMP), Clean Water Act (CWA) and Safe Drinking Water Act (SDWA) Projects:
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Report Production and Distribution Support Personnel

Lastly, my appreciation goes to the following individuals who were responsible for improving the quality, appearance, and timely production and distribution of this report:

Charles Davis of EnviroStat provided support for the statistical analyses and interpretation of NTS radiological monitoring data collected by ETS. Charles also collaborated in editing the document for clarity and accuracy of the text and data presentation.

Bob Arnold of BN Technical Publications and Graphics Services (TPGS) designed the cover for this document and the *2004 Nevada Test Site Environmental Report Summary* (NTSER Summary). Elaine Upson of BN TPGS designed the layout of the NTSER Summary.

Tom Fitzmaurice of BN Environmental Restoration provided his artistic talents to produce the drawing of possible pathways of radiological exposure to the public presented in the NTSER Summary.

Ashley Cushman of BN Geographic Information Systems (GIS)/Data Management is a GIS specialist who worked with all the authors to produce the high-quality GIS-generated maps and figures.

Kurt Jahn and Mark Shaw of Office Services are thanked for producing high-quality hardcopies and compact discs of the NTSER and the NTSER Summary under a tight production schedule.

Fina Martinez-Myers of Office Services oversaw the Government Printing Office subcontract, the print production schedule, the acquisition of all printing and mailing supplies, and the timely distribution of all of the NTSER products. Thank you for your impeccable customer service.

A very special thank you is reserved for Angela McCurdy of BN TPGS. She is the word processing specialist responsible for the final layout and format of the NTSER. Her skill and dedication applied to this project year after year are acknowledged. Thank you, Angela.

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Executive Summary

The *Nevada Test Site Environmental Report 2004* was prepared by Bechtel Nevada (BN) 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. This Executive Summary presents the purpose of the document, the major programs conducted at the Nevada Test Site (NTS), NTS key environmental initiatives, radiological releases and potential doses to the public resulting from site operations, a summary of non-radiological releases, implementation status of the NTS Environmental Management System, and significant environmental accomplishments. Much of the content of this Executive Summary is also presented in a separate stand-alone pamphlet titled *Nevada Test Site Environmental Report Summary 2004*. It was produced this year to provide a more cost-effective and wider distribution of a hardcopy summary of the *Nevada Test Site Environmental Report 2004* to interested DOE stakeholders.

Purpose of the NTS Environmental Report

BN prepares this document to satisfy DOE Order 231.1A *Environment, Safety and Health Reporting*. It is prepared in order 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 NTS Environmental Management System and characterize its performance, and (6) highlight significant environmental programs and efforts. This report meets these objectives for the NTS and its three Nevada satellite sites mentioned below.

Major Site Programs

The U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office (NNSA/NSO) directs the management and operation of the NTS and seven satellite sites across the nation. The NTS is located about 105 kilometers (km) (65 miles [mi]) northwest of Las Vegas. The seven satellite sites include three sites in Nevada (North Las Vegas Facility, Cheyenne Las Vegas Facility, and the Remote Sensing Laboratory – Nellis) and four sites in other states (Remote Sensing Laboratory – 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 NTS. BN is the Management and Operations (M&O) contractor accountable for the successful execution of work and ensuring that work is performed in compliance with environmental regulations. The NTS and its seven satellite sites all provide support to enhance the NTS as a site for weapons experimentation and nuclear test readiness. The three major NTS programs are Stockpile Stewardship, National Security Response Program and Operations, and Environmental Management.

Other Key Initiatives

Apart from the major site programs, other NTS activities include demilitarization activities, controlled spills of hazardous material at the Non-Proliferation Test and Evaluation Complex (NPTEC) (formerly known as the Hazardous Materials Spill Center) for research purposes, remediation of industrial sites, processing of waste destined for the Waste Isolation Pilot Plant in Carlsbad, New Mexico, disposal of radioactive and mixed waste, and environmental research. In addition, there are continued efforts to bring other business to the NTS, such as aerospace and alternative energy technology development and support of U.S. Department of Homeland Security National Center for Combating Terrorism.

Environmental Performance Measure Programs

During the conduct of the major programs and other key initiatives mentioned above, NNSA/NSO complies with applicable environmental and public health protection regulations and strives to manage the land and facilities at the NTS as a unique and valuable national resource. For the identification of NTS environmental initiatives, BN relies upon BN's Integrated Safety Management System (ISMS), contractual Work Smart Standards (WSS), and the 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 NTS missions are accomplished safely and in a manner which protects the environment. Implementation of an ISMS at the NTS was verified by NNSA/NSO in July 2001. NNSA/NSO oversees ISMS implementation through the Integrated Safety Management Council. Each Council member performed a self-assessment in September 2004 and verified that the ISMS continues to be effectively implemented at the NTS.

WSS are an integral part of the ISMS whereby hazards and environmental aspects of work are identified and standards of operation are established that are specific to the work environment, its associated hazards, and its threats to the environment. WSS are developed at the management level with the most expertise in the work. NNSA/NSO approved the initial complete set of BN WSS in September 1996. The approved WSS identify within each BN program the contractual commitment to meet applicable laws, regulations, and policies which protect the public and the environment. Compliance with WSS is tracked through management assessments.

In 2000, Executive Order (EO) 13148 *Greening of the Government Through Leadership in Environmental Management* was issued. This EO requires all federal agencies to adopt an environmental management system (EMS). EMSs are designed to incorporate concern for environmental performance throughout an organization, with the ultimate goal being continual reduction of the organization's impact on the environment. DOE requires contractors who operate DOE sites to develop an EMS and expects full integration of their EMS into their ISMS by December 2005. In 2004, the ISMS Program Plan was updated to specify that the EMS and DOE Order 450.1 are the method by which the environmental part of ISMS is implemented (see Section 17.0). A committee during 2004 was formed that identified priority areas of improvement (Objectives) and is starting to identify organization specific goals (Targets) within these priority areas. These Targets and Objectives will be approved by the Executive Safety Committee, and the progress will be tracked and reported. During 2004, the employee environmental awareness program was expanded. Copies of the revised Environmental Policy were mailed to BN organizations, posted on bulletin boards and the BN intranet home page. Articles about the new Policy and the EMS were put in BN employee publications, and a section on environmental issues was added to the BN project manager training course. Full integration of EMS into ISMS should be complete by the deadline of December 31, 2005.

Performance Measures

Performance measures are used to evaluate the achievement of organization or process goals and to identify the need to institute changes in an organization or process. The NTS performance measures, defined from the WSS, relate to protection of the environment and the public from effects of NTS operations. These performance measures apply to several programs and processes. They include (1) the potential radiological dose received by the maximally exposed offsite individual, (2) the identification, notification, and mitigation of spills and releases to the environment, (3) the reduction in the generation of wastes, and (4) compliance with applicable environmental protection regulations. The performance measures tracked by each process or program (e.g., air quality protection) are consolidated and presented in this report in Section 2.0, Compliance Summary.

Offsite Radiological Releases into Air

An oversight radiological air monitoring program is run by the Community Environmental Monitoring Program (CEMP) and is coordinated by the Desert Research Institute (DRI) of the University and Community College System of Nevada under contract with NNSA/NSO (see Section 6.0). Its purpose is to provide monitoring for radionuclides that might be released from the NTS. A network of 26 CEMP stations, located in selected towns and communities within 386 km (240 mi) from the NTS, was operated continuously during 2004. The CEMP stations monitored gross alpha and beta radioactivity in airborne particulates using low-volume particulate air samplers, penetrating gamma radiation using thermoluminescent dosimeters (TLDs), gamma radiation exposure rates using pressurized ion chamber (PIC) detectors, and meteorological parameters using automated weather instrumentation.

No airborne radioactivity related to historic or current NTS operations was detected in any of the samples from the CEMP particulate air samplers during 2004. Gross alpha and gross beta radioactivity was detected at all CEMP stations at levels which were consistent with previous years and which reflect radioactivity from naturally-occurring radioactive materials (see Section 6.1.1.1). No man-made gamma-emitting radionuclides were detected.

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.

The highest total annual gamma exposure measured offsite, based on PIC data, was 178 milliroentgen (mR) at Milford, Utah. The lowest offsite gamma exposure rate measured was 67 mR per year (yr) at Pahrump, Nevada (see Section 6.1.3).

Onsite Radiological Releases into Air

A network of 19 air sampling stations (three having low-volume particulate air samplers, one having a tritium water vapor sampler, and 15 having both) and a network of 107 TLDs were used to monitor onsite NTS radioactive emissions in 2004 (see Section 3.1). The 2004 monitoring results were also used, in conjunction with U.S. Environmental Protection Agency (EPA)-approved mathematical models, to calculate the radiological dose to the public residing within 80 km (50 mi) of the NTS. There were minimal radioactive air emissions from current NTS projects in 2004 which came from only one NTS facility: Building 650 in Mercury, Area 23. A total of 0.000042 Curies (Ci) of tritium gas was released at Building 650 during the calibration of laboratory equipment (see Section 8.1.2).

Gross alpha and gross beta radioactivity was detected at all stations on the NTS, but no increasing trend in levels of radioactivity was observed at any station (see Section 3.1.4.6). The highest average gross alpha and gross beta activities were seen at Sugar Bunker, an unoccupied structure used during past nuclear testing, located about 1 km (0.6 mi) south-southwest of the Area 5 Radioactive Waste Management Complex (RWMC). The lowest average gross alpha and beta activities were measured at the Little Feller 2 air sampler in Area 18 and the 3545 Substation air sampler in Area 16, respectively. The mean gross alpha concentrations were slightly higher at the locations near sites with known deposits of radioactivity from past nuclear tests in Areas 1, 3, 5, 6, 9, 10, and 20. The mean gross beta concentrations varied less by location throughout all NTS areas. Both the weekly gross alpha and gross beta concentrations continued to show a general temporal variation that was common for all locations.

Background gamma radiation exposure rates on the NTS, measured at TLD stations located away from radiologically contaminated sites, ranged from 60 to 156 mR/yr during 2004 (see Section 5.3). Direct gamma radiation exposure to the public from NTS operations was negligible (see Section 5.3.1). Areas accessible to the public (e.g., the NTS entrance gate) had exposure rates comparable to natural background rates, with one exception. During the fourth quarter of 2004, the daily average gamma radiation exposure rate measured on the west side of the parking area outside the NTS entrance gate rose to 358 mR/yr. It is likely that waste shipments entering the NTS were responsible for this increase in the fourth quarter. Radionuclide contamination at legacy sites has resulted in localized elevated gamma exposure rates, but the public has no access to these sites nor are there NTS personnel working in these areas. The highest exposure rate at monitored locations was 888 mR/yr at Schooner, one of the legacy Plowshare sites on Pahute Mesa (see Table 5-1). Sixteen TLD stations monitor the RWMC in Areas 3 and 5 (see Section 5.3.2). The mean gamma exposure rate at these stations was 148 mR/yr; exposure rates ranged from 106 to 401 mR/yr. The public is not allowed unsupervised access to these sites.

Several man-made radionuclides from legacy contamination were measured in air samples at levels above their minimum detectable concentrations (MDCs) in 2004: americium-241 (^{241}Am); tritium (^{3}H); and plutonium isotopes (^{238}Pu and $^{239+240}$Pu) (see Section 3.1.4). These were attributed to the resuspension of contamination in surface soils from legacy sites and to the evaporation and transpiration of tritium from the soil, plants, and containment ponds at legacy sites. The highest mean level of ^{241}Am (48.07×10^{-18} micro-curies per milliliter [μCi/mL]) was detected at Bunker 9-300 in Area 9, a vacant building located within an area of known soil contamination from past nuclear tests.

The highest mean level of tritium (364.69 x 10^{-6} picocuries [pCi]/mL) was detected at Schooner, site of the second-highest yield Plowshare cratering experiment on the NTS where tritium-infused ejecta surrounds the crater. The highest mean levels of plutonium isotopes in air were at Bunker 9-300 (5.61 x 10^{-18} µCi/mL for ^{238}Pu and 294.12 x 10^{-18} µCi/mL for $^{239+240}$Pu). The relatively high plutonium values occur most often at the Bunker 9-300 air sampling station, due to historical nuclear testing in Area 9 and surrounding Areas 3, 4, and 7. Uranium isotopes are also detected in air samples collected in areas where depleted uranium ordnance have been used or tested. However, the samples' isotopic ratios were what one would expect from naturally-occurring uranium in soil and not from either man-made depleted or enriched uranium.

Both $^{239+240}$Pu and tritium continued to show overall decreasing trends in concentrations at air sampler sites (see Section 3.1.4.3 and Section 3.1.4.5). The decrease in tritium air concentrations is a result of the cessation of testing in 1992 (no additional releases), of radioactive decay (half-life of tritium is 12 years), and of its depletion from the soil over the years due to evaporation and transpiration (uptake and release of water through plants). Annual mean tritium concentrations, grouped by NTS administrative areas, have dropped a factor of one thousand for all areas except Area 20 (where Schooner is located). The gradual decrease in plutonium concentrations in air over time is attributed to its dispersal by wind and its weathering in the ground where it is bound to less mobile particles.

Offsite Radiological Monitoring of Water

Offsite water monitoring conducted annually by BN (see Section 4.1), as well as by DRI through the CEMP (see Section 6.2), verifies that there has been no offsite migration of man-made radionuclides from NTS underground contamination areas.

In 2004, BN conducted radiological monitoring of 14 offsite wells and 2 offsite springs. The 14 wells include 6 private domestic and local community wells and 8 NNSA/NSO wells drilled for hydrogeologic investigations including groundwater flow modeling. All of the BN-sampled wells and springs are in Nevada within 18.6 mi (30 km) from the western and southern borders of the NTS. The DRI, through the CEMP, sampled 24 offsite sampling locations in 2004. They include 17 wells, 3 water supply systems, and 4 springs located in selected towns and communities within 240 mi from the NTS. One site, the Beatty Water and Sewer well, is sampled by both BN and CEMP.

CEMP and BN water samples are both analyzed for tritium. To be able to detect the smallest possible amounts of tritium in offsite water supplies, enriched tritium analyses were run on all samples. The MDC for tritium using this enrichment process was approximately 25 pCi/L and 26 pCi/L for the BN and the CEMP samples, respectively. Without enrichment, the MDC for tritium typically ranges from 200-400 pCi/L. To put these values in perspective, the drinking water Maximum Contaminant Level (MCL) for tritium is 20,000 pCi/L.

BN offsite water samples are also analyzed for man-made gamma-emitting radionuclides that would signify contamination from nuclear testing and for gross alpha and gross beta activity to determine if alpha or beta activity at any well or spring are increasing over time.

CEMP results this year, as in past years, continue to verify that no contaminated groundwater has migrated beyond the NTS boundaries into surrounding water supplies used by the public. Samples from only two locations, Boulder City and Henderson municipal water supplies, contained tritium at levels barely above detection (see Section 6.2.4). All other wells had non-detectable levels of tritium. These two municipal water systems obtain water from Lake Mead, which has documented levels of residual tritium persisting in the environment that originated from global atmospheric nuclear testing.

Similarly, the results of BN offsite water monitoring verified that there has been no offsite migration of man-made radionuclides from NTS underground contamination areas. BN detected tritium in only one offsite well, PM-3 at 20 pCi/L, slightly above the sample-specific MDC (see Section 4.1.4). A duplicate sample from PM-3 collected on the same date was below the sample-specific MDC. All offsite well and spring samples contained detectable gross alpha and gross beta activity which are believed to come from natural sources. Gross alpha was found at levels which exceeded drinking water standards at only one offsite monitoring well, ER-OV-02. This well is an NNSA/NSO well that is not used for drinking water and is closed to the public. This well produces water from a volcanic aquifer that may have relatively high quantities of natural alpha-yielding elements in the host rock. All gross beta concentrations in samples from offsite wells sampled by BN were less than the EPA Level of Concern for drinking water. No offsite wells contained any man-made gamma-emitting radionuclides.

Onsite Radiological Releases into Water

Radioactivity in onsite groundwater and surface waters on the NTS is monitored to (1) ensure that NTS drinking water is safe, (2) determine if permitted facilities on the NTS are in compliance with permit discharge limits for radionuclides, (3) estimate radiological dose to onsite wildlife using natural and man-made water sources, and (4) verify that groundwater is being protected from disposed radioactive wastes at the Area 3 and Area 5 Radioactive Waste Management Sites (RWMSs). In 2004, the onsite monitoring network was comprised of 10 potable water supply wells, 12 monitoring wells (which include 3 compliance wells for the Area 5 RWMS and 1 compliance well for the Area 23 sewage lagoon), 1 tritiated water containment pond system, and 2 sewage lagoons.

The 2004 data continue to indicate that underground nuclear testing has not impacted the NTS potable water supply network (see Section 4.1.6). All of the water samples from the ten supply wells had non-detectable concentrations of tritium and man-made gamma-emitting radionuclides. The gross alpha and gross beta radioactivity detected in potable water supply wells represent the presence of naturally-occurring radionuclides.

Four onsite monitoring wells (PM-1, U-19BH, UE-7NS, and WW A) had detectable concentrations of tritium in 2004 ranging from 23 ± 14 to 475 ± 27 pCi/L, all well below the MCL of 20,000 pCi/L (see Section 4.1.7). Each of the four monitoring wells is located within 1 km (0.6 mi) of an historical underground nuclear test; all have consistently had detectable levels of tritium in past years. There were also tritium levels above the MDC from three wells sampled to validate performance of a radioactive waste disposal pit at the Area 5 RWMS (UE5PW-1, UE5PW-2, and UE5PW-3). Tritium concentrations ranged from 30 ± 12 to 37 ± 13 pCi/L in these wells; in each case duplicate samples collected at the same times from each well had measured tritium levels below their MDCs.

Five constructed basins collect and hold water discharged from E Tunnel in Area 12, where nuclear testing was conducted in the past. Tunnel effluent water and sediment samples are analyzed for tritium, gross alpha, gross beta, and other radionuclides. Most samples had detectable radionuclide concentrations in 2004 (see Section 4.1.8). The average tritium concentration in tunnel effluent water was 710,000 pCi/L, lower than the limit allowed under a discharge permit (1,000,000 pCi/L). Gross alpha and gross beta values in 2004 were also less than their permitted limits: 13.4 pCi/L with a permissible limit of 35.1 pCi/L for gross alpha and 72 pCi/L with a permissible limit of 101 pCi/L for gross beta.

Tritiated water is also pumped into lined sumps during studies conducted by the Underground Test Area (UGTA) Project. To characterize the groundwater regime under the NTS, suitable wells are being drilled and existing wells re-completed in the vicinity of certain underground tests and at other locations on the NTS designated by hydrologists. During these drilling operations, if the tritium level exceeds 200,000 pCi/L, contaminated water is pumped from the wells and diverted to lined containment ponds, as required by the state. During 2004, water containing tritium was pumped from Wells U-3cn PS#2, U-19ad PS#1, ER-20-5 #1, and ER-20-5 #3 into lined containment ponds. Levels of tritium in these ponds ranged from 113,000 pCi/L at ER-20-5 #3 to 38,000,000 pCi/L at ER-20-5 #1 (see Section 4.1.10).

Estimated Radiation Dose to the Public

Man-made radionuclides from past nuclear testing have not been detected in offsite groundwater in the past or during 2004. The only pathways, therefore, by which the offsite public could receive a radiation dose from NTS operations are from inhalation and ingestion.

Measured Background NTS Radiation Dose - Background gamma radiation exposure rates on the NTS were measured at eight TLD stations located away from radiologically contaminated sites; these ranged from 0.16 to 10.43 mR/day during 2004 (see Section 5.3). This equates to an annual estimated background external dose of 60 to 156 millirem per year (mrem/yr)[1] to a hypothetical person residing at those locations all year.

Inhalation Pathway - The radiation dose to the general public via just the air transport pathway was estimated using the air sampling results from six onsite EPA-approved "critical receptor" sampling stations. Among these six stations, the Schooner air station in the far northwest corner of the NTS experienced the highest concentrations of radioactive air emissions (see Section 3.1.5). An individual residing at this station would experience a dose from air emissions of 2.5 mrem/yr. This dose is less than the limit of 10 mrem/yr. No one resides at this location, of course; the dose at offsite populated locations 20-80 km from the Schooner station would be much lower due to wind dispersion.

Inhalation and Ingestion Pathway - The radiation dose to the general public from inhalation and ingestion of airborne radioactive contaminants was estimated using the air sampling results and air transport models. Estimates of radionuclide emissions from the following sources were used to compute total air emissions from source locations on the NTS: (1) NTS facilities; (2) the resuspension of legacy deposits of radionuclides in NTS soil; (3) the transpiration and evaporation of tritium at sites of past nuclear tests; and (4) the evaporation of tritium from ponds used to contain tritium-contaminated groundwater. The radiation dose to the general public is expressed as the effective dose equivalent [EDE]) to the maximally-exposed individual (MEI); this was computed to be 0.12 mrem/yr (0.0012 mSv/yr) for a resident of Cactus Springs, Nevada (see Section 8.1.3). This is well below the dose limit of 10 mrem/yr specified by the National Emission Standards for Hazardous Air Pollutants under the Clean Air Act. This dose is consistent with those calculated for past years.

Ingestion Pathway for Radionuclides in Game Animals - Game animals from different contaminated NTS sites are trapped each year and analyzed for their radionuclide content. These results are used to construct worst-case scenarios for the dose to hunters who might consume these animals if the animals moved off the NTS. NTS game animals include pronghorn antelope, mule deer, chukar, Gambel's quail, mourning doves, cottontail rabbits, and jackrabbits. The MEI who is a hunter is assumed to eat 20 doves, 20 quail, 20 chukar, 20 jackrabbits, and 1 pronghorn antelope in a year. It is also assumed that the dose from each animal consumed is the average calculated dose for that species which was sampled from the NTS location where the highest levels of radionuclides in that species' muscle tissues were found. The resultant potential dose from consuming NTS game animals representative of those sampled is 0.39 mrem/yr (see Section 8.1.4). To put this dose into perspective, it is less than the dose from cosmic radiation received by an individual while on a one-hour plane ride at 39,000 ft.

All Possible Pathways - The hypothetical MEI was also assumed to be a hunter who harvested NTS game animals and received the additional radiation dose of 0.39 mrem/yr. The resultant total radiation dose to the MEI attributable to NTS operations from all possible pathways combined was 0.51 mrem/yr (0.0051 mSv/yr (see Section 8.1.6) This dose is a very small fraction (0.15 percent) of the total radiation dose from naturally-occurring sources. This total dose is also well below the dose limit of 100 mrem/yr established by DOE Order 5400.5 *Radiation Protection of the Public and the Environment.*

The collective population dose within 80 km (50 mi) of the emission sources was estimated to be 0.47 person-rem/yr (0.0047 person-Sv/yr) (see Section 8.1.7).

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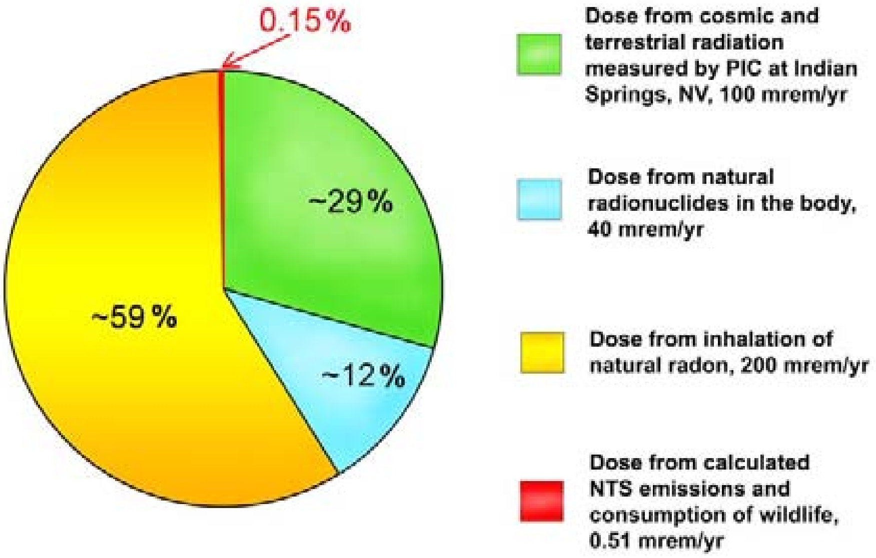
[1] Direct radiation exposure is usually measured in the unit milli-roentgen (mR), which is a measure of *exposure* in terms of a specified number of ionizations in air. Generally, the *dose* resulting from an exposure from the most common external radionuclides can be approximated by equating a 1 mR exposure with a 1 mrem (0.01 mSv) dose.

Estimated Radiation Dose to the General Public from the NTS in 2004

Pathway	Dose to Maximally Exposed Individual (mrem/yr)	(mSv/yr)	Percent of DOE 100-mrem/yr Limit	Estimated Collective Population Dose(a) (person-rem/yr)	(person-Sv/yr)
Air	0.12	0.0012	0.12	0.47(a)	0.0047
Water	0	0	0	0	0
Wildlife	0.39	0.0039	0.39	U(b)	U
All Pathways	0.51	0.0051	0.51	0.47(c)	0.0047

(a) Sum of radiation doses from all emission sources at each populated location within 80 km of emission sources multiplied by the population at each location, and then summed over all locations.
(b) Unable to make this estimate due to a lack of data on number of game animals harvested near the NTS by hunters in 2004.
(c) The dose contribution from wildlife is not included. It is likely to be negligible when averaged over the entire population within an 80-km radius.

Comparison of Radiation Dose to the MEI and the Natural Radiation Background (Percent of Total)



Onsite Non-Radiological Releases into Air

There were no discharges of non-radiological hazardous materials to offsite areas in 2004. Therefore, only onsite non-radiological environmental monitoring of NTS operations was conducted. Air quality was monitored on the NTS throughout the year as required by state of Nevada permits for those operations that release criteria air pollutants, hazardous air pollutants (HAPs), or toxic and hazardous chemicals. The NTS has been issued a Class II air permit from the state of Nevada. Class II permits are issued to facilities which emit small quantities of air pollutants within a year (less than 100 tons of each criteria air pollutant, or 10 tons of any one HAP, or 25 tons of any combination of HAPs).

An estimated 6.91 tons of criteria air pollutants were released on the NTS in 2004. They included: particulate matter equal to or less than 10 microns in diameter (PM10), carbon monoxide (CO), nitrous oxides (NO_X), sulfur dioxide (SO_2), and volatile organic compounds (VOCs) (see Section 3.2.1). The majority of these emissions (4.60 tons) were VOCs. The NPTEC facility, where controlled spills of hazardous materials are conducted, produced more VOCs than all other permitted NTS facilities. Total air emissions of lead, also a criteria pollutant, in 2004 was 10.4 pounds. The quantity of HAPS released in 2004 was 0.41 tons. No emission limits for any criteria air pollutants of HAPS were exceeded. On May 12, 2004, the state of Nevada conducted an inspection of the following facilities regulated by the NTS air quality permit: the Area 1 Aggregate Plant, Area 1 Batch Plant, and the NPTEC. There were no findings or exceedances of permit limits.

Asbestos is the only non-radiological HAP of regulatory concern on the NTS. In 2004, all materials containing regulated asbestos that were removed from NTS facilities were disposed of in the Mercury landfill. The quantities removed did not exceed EPA's notification threshold (see Section 3.2.7). The Mercury landfill documented receipt of 15 tons of such material in 2004.

A combined total of 5 tests consisting of 25 releases of hazardous chemicals were conducted at the Area 5 and the Area 25 Test Cell C NPTEC facilities in 2004 (see Section 3.2.4). An annual report of the types and amounts of chemicals released and the test plans and final analysis reports for each chemical release were submitted to the state. No ecological monitoring was performed since each test posed a very low level of risk to the environment and biota.

Onsite Non-Radiological 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 NTS. Therefore, no Clean Water Act National Pollution Discharge Elimination System (NPDES) permits are required for NTS operations.

In 2004, industrial discharges on the NTS were limited to two operating sewage lagoon systems, the Area 6 Yucca Lake and Area 23 Mercury systems. Under the conditions of state of Nevada operating permits, liquid discharges to these sewage lagoons are tested quarterly for biochemical oxygen demand, pH, and total suspended solids. Annually, sewage lagoon pond waters are sampled for a suite of toxic chemicals. In 2004, quarterly and annual analyses of sewage influent and pond waters, respectively, both showed that all water measurements were within permit limits (see Section 4.2.3). The majority of samples had concentrations of toxic chemicals below detectable levels. The few toxic chemicals which were detectable were found at levels all less than 0.1 percent of their permit limits.

Onsite Non-Radiological Drinking Water Quality

NNSA/NSO operates a network of nine permitted wells that comprise three permitted public water systems on the NTS; these supply the potable water needs of NTS workers and visitors. In addition, three private water systems are maintained but are not regulated under state permit. NNSA/NSO hauls potable water for use in decontamination and sanitation for work locations at the NTS that are not part of a public water system. Monitoring results indicate that water samples from the three public water systems and from the potable water hauling trucks met the National Primary and Secondary Drinking Water Standards in 2004 (see Section 4.2.1). Samples from two of the water systems slightly exceeded a Secondary Standard for pH. No monitoring of the private water systems was conducted.

Non-Radiological Releases into Air and Water at the NLVF

Like the NTS, the North Las Vegas Facility (NLVF) is regulated for the emission of criteria air pollutants and HAPs. Air quality operating permits are maintained for a variety of equipment at the NLVF. There are no monitoring requirements associated with these permits. The Clark County Health District requires submittal of an annual emissions inventory. The estimated quantities of criteria air pollutants and HAPs emitted at the NLVF in 2004 were minimal; they ranged from 0.0009 tons for HAPS to 0.679 tons for nitrous oxides (see Appendix B, Section B.1.3).

Water discharges at the NLVF are regulated by a permit with the City of North Las Vegas (CNLV) for sewer discharges and by temporary NPDES discharge permits with the state for groundwater discharges into the CNLV storm water drainage system. The NPDES permits were obtained for a groundwater characterization and dewatering project at the facility. Self-monitoring and reporting of the levels of non-radiological contaminants in sewage and industrial outfalls is conducted. In 2004, all water samples from NLVF outfalls and all sludge and liquid samples from the NLVF sand/oil interceptor had contaminant levels below established permit limits (see Appendix B, Section B.1.1). An unauthorized discharge of tritiated water occurred at the NLVF in 2004, as discussed below.

Accidental or Unplanned Environmental Releases or Occurrences

On the NTS, one environmental occurrence was reportable in 2004. About 75 gallons of oil leaked onto the soil from a 650-gallon oil holding tank mounted on a lubrication truck (see Section 2.11).

At the NLVF, one environmental occurrence was reportable in 2004 (see Appendix B, Section B.1.1.2). Parts of Building A-1 at the NLVF were contaminated with tritium by a previous contractor in 1995. During a pre-inspection and safety walkthrough in 2004, it was observed that a 5-gallon bucket of water was located near a floor drain and under the drainpipe of the air-handling unit in Room 4520 of Building A-1. The bucket was being used to catch condensate from the air handler. Tritiated water from the bucket had been emptied into the floor drain, constituting an unauthorized discharge to the city of North Las Vegas sewer system. Water samples from the bucket indicated a tritium concentration of 23,000 ± 4,000 (pCi/L). NNSA/NSO reported the unauthorized discharge to the CNLV. Several actions required by the CNLV were taken to prevent future discharges and to document that the tritium was not detectable at the sewage outfall for the NLVF following each of the discharge incidents.

During preparation of this report, EPA informed the state that it was in direct violation of the Clean Water Act by issuing the temporary NPDES discharge permits for the NLVF that allowed discharge of pumped groundwater to the CNLV storm water drainage system. BN will implement one of several corrective action options presented by the state in order to comply with the EPA ruling and resolve this issue.

Pollution Prevention/Waste Minimization Activities

Decommissioned NTS buildings destined for disassembly and disposal were donated or sold for reuse. This waste minimization effort diverted approximately 27.9 metric tons (mtons) (30.8 tons) of waste from the NTS landfills in 2004. The Material Exchange Program reused 1.97 mtons (2.17 tons) of non-hazardous chemicals, equipment, and supplies. The BN Payroll Department converted to a paperless, electronic time keeping system. This new process eliminated the need for paper timecards and reduced the amount of paper waste by about 2.0 mtons (2.2 tons). Other significant waste reduction efforts continued in 2004, such as selling scrap ferrous metal to a vendor for recycling (751.2 mtons [826.3 tons]) and offsite recycling of mixed paper and cardboard (518.7 mtons [570.6 tons]). Overall, a reduction of 114.8 mtons (126.3 tons) of hazardous wastes and 1,437.5 mtons (1,581.3 tons) of solid wastes were realized in 2004 (see Section 11.0).

Overall Compliance with Environmental Laws, Regulations, and Policies

NTS compliance status with over 100 applicable environmental laws, regulations, and policies are summarized in Section 2.0. The major categories of these drivers are listed below along with the 2004 percent compliance within each category. Where compliance for a category is not 100 percent, the non-compliance incidents are noted.

Environmental Compliance Summary for the NTS in 2004

Category	Number of Compliance Measures/Actions	Percent in Compliance
Air Quality	18	94 One incidence of excessive fugitive dust
Water Quality and Protection	26	96 pH (a Secondary Standard for water quality) was exceeded in samples from two NTS public water systems
Radiation Dose Protection	12	100
Radioactive and Non-Radioactive Waste Management and Environmental Restoration	16	100
Hazardous Materials Control and Management	11	100
Pollution Prevention and Waste Minimization	9 measurable annually 5 future goals measurable in 2005	100 NA
Historic Preservation and Cultural Resource Protection	12	100
Conservation and Protection of Biota and Wildlife Habitat	13	92 16 accidental bird deaths attributable to NTS activities (e.g., roadkill), represented 8 species protected as migratory birds

1.0 Introduction

1.1 Site Location

The U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office (NNSA/NSO) directs the management and operation of the Nevada Test Site (NTS) which is located in Nye County in south-central Nevada (Figure 1-1). The southeast corner of the NTS 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, located at the southern end of the NTS, is the main base camp for worker housing and administrative operations for the NTS.

The NTS encompasses about 3,561 square kilometers (km^2) (1,375 square miles [mi^2]). 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 NTS is surrounded on all sides by federal lands. As shown in Figure 1-1, the NTS is bordered on the southwest corner by the Yucca Mountain Project Area, on the west and north by the Nevada Test and Training Range (NTTR) (previously known as the Nellis Air Force Range), on the east by an area used by both the NTTR and the Desert National Wildlife Range (DNWR), and on the south by Bureau of Land Management lands. The combination of the NTTR and the NTS represents one of the larger unpopulated land areas in the United States, comprising some 14,200 km^2 (5,470 mi^2).

1.2 Environmental Setting

The NTS is located in the southern part of the Great Basin, the northern-most sub-province of the Basin and Range Physiographic Province. The NTS 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 NTS by very large volcanic calderas (Figure 1-2).

The principal valleys within the NTS 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 NTS via the Fortymile Wash. The dominant highlands of the NTS 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 NTS is 823 m (2,700 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 NTS has been altered by historic 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 a lesser number of "craters" on Pahute and Rainier Mesas. Shallow detonations were also performed during Project Plowshare to determine the potential uses of nuclear devices for large-scale excavation.

Figure 1-3 shows the general layout of the NTS, including the location of major facilities and the numbered operational areas of the NTS referred to in this report. The geographical areas previously used for nuclear testing are also shown in Figure 1-3.

The reader is directed to Appendix A where the geology, hydrology, climatology, ecology, and cultural resources of the site are described.

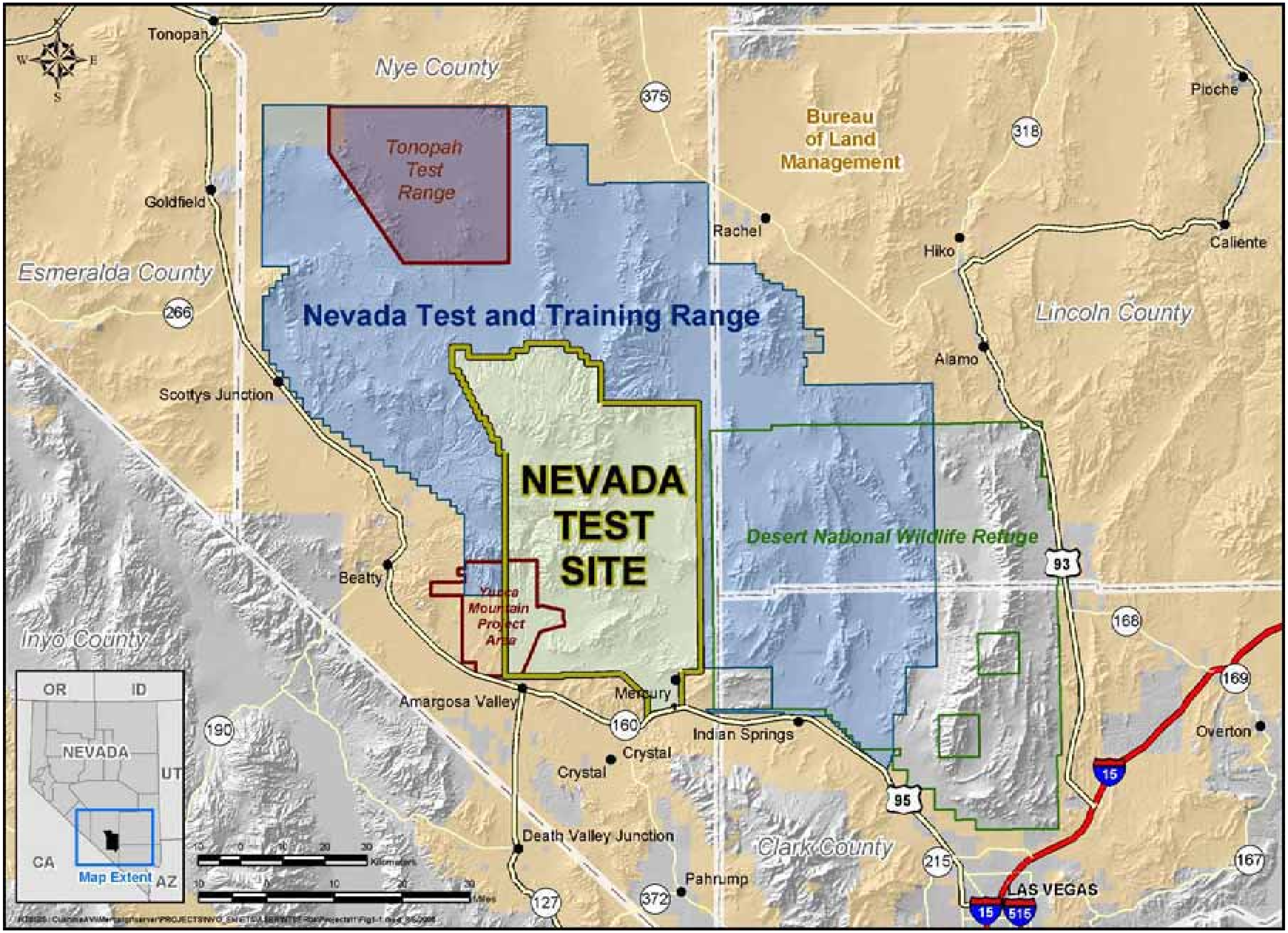


Figure 1-1. NTS vicinity map

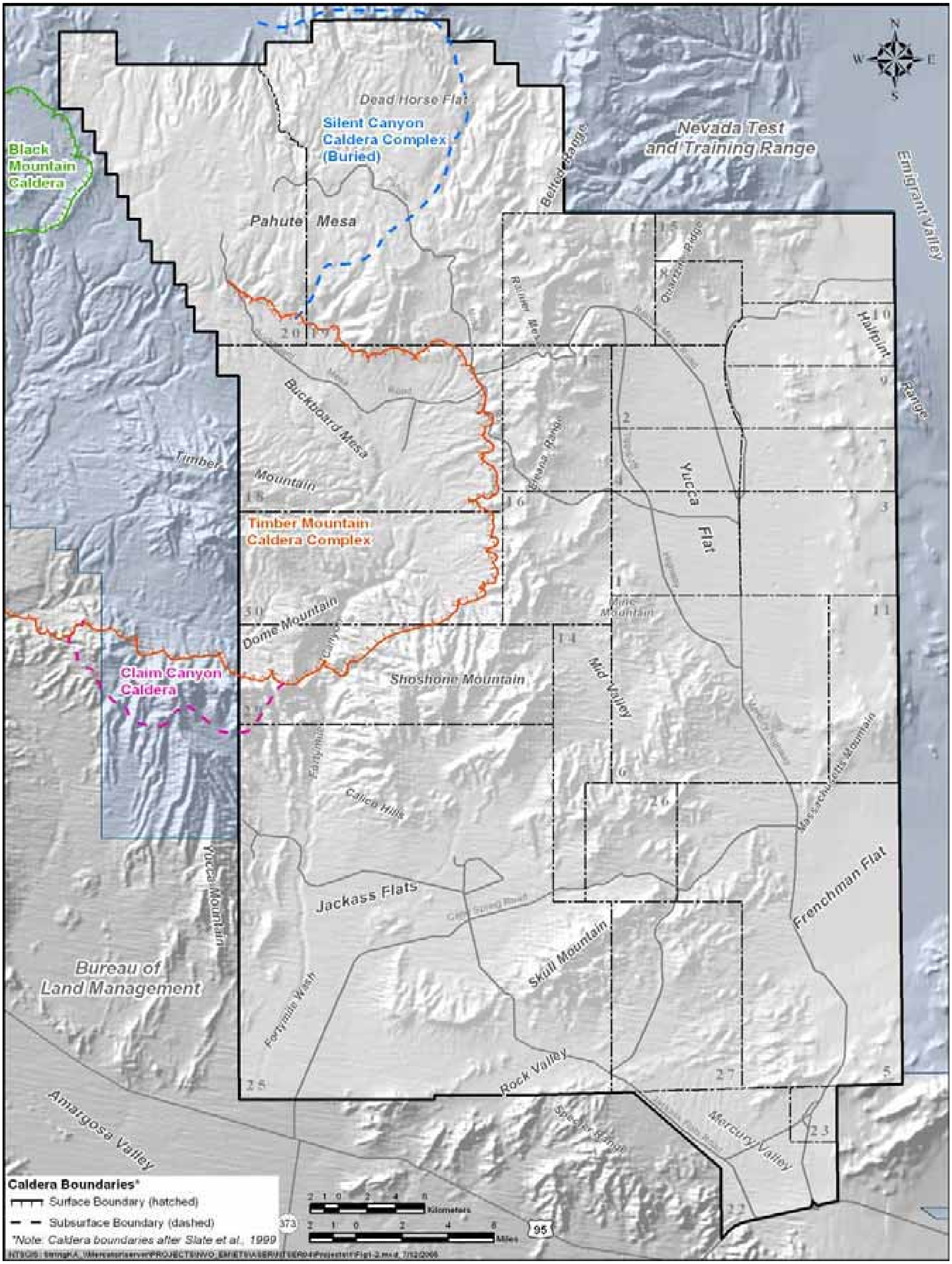


Figure 1-2. Major topographic features of the NTS

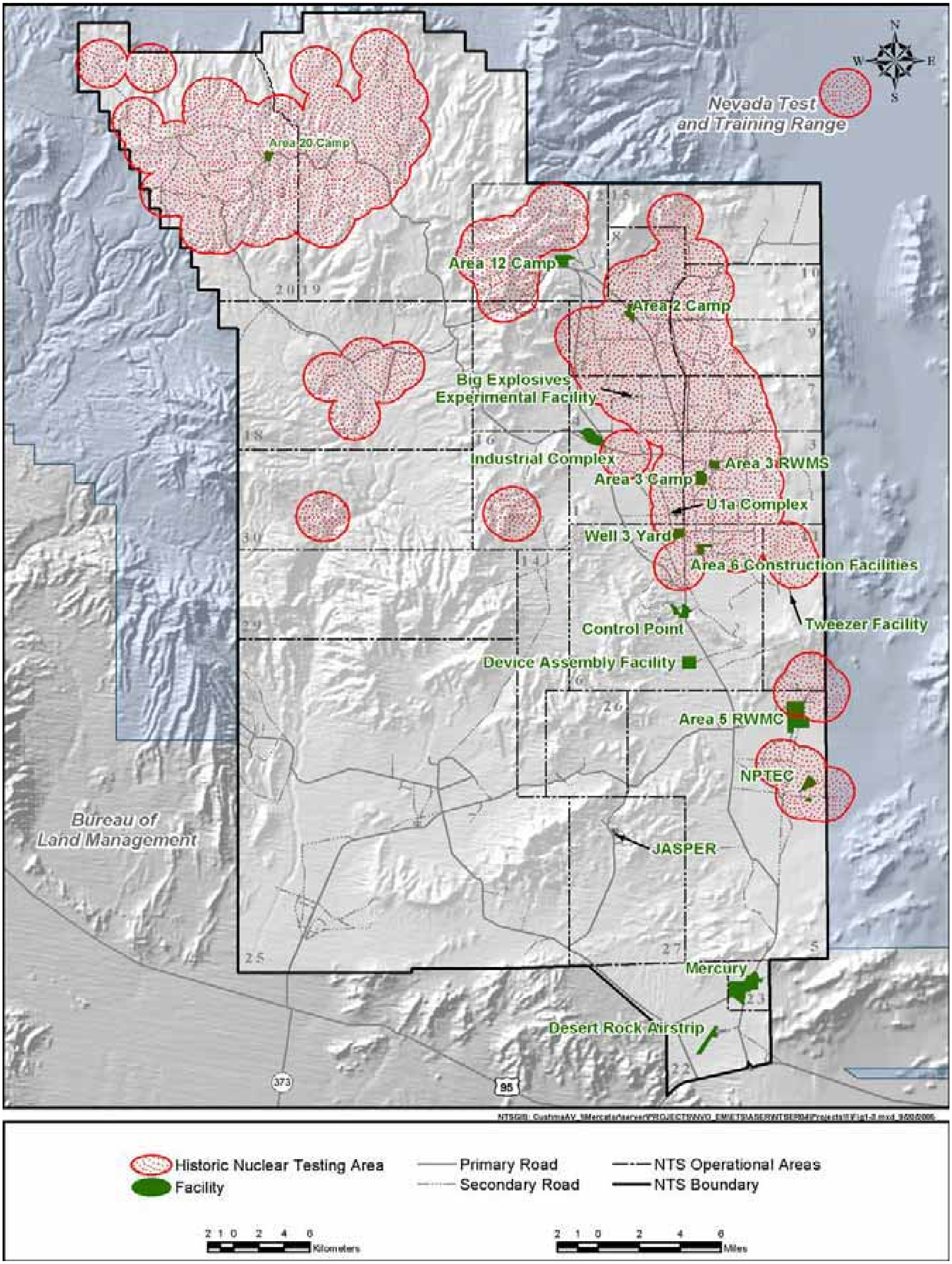


Figure 1-3. NTS operational areas, principal facilities, and past nuclear testing areas

1.3 Site History

The history of the NTS, 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 now known as the NTS was under the jurisdiction of Nellis Air Force Base and was part of the Nellis Bombing and Gunnery Range. The NTS was established in 1951 to be the primary location for testing the nation's nuclear explosive devices and supported nuclear testing from 1951 to 1992. The NTS currently conducts only subcritical nuclear experiments.

Atmospheric Tests - Tests conducted through the 1950s were predominantly atmospheric tests. These tests involved a nuclear explosive device detonated while 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 NTS boundary at the south end of the NTTR, and four others involving storage-transportation are at the north end of the NTTR. These test areas have been monitored for radionuclides in the past (1996 – 2000) in support of remediation projects, two of which were completed. The three remaining sites will be monitored again once restoration of these sites begins. All nuclear device tests are listed in *United States Nuclear Tests, July 1945 through September 1992* (DOE, 2000a).

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 moratorium that began October 31, 1958, but was resumed in September 1961 after tests by the Union of Soviet Socialist Republics began. Since late 1962, nearly all tests have been conducted in sealed vertical shafts drilled into Yucca Flat and Pahute Mesa or in horizontal tunnels mined into Rainier Mesa. From 1951 to 1992, a total of 828 underground nuclear tests were conducted at the NTS. Approximately one third of these tests were detonated near or below the water table; this has resulted in the contamination of groundwater in some areas. In 1996, DOE, U.S. Department of Defense (DoD), and the state of Nevada entered into a Federal Facilities Agreement and Consent Order (FFACO) which established Corrective Action Units (CAUs) on the NTS that delineated and defined areas of concern for groundwater contamination.

Cratering Tests - Five earth-cratering (shallow-burial) tests were conducted over the period of 1962 through 1968 as part of the Plowshare Program that explored peaceful uses of nuclear explosives. The first and highest yield Plowshare crater test, Sedan (PHS, 1963) was detonated at the northern end of Yucca Flat on the NTS. The second highest yield crater test was Schooner, located in the northwest corner of the NTS. 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 tests and experiments at the NTS have included the Bare Reactor Experiment - Nevada (BREN) series in the 1960s conducted in Area 25. These tests were performed with a 14 million electron volt (MeV) neutron generator mounted on a 465-meter (1,530-feet) steel tower used to conduct neutron and gamma-ray interaction studies on various materials. From 1959 through 1973, a series of open-air nuclear reactor, nuclear engine, and nuclear furnace tests were conducted in Area 25, and a series of tests with a nuclear ramjet engine were 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, radio-kryptons.

1.4 Site Mission

NNSA/NSO directs the management and operation of the NTS and seven satellite sites across the nation. Los Alamos National Laboratory (LANL), Lawrence Livermore National Laboratory (LLNL), and Sandia National Laboratories (SNL) are the principal organizations that sponsor and implement the nuclear weapons programs at the NTS. Bechtel Nevada (BN) is the Management and Operations (M&O) contractor who is accountable for the successful execution of work and ensuring that work is performed in compliance with environmental regulations. The seven satellite sites of the NTS include the North Las Vegas Facility (NLVF), Cheyenne Las Vegas Facility (CLVF), Remote Sensing Laboratory (RSL) – Nellis, RSL – Andrews, Livermore Operations, Los Alamos Operations, and

Special Technologies Laboratory. These sites all provide support to enhance the NTS as a site for weapons experimentation and nuclear test readiness. This report addresses environmental monitoring and compliance only at the NTS and its three Nevada satellite sites: NLVF, CLVF, and RSL-Nellis (see Appendix B). The three major NTS programs include: (1) Stockpile Stewardship, (2) National Security Response Program and Operations, and (3) Environmental Management.

NTS Program Missions

Stockpile Stewardship – The primary mission of this program is to conduct high-hazard operations in support of defense-related nuclear and national security experiments and to maintain the capabilities to resume underground nuclear weapons testing, if directed.

National Security Response Program and Operations – The goal of this program is to provide support facilities, training facilities, and capabilities for government agencies involved in counterterrorism activities, emergency response, first responders, national security technology development, and nonproliferation technology development.

Environmental Management – This program includes Waste Management and Environmental Restoration. The goals of this program are to manage and safely dispose of low-level waste received from DOE and DoD-approved facilities throughout the United States and mixed low-level waste generated in Nevada by NNSA/NSO operations, safely manage and characterize for offsite disposal hazardous and transuranic wastes, characterize and remediate the environmental legacy of nuclear weapons and other testing at the NTS and at offsite locations, and develop and deploy technologies that enhance environmental restoration.

1.5 *Primary Operations and Activities*

NTS activities in 2004 continue to be diverse, with the primary role being to help ensure that the existing United States stockpile of nuclear weapons remains safe and reliable. Facilities that support this mission include the U1a Facility, Big Explosives Experimental Facility (BEEF), Device Assembly Facility (DAF), and Joint Actinide Shock Physics Experimental Research (JASPER) Facility. Other NTS activities include demilitarization activities; controlled spills of hazardous material at the Non-Proliferation Test and Evaluation Complex (NPTEC) (formerly known as the Hazardous Materials Spill Center); remediation of industrial sites; processing of waste destined for the Waste Isolation Pilot Plant in Carlsbad, New Mexico; disposal of radioactive and mixed waste; and environmental research. In addition, there are continued efforts to bring other business to the NTS, like aerospace and alternative energy technologies and support of U.S. Department of Homeland Security National Center for Combating Terrorism work.

1.6 *Demography*

The population of the area surrounding the NTS is predominantly rural. The population estimates for Nevada communities has been estimated by the Nevada State Demographer Office (NSDO) up through July 1, 2004 (Hardcastle, 2005). The annual population estimate for Nevada counties, cities, and unincorporated towns is 2,410,768, with all but 695,431 residing in Clark County. The total population estimate for Nye County is 38,131 and includes the communities of Amargosa Valley (1,211), Beatty (981), Gabbs (316), Manhattan (128), Pahrump (30,465), Round Mountain (767), and Tonopah (2,341). The largest of the Nye County communities is Pahrump Valley, which is approximately 50 mi (80 km) south of the NTS Control Point facility, which is near the center of the NTS (see Figure A-2). Neighboring Lincoln County to the east of the NTS includes a few small communities including Alamo (441), Caliente (1,014), Panaca (552), and Pioche (669). Neighboring Clark County is the major population center of Nevada and has an estimated total population of 1,715,337.

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 during mild weather.

The extreme southwestern region of Utah is more developed than the adjacent portion of Nevada. The population estimates for Utah communities are based on the 2000 Census data and were obtained from the U.S. Census Bureau. The largest community is St. George, located 220 km (137 mi) east of the NTS, with a population of 49,663. The next largest town, Cedar City, is located 280 km (174 mi) east-northeast of the NTS and has a population of 20,527.

The extreme 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 NTS, with an estimated population of 37,325, and Kingman, located 280 km (174 mi) southeast of the NTS, with an estimated population of 24,600 (July 1, 2004 population estimates, Arizona Department of Economic Security, 2004).

The offsite population density within an 80-km radius of all emission sources of radioactivity on the NTS is about 1.0 persons/km^2 (2.6 persons/mi^2). In comparison, the 48 contiguous states have a population density of about 36 persons/km^2 (94 persons/mi^2) (U.S. Census Bureau, 2005).

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2.0 Compliance Summary

Environmental regulations pertinent to operations on the Nevada Test Site (NTS) and its Nevada satellite facilities (North Las Vegas Facility [NLVF], Cheyenne Las Vegas Facility [CLVF], and Remote Sensing Laboratory [RSL]-Nellis) are listed in this Compliance Summary. They include federal and state laws, state permit requirements, Executive Orders (EOs), DOE Orders, and state agreements. They dictate how the U. S. Department of Energy, National Nuclear Security Administration Nevada Site Office (NNSA/NSO) conducts operations on and off the NTS to ensure the protection of the environment and the public. The regulations are grouped by topic. A compliance status table is presented for each topical group of regulations. Each table lists those measures or actions which are tracked or performed annually to ensure compliance with a regulation. A description of the field monitoring efforts, actions, and results which support the data in each table can be found in subsequent sections of this document, as noted in the "Reference Section" column of each table. Non-compliance incidents or compliance issues, if any, are included in the topical subsections along with a listing of compliance reports generated during the reporting year. The last table presented in this section is a list of all NNSA/NSO environmental permits for the NTS and its satellite facilities for the year 2004.

2.1 Air Quality

Clean Air Act (CAA), National Emission Standards for Hazardous Air Pollutants (NESHAP) – Under Title III of the CAA, NESHAP was established to control those pollutants that might reasonably be anticipated to result in either an increase in mortality or an increase in serious irreversible or incapacitating but reversible illness. Industry-wide national emissions standards were developed for 22 of the 189 designated hazardous air pollutants (HAPs). Radionuclides and asbestos were among the 22 HAPs for which standards were established. These standards are promulgated through Title 40 of the Code of Federal Regulations (CFR), Part 61, in Subparts H and M, respectively. Under Subpart H, NESHAP establishes a radiation dose limit for individuals of the general public. Subpart M addresses protection of the public from asbestos. Both subparts define the methods to use in determining compliance, recordkeeping, reporting, and in determining whether federal approval is required prior to the construction of new facilities or the modification of existing facilities. NESHAP compliance activities at the NTS are limited to radionuclide monitoring and reporting and notification of asbestos abatement. No NESHAP compliance activities are required at the Nevada satellite facilities.

CAA, National Ambient Air Quality Standards (NAAQS) – Title I of the CAA established the NAAQS to limit levels of pollutants in the air for six "criteria" pollutants: sulfur dioxide, nitrogen oxides, carbon monoxide, ozone, lead, and particulate matter. Title V of the CAA authorizes the states to implement permit programs in order to regulate emissions of the criteria pollutants. At the NTS there is one main permit that regulates operations and emissions from aggregate-producing facilities, fuel-burning equipment, fuel storage, project-specific activities associated with the Non-Proliferation Test and Evaluation Complex (NPTEC) (formerly the Hazardous Materials Spill Center), Test Cell C Facility, and the Tactical Demilitarization Development Project (TaDD). Detonations conducted at the Big Explosives Experimental Facility (BEEF) and the Explosives Ordnance Disposal Unit (EODU), which heretofore did not require permitting, are now included in the permit. The NTS also has a temporary air permit for a portable screening and crushing plant in Area 6. Nevada air quality permits specify emission limits for criteria pollutants (except ozone and lead) that are based on published emissions values for other similar industries and on operational data specific to the NTS. Lead is considered a HAP as well as a criteria pollutant. Emissions from lead are reported as part of the total HAPs emissions rather than as a separate criteria pollutant. Lead emissions above a specified threshold are also reported under Section 313 of the Emergency Planning and Community Right-to-Know Act (see Section 2.5). Quantities of NAAQS and HAPS emissions from operations at the NTS are calculated and submitted each year to the state of Nevada. The NTS air permit also specifies recordkeeping and reporting requirements, visible emissions (opacity) limits for equipment or facilities, opacity field monitoring requirements, and certification requirements for personnel conducting opacity monitoring. The permit also grants the state access to the NTS to conduct inspections of permitted facilities.

State of Nevada regulations prohibit the open burning of combustible refuse and other materials unless specifically exempted by an authorized variance (Nevada Administrative Code 445B.122). At the NTS, Open Burn Variances are routinely obtained for fire extinguisher training and various emergency management exercises.

The NTS satellite facilities discussed in Appendix B operate under air quality permits that require the reporting of estimated annual emissions of criteria pollutants.

CAA, New Source Performance Standards (NSPS) – The NSPS were established by Title I of the CAA to set minimum nationwide emission limitations of regulated air pollutants (HAPs and criteria pollutants mentioned above) and for various industrial categories of facilities. The state of Nevada has adopted the NSPS and regulates emissions from subject facilities through state law (NRS 445B as codified in NAC 445B). At the NTS, some of the screens and conveyor belts that were manufactured after August 1981 are subject to NSPS under the category of Nonmetallic Mineral Processing Plants. The NSPS imposes more stringent standards, including a reduced allowance of visible emissions (opacity) than under NAAQS. NSPS compliance activities on the NTS are reported to the state of Nevada. The NTS satellite facilities discussed in Appendix B operate under air quality permits that require the reporting of estimated annual emissions of HAPs.

CAA, Stratospheric Ozone Protection – Title VI (Section 608) of the CAA establishes production limits and a schedule for the phase-out of ozone-depleting substances (ODS). ODS are defined as those substances that are known or could reasonably be anticipated to cause or contribute to stratospheric ozone depletion. Under Section 608, the U.S. Environmental Protection Agency (EPA) has established regulations through 40 CFR Part 82 that include: (1) maximizing recycling of ozone-depleting compounds during servicing and disposal of air conditioning and refrigeration equipment, (2) establishing requirements for recycling and recovery equipment, technicians and reclaimers, (3) requiring the repair of substantial leaks in certain air conditioning and refrigeration equipment, and (4) establishing safe disposal requirements. While there are no reporting requirements for ODS, recordkeeping to document the usage of ODS and technician certification is required. Under Section 608, the EPA may conduct random inspections to determine compliance.

At the NTS, refrigerants containing ODS are mainly used in air conditioning units in vehicles, buildings, refrigerators, water fountains, vending machines, and laboratory equipment. Halon 1211 and 1301, now classified as ODS, have been used in the past in fire extinguishers. Self-assessments are conducted periodically to document adherence to Title VI of the CAA.

Other NTS Air Quality Permit Requirements – Under Title V, Part 70 of the CAA amendments, all owners or operators of Part 70 sources must pay annual fees to the state. Any source which has the potential to emit 45.4 metric tons (mtons) (50 tons) or more of any regulated air pollutant, except carbon monoxide, must pay an annual fee of $3,000. Any source that has the potential to emit less than 22.7 mtons (25 tons) per year of any regulated air pollutant, except carbon monoxide, must pay an annual fee of $250. NTS operations are subject to these fees. In addition to permit fees, NNSA/NSO must allow the state of Nevada Bureau of Air Pollution Control to conduct inspections of NTS facilities and operations that are regulated by state air quality permits.

Section VII of the NTS Class II Air Quality Operating Permit, No. AP9711-0549.01 *Surface Area Disturbance Conditions* requires implementation of an ongoing program to control fugitive dust using the best practicable methods.

2.1.1 Compliance Issues

During the summer of 2004, NNSA/NSO personnel observed an excess of fugitive dust resulting from an operation at the Area 5 Radioactive Waste Management Complex. NNSA/NSO determined that Bechtel Nevada (BN) was failing to monitor operations sufficiently to prevent excessive fugitive dust. In response, BN Environmental Services finalized a fugitive dust control policy in November (Organization Instruction, OI-0442.002 *Fugitive Dust Monitoring*). This policy establishes periodic monitoring of dust-producing activities and operations.

2.1.2 Compliance Reports

The following reports were generated for NTS operations in 2004 in compliance with air quality regulations:

- *National Emissions Standards for Hazardous Air Pollutants, Calendar Year 2004* (submitted to EPA Region IX)
- Annual Asbestos Abatement Notification Form, submitted to EPA Region IX
- *Calendar Year 2004 Actual Production/Emissions Reporting Form,* submitted to the Nevada Division of Environmental Protection
- *Quarterly Class II Air Quality Report,* submitted to the Nevada Division of Environmental Protection
- NPTEC Pre-test and Post-test Reports, submitted to the Nevada Division of Environmental Protection

The following reports were generated for operations at NTS satellite facilities in 2004 in compliance with air quality regulations:

- *Clark County Air Emission Inventory for North Las Vegas Facility,* submitted to the Clark County Department of Air Quality and Environmental Management
- *Clark County Air Emissions Inventory for Remote Sensing Laboratory,* submitted to the Clark County Department of Air Quality and Environmental Management

2.1.3 Compliance Status

See Table 2-1 for a summary of how NNSA/NSO complied with air quality and protection regulations at the NTS and its satellite facilities in 2004.

Table 2-1. NTS compliance status with applicable air quality regulations

Compliance Measure/Actions	Compliance Limit	Compliance Status - 2004	Section Reference(a)
Clean Air Act – NESHAP			
Annual dose equivalent from all radioactive air emissions	10 mrem/yr(b) (0.1 mSv/yr)	Compliant - 0.12 mrem/yr(b) (0.0012 mSv/yr)	3.1.5; 8.1.3
Notify EPA Region IX if the number of linear or square feet (ft) of asbestos to be removed from a facility exceeds limit	260 linear ft or 160 ft^2(c)	Compliant	3.2.7
Maintain asbestos abatement plans, data records, and activity/ maintenance records	For up to 25 or 75 years	Compliant	3.2.7
Clean Air Act – NAAQS			
Submit quarterly reports of calculated emissions to state of Nevada	Due 30 days after end of quarter	Compliant	3.2.1
Submit annual report of calculated emissions to state of Nevada	Due March 1	Compliant	3.2.1
Number of gallons of fuel used, hours of operation, and rate of aggregate/concrete production by permitted equipment/facility	Limit varies(d)	Compliant	3.2.2
Tons of emissions of each criteria pollutant produced by permitted equipment/facility based on calculations	PTE varies(e)	Compliant	3.2.1; Table 3-12
Conduct opacity readings from permitted equipment/facility	Quarterly	Compliant	3.2.3
Percent opacity of emissions from permitted equipment/facility	20%	Compliant 0 to 10% for 6 facilities	3.2.3
Submit test plans/final analysis reports for tests at NPTEC facilities and annual report of all chemicals released during the year to the state	Annual report due March 1	Compliant 5 tests conducted	3.2.4; Table 3-14
Estimated quantities of criteria air pollutants and HAPs emitted annually at the NLVF and the RSL submitted in annual emissions inventory reports to Clark County Health District	No emissions limits, Emissions Inventories due March 31	Compliant	B.1.3; Table B-4; B.3.2; Table B-8
Clean Air Act - NSPS			
Conduct opacity readings from permitted equipment/facility	Quarterly	Compliant	3.2.3
Percent opacity of emissions from permitted equipment/facility	10%	Compliant < 10% for 1 facility	3.2.3

Table 2-1. (continued)

Compliance Measure/Actions	Compliance Limit	Compliance Status - 2004	Section Reference[a]
Clean Air Act - Stratospheric Ozone Protection			
Maintain ODS technician certification records, approvals for ODS-containing equipment recycling/recovery, and applicable equipment servicing records	NA[f]	Compliant	3.2.6
Generic Nevada Air Quality Permit Regulations			
Implement program to control fugitive dust for land disturbing activities	NA	Non-compliant One incidence of excessive fugitive dust	3.2.8
Allow Nevada Bureau of Air Pollution Control access to conduct inspections of facilities and operations regulated by state air permits	NA	Compliant Inspection conducted in May	- -

(a) The section(s) within this document that describe how compliance summary data were collected

(b) mrem/yr = millirem per year; mSv/yr = millisievert per year

(c) 260 linear ft or 160 ft^2 = 79.3 linear meters (m) or 14.9 m^2

(d) Compliance limit is specific for each piece of permitted equipment/facility

(e) Potential to emit (PTE) = the quantities of criteria pollutants that each facility/piece of equipment would emit annually if it were operated for the maximum number of hours specified in the state air permit

(f) Not applicable

2.2 Water Quality and Protection

Clean Water Act (CWA) –Prohibits the discharge of pollutants from point sources to waters of the U.S. without a National Pollutant Discharge Elimination System (NPDES) permit. The CWA also gives the EPA, or the approved state environmental control agency, the authority to implement pollution control programs. The CWA also sets water quality standards for all contaminants in surface waters. At the NTS, applicable CWA regulations are followed through compliance with permits issued by the Nevada Division of Environmental Protection (NDEP) and the Nevada State Health Division, Bureau of Health Protection Services (BHPS) for wastewater discharges and disposal of wastewater from facilities. On the NTS, no wastewater discharges are released into any waters of the U.S. Therefore, NTS operations do not require any NPDES permits. Three NPDES permits have been issued to NNSA/NSO for the discharge of pumped groundwater at the NLVF into the North Las Vegas storm water drainage system during the conduct of a groundwater characterization study (see Appendix B).

Safe Drinking Water Act (SDWA) – Protects the quality of drinking water in the U.S. This law focuses on all waters actually or potentially designed for drinking use, whether from above-ground or underground sources. It authorizes the EPA to establish safe standards of purity and requires all owners or operators of public water systems to comply with National Primary Drinking Water Standards (health-related standards). State governments, which assume this power from the EPA, also set Secondary Standards which are related to taste, odor, and visual aspects of drinking water. Nevada state law pertaining to public water systems (NAC 445A) ensures that such water systems meet the EPA water quality standards specified under the SDWA.

Nevada Administrative Code (NAC) 445A - Water Controls (Public Water Systems) – Enforces the SDWA requirements and sets standards for permitting, design, construction, operation, maintenance, certification of operators, and water quality of public water systems (PWSs). The NTS has three PWSs and two potable water hauler trucks which BHPS regulates through the issuance of permits. Although the SDWA sets drinking water standards for radionuclides, the state of Nevada does not require radionuclide monitoring of drinking water on the NTS because the NTS does not have a "community water system" (i.e., a PWS having at least 15 service connections and used by year-round residents). However, all potable water supply wells are monitored on the NTS for radionuclides in compliance with DOE Order 5400.5 *Radiation Protection of the Public and the Environment* (see Section 2.3).

NAC 444 and 445A - Water Controls (Water Pollution Control) – Regulates the collection, treatment, and disposal of wastewater and sewage at the NTS. The requirements of this state regulation are issued in permits for E Tunnel effluent waters, sewage lagoons, septic tanks, and septic hauler contractors and pumpers. Perched groundwater which seeps out of E Tunnel in Area 12 is contained and monitored annually for radiological contaminants and quarterly for non-radiological contaminants as required under an NDEP permit issued to the Defense Threat Reduction Agency (DTRA). NNSA/NSO holds a general permit issued by NDEP covering two active and nine inactive sewage lagoon systems (see Table 2-12). Water quality and toxicity of the active sewage lagoons are monitored quarterly and annually, respectively, to meet permit requirements. The 19 septic systems on the NTS each process less than 5,000 gallons per day (gal/d) (18,927 liters/day), therefore they are not regulated by NDEP. The BHPS regulates the NTS septic systems as commercial individual systems which treat domestic sewage only in quantities less than5,000 gal/d. The BHPS does not require collection or analysis of sewage samples from these septic systems. The BHPS also regulates the permits that NNSA/NSO holds for the four septic tank pumpers, one septic tanker, and one septic tank pumping contractor.

Discharges of sewage and industrial wastewater from the NLVF are required to meet permit limits set by the City of North Las Vegas. Discharges of wastewater from the RSL are required to meet permit limits set by the Clark County Water Reclamation District.

NAC 534 - Nevada Division of Water Resources Regulations for Water Well and Related Drilling – Regulates the drilling and construction of new wells and the reworking of existing wells in order to prevent the waste of underground waters and their pollution or contamination. Two site operations that are affected by this state regulation are the Underground Test Area (UGTA) Project and the Borehole Management Project. New water wells are drilled for ongoing UGTA investigations of site-specific hydrogeologic characteristics, underground source terms, and contaminant movement through groundwater. Over 1,100 existing boreholes on the NTS are being plugged according to these regulations, under the Borehole Management Project.

2.2.1 Out-of-Compliance Incidents

Septic System, Area 27, Able Compound Permit NY-1087 – On Monday, March 1, 2004, approximately 30 gallons of raw sewage was accidentally released onto the ground from the manhole above the Able Compound septic tank. The manhole was pumped and the sewer line was jetted to clear the obstruction (roots and sediment). No fines or penalties were incurred from this discharge.

Septic System, Area 25, Reactor Control Point Permit NY-1086 – On Thursday, April 8, 2004, at Building 25-3102, a valve was missing from a cooling radiator. While the laborers were cutting water pipes on the inside of the building, water started to flow from the radiator and approximately 2.8 liters of water made it into a drain about 10 feet away. No fines or penalties were incurred from this discharge.

2.2.2 Compliance Reports

The following reports were generated for NTS operations in 2004 in compliance with water quality regulations:

- *Quarterly Monitoring Report for Nevada Test Site Sewage Lagoons,* submitted April 13, July 13, and October 18, 2004, and January 13, 2005 to NDEP (in compliance with permit GNEV93001)
- Results of water quality analyses for PWSs were sent to the state throughout the year as they were obtained from the laboratory.
- *Water Pollution Control Permit NEV 96021, Quarterly Monitoring Report* (for E Tunnel effluent monitoring), submitted April 20, July 20, and October 19, 2004, and January 24, 2005 to NDEP
- *Water Pollution Control Permit NEV 96021 Quarterly Monitoring Report and Annual Summary Report for E Tunnel Waste Water Disposal System* (DTRA, 2004)

The following reports were generated for operations at the NTS satellite facilities in 2004 in compliance with water quality regulations:

- *Self-Monitoring Report for the National Nuclear Security Administration's North Las Vegas Facility: Permit VEH-112,* submitted October 25, 2004 to the City of North Las Vegas
- Quarterly reports titled *Remote Sensing Laboratory Self Monitoring Report- Permit No. CCWRD-080,* submitted March 3, May 6, September 7, and December 1, 2004 to the Clark County Water Reclamation District
- Two additional monitoring reports titled *Remote Sensing Laboratory Additional Monitoring Reports - Permit No. CCWRD-080* were submitted February 4 and July 1, 20
- Reports of groundwater discharge volumes for NLVF temporary NPDES permits TNEV2003461, TNEV2004348, and TNEV2004364 04, submitted each month to NDEP

2.2.3 Compliance Status

See Table 2-2 for a summary of how NNSA/NSO complied with water quality and protection regulations at the NTS and its satellite facilities in 2004.

Table 2-2. NTS compliance status with applicable water quality and protection regulations

Compliance Measure/Action	Compliance Limit	Compliance Status - 2004	Section Reference[a]
Safe Drinking Water Act and Nevada Water Controls (NAC 445A - Water Controls - Public Water Systems)			
Number of water samples containing coliform bacteria	1 per month	0	4.2.1.1; Table 4-10
Concentration of nitrates in all PWSs (in milligrams per liter [mg/L])	10 mg/L	ND[b] – 4.3 mg/L	4.2.1.1; Table 4-10
Concentration of organic contaminants in all PWSs	Limit varies[c]	Compliant	4.2.1.1; Table 4-10
Concentration of Phase V inorganic contaminants in all PWSs	Limit varies	Compliant	4.2.1.1; Table 4-10
Concentration of disinfection byproducts in all PWSs	0.06 – 0.08 mg/L	0.0011 – 0.0066	4.2.1.1; Table 4-10
Concentration of secondary standards in all PWSs	Limit varies	Compliant for all standards except pH from Area 23 and 6 PWS and Area 25 PWS	4.2.1.1; Table 4-10
Concentration of lead and copper in Area 12 PWS	Limit varies	Compliant	4.2.1.1; Table 4-10
Concentration of fluoride in Area 25 PWS	4.0 mg/L	1.8 - 2.4 mg/L	4.2.1.1; Table 4-10
Adhere to design, construction, maintenance, and operation regulations specified by permits	NA[d]	Compliant	
Allow BHPS access to conduct inspections of PWS and water hauling trucks	NA	Compliant	4.2.1.2
Clean Water Act – National Pollutant Discharge Elimination System/State Pollutant Discharge Elimination System Permits			
Measure and report volume of pumped groundwater discharged at the NLVF	NA	Compliant	Appendix B, B.1.1.3; Table B-3
Clean Water Act and Nevada Water Pollution Controls - Sewage Disposal (NAC 444 – Sewage Disposal)			
Adhere to all design/construction/operation requirements for new systems and those specified in 16 septic system permits, 5 septic tank pumper permits, and 1 septic tank pumping contractor permit	NA	Compliant	4.2.3
Clean Water Act and Nevada Water Pollution Controls (NAC 445A - Water Pollution Controls)			
Value of 5-day Biological Oxygen Demand (BOD_5), total suspended solids (TSS), and pH in one sewage lagoon water sample sampled quarterly	BOD_5: varies TSS: no limit pH: 6.0 - 9.0 S.U.	Compliant – Samples collected in Jan., Apr., Jul, and Oct.	4.2.3.1; Table 4-11
Concentration of 36 contaminants in the filtrate from one sewage lagoon sample collected annually from each of two permitted facilities	Limit varies	Compliant - concentrations within limits	4.2.3.2; Table 4-12

Table 2-2. (continued)

Compliance Measure/Action	Compliance Limit	Compliance Status - 2004	Section Reference[(a)]
pH value and concentration of 18 contaminants in a water sample collected annually from groundwater monitoring well SM-23-1	Limit varies	Compliant	4.2.3.3; Table 4-13
Inspection by operator of active sewage lagoon systems	Weekly	Compliant	4.2.3.4
Inspection by operator of inactive sewage lagoon systems	Quarterly	Compliant	4.2.3.4
Submit quarterly monitoring reports for 3 active sewage lagoons (for Area 6, 12, and 23)	Due end of Jan., Apr., Jul., Oct.	Compliant	
Allow NDEP access to conduct inspections of active sewage lagoon systems	NA	Compliant Inspection conducted April, 2004	4.2.3.4
Concentrations of tritium (^{3}H), gross alpha (α), and gross beta (β), (in picocuries per liter [pCi/L]), and 16 non-radiological contaminants/water quality parameters in E Tunnel effluent water samples collected quarterly	^{3}H: 1,000,000 pCi/L α: 35.1 pCi/L β: 101 pCi/L Non-rad: Limit varies	^{3}H: 710,000 pCi/L α: 13.4 pCi/L β: 72 pCi/L Non-rad: Compliant	4.1.6: Table 4-6
Concentrations of 19 contaminants in water samples from three NLVF sewage outfalls and all sludge and liquid samples from the NLVF sand/oil interceptor	Limit varies	Compliant	B.1.1.1; Table B-2
Concentrations of 12 contaminants in water samples from sewage outfall at the RSL	Limit varies	Compliant	B.3.1; Table B-7
NAC 534 - Nevada Division of Water Resources Regulations for Water Well and Related Drilling			
Maintain state well-drilling license for personnel supervising well construction/reconditioning	NA	Compliant - 5 licensed personnel supervised well activities	- -
File notices of intent and affidavits of responsibility for plugging	NA	Compliant - 3 notices of intent with 2 affidavits were filed	- -
Adhere to well construction requirements/waivers	NA	Compliant - no new wells constructed for UGTA Project; 90 boreholes plugged for Borehole Management Program	- -
Maintain required records and submit required reports	NA	Compliant	- -

(a) The section(s) within this document that describe how compliance summary data were collected

(b) Not detectable

(c) Compliance limit is specific for each contaminant; see referenced tables for specific limits

(d) Not applicable

2.3 Radiation Dose Protection

Clean Air Act (CAA), National Emission Standards for Hazardous Air Pollutants (NESHAP) – NESHAP (40 CFR 61 Subpart H) establishes a radiation dose limit of 10 millirem per year (mrem/yr) (0.1 millisievert per year [mSv/yr]) to individuals in the general public from the air pathway. Sources of radioactive emissions on the NTS include: (1) evaporation of tritiated water (HTO) from containment ponds, (2) diffusion of HTO vapor from the soil at Area 5 Radioactive Waste Management Complex (RWMC), Sedan crater, and Schooner crater, (3) release of tritium gas during calibration of analytical equipment at Building 650 in Area 23, and (4) re-suspension of plutonium and americium from contaminated soil at nuclear device safety test and atmospheric test locations. NESHAP also specifies "Concentration Levels for Environmental Compliance" (abbreviated as CLs) for radionuclides. A CL is the annual average concentration of a radionuclide that could deliver a dose of 10 mrem/yr. The CLs are provided for facilities which use air sampling at offsite receptor locations to demonstrate compliance.

Safe Drinking Water Act (SDWA) – The National Primary Drinking Water Regulations (40 CFR 141), promulgated by the SDWA (Federal Register, Vol. 65, No. 236, December 7, 2000), requires that the maximum contaminate level goal for any radionuclide be zero. But, when this is not possible (e.g., in groundwater containing naturally-occurring radionuclides), the SDWA specifies that the concentration of one or more radionuclides should not result in a whole body or organ dose greater than 4 mrem/yr (0.04 mSv/yr). Sources of radionuclide contamination in groundwater are the numerous underground nuclear tests conducted at the NTS which were detonated near or below the water table.

DOE Order 450.1 *Environmental Protection Program* – This DOE Order requires federal facilities to: (1) conduct environmental monitoring to detect, characterize, and respond to releases from DOE activities, (2) assess impacts, (3) estimate dispersal patterns in the environment, (4) characterize the pathways of exposure to members of the public, (5) characterize the exposures and doses to individuals and to the population, and (6) evaluate the potential impacts to the biota in the vicinity of a DOE activity. Such releases, exposures, and doses apply to radiological contaminants.

DOE Order 5400.5 *Radiation Protection of the Public and the Environment* – Protection of the public and the environment is further mandated by this Order and by flow-down procedural standards established to help implement the objectives of the Order. DOE Order 5400.5 establishes requirements for: (1) measuring radioactivity in the environment, (2) applying the ALARA (As Low As Reasonably Achievable) process to all operations, (3) using mathematical models for estimating radiation doses, (4) releasing property having residual radioactive material, and (5) maintaining records demonstrating compliance with the requirements. DOE Order 5400.5 specifies 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. DOE Order 5400.5 also provides the derived concentration guides (DCGs) for all radionuclides. The DCGs are the annual average concentrations of a radionuclide that could deliver a dose of 100 mrem/yr. The DCGs are provided as reference values to use in radiological protection programs at DOE facilities. The NESHAP CLs mentioned above are more conservative than one-tenth of the DCGs because they are computed with different dose models.

DOE Standard DOE-STD-1153-2002 – This Standard, titled *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (DOE, 2002a), provides methods, computer models, and guidance in implementing a graded approach to evaluating the radiation doses to populations of aquatic animals, terrestrial plants, and terrestrial animals residing on DOE facilities. A dose limit of 1 rad per day (rad/d) (10 milligray per day [mGy/d]) for terrestrial plants and aquatic animals, and of 0.1 rad/d (1 mGy/d) for terrestrial animals is specified by this DOE standard. Dose rates below these levels are believed to cause no measurable adverse effects to populations of plants and animals.

DOE Order 435.1 *Radioactive Waste Management* – This order ensures that all DOE radioactive waste is managed in a manner that is protective of the worker, public health and safety, and the environment. The directive manual for this Order (DOE M435.1-1) specifies that operations at the Area 3 and Area 5 Radioactive Waste Management Sites (RWMSs) must not contribute a dose to the general public in excess of 25 mrem/yr. The order also directs how radioactive waste management operations are conducted on the NTS. These operational requirements are summarized in Section 2.4.

2.3.1 Compliance Reports

In compliance with NESHAP under the CAA, the report *National Emission Standards for Hazardous Air Pollutants, Calendar Year 2004*, was submitted to EPA Region IX in June 2004. This *Nevada Test Site Environmental Report 2004* was generated to report 2004 compliance with DOE Order 5400.5 and DOE-STD-1153-2002.

2.3.2 Compliance Status

Table 2-3 presents a summary of how NNSA/NSO complied with radiation protection regulations at the NTS and its satellite facilities in 2004.

Table 2-3. NTS compliance status with regulations for radiation protection of the public and the environment

Compliance Measure	Compliance Limit	Compliance Status - 2004	Section Reference(a)
Clean Air Act - NESHAP			
Annual dose to the general public from all radioactive air emissions	10 mrem/yr (0.1 mSv/yr)	0.12 mrem/yr (0.0012 mSv/yr)	3.1.5; 8.1.3
Safe Drinking Water Act			
Annual dose to the general public from drinking water	4 mrem/yr (0.04 mSv/yr)	0 mrem/yr(b) (0 mSv/yr)	4.1.4; Table 4-1
DOE Order 5400.5 *Radiation Protection of the Public and the Environment*			
Annual dose above background levels to the general public from all pathways	100 mrem/yr (1 mSv/yr)	0.51 mrem/yr (0.0051 mSv/yr)	8.1.6; Table 8-6; B.1.5; Table B-5
Total residual surface contamination of property released offsite (in disintegrations per minute per 100 square centimeters [dpm/100 cm^2])	300–15,000 dpm/100 cm^2 depending on radionuclide	Compliant No detectable releases	8.1.5
DOE Standard 1153-2002			
Absorbed radiation dose to terrestrial plants	1 rad/d (0.01 Gy/d)	<1 rad/d (<0.01 Gy/d)	8.2
Absorbed radiation dose to aquatic animals	1 rad/d	<1 rad/d	8.2
Absorbed radiation dose to terrestrial animals	0.1 rad/d (1 mGy/d)	<0.1 rad/d (<1 mGy/d)	8.2
DOE Order 435.1 *Radioactive Waste Management*			
Annual dose to the general public due to RWMS operations	25 mrem/yr (0.25 mSv/yr)	Compliant(c)	5.3.2
DOE Order 450.1 *Environmental Protection Program*			
Conduct radiological environmental monitoring	NA(d)	Compliant	3.1; 4.1; 5.0; 6.0; 7.0
Detect and characterize radiological releases	NA	Compliant	3.1; 4.1; 5.0; 6.0; Table 3-12
Characterize pathways of exposure to the public	NA	Compliant	8.1.1
Characterize exposures and doses to individuals, the population, and biota	NA	Compliant	8.1.6; 8.1.7; 8.2

(a) The section(s) within this document that describe how compliance summary data were collected

(b) Migration of radioactivity in groundwater to offsite wells has never been detected

(c) Nearest populations to the Area 3 and 5 RWMSs are Amargosa Valley (55 km away) and Cactus Springs (36 km away), respectively. They are too distant to receive any radiation exposure from operations at the sites.

(d) Not applicable

2.4 Radioactive and Non-Radioactive Waste Management and Environmental Restoration

10 CFR 830: Nuclear Safety Management – Establishes requirements for the safe management of DOE contractor and subcontractor work at DOE's nuclear facilities. It governs the possession and use of special nuclear material and byproduct materials deemed necessary for the protection of health and minimization of danger to life or property. Part 830 also covers activities at facilities where no nuclear material is present such as facilities that prepare the non-nuclear components of nuclear weapons, but which could cause radiological damage at a later time. It governs the conduct of the "management and operating contractor and other persons at DOE nuclear facilities" (including visitors to the facility). When coupled with the **Price-Anderson Amendments Act (PAAA) of 1988 (Section 234A to the Atomic Energy Act)**, it provides DOE with authority to assess civil penalties for violation of rules, regulations or orders relating to nuclear safety by contractors, subcontractors, and suppliers who are indemnified under PAAA. The broad intent of the regulation is to ensure compliance with all enforceable rules, regulations, or orders relating to nuclear safety adopted by DOE for the NTS.

DOE Order 435.1 ***Radioactive Waste Management*** – Ensures that all DOE radioactive waste is managed in a manner that is protective of the worker, public health and safety, and the environment. Radioactive waste management activities conducted on the NTS which are subject to this Order include: (1) characterization of low level radioactive waste (LLW) and mixed low level radioactive waste (MW) generated by DOE within the state of Nevada, (2) disposal of LLW and MW at the RWMC which includes the Area 3 RWMS and the Area 5 RWMS, (3) characterization, visual examination, and repackaging of transuranic (TRU) waste at the Waste Examination Facility (WEF) just south of the Area 5 RWMS, and (4) loading of TRU waste at the Mobile Loading Unit (MLU) at the Area 5 RWMS for shipment to the Waste Isolation Pilot Plant at Carlsbad, New Mexico.

Atomic Energy Act (AEA) of 1954 (42 U.S.C. Sect. 2011 et seq.) – Ensures the proper management of source, special nuclear, and byproduct material. At the NTS, AEA regulations are followed through compliance with DOE Order 435.1 and 10 CFR 830.

Resource Conservation and Recovery Act (RCRA) – Ensures the safe and environmentally responsible management of hazardous (see Glossary, Appendix D) and non-hazardous solid waste. RCRA (1976, 1996) and the Hazardous and Solid Waste Amendments of 1984 constitute the statutory basis for the regulation of hazardous waste and underground storage tanks (USTs). Under Section 3006, the EPA has authorized the state of Nevada to administer and enforce hazardous waste permits for many NNSA/NSO facilities. Nevada has issued a RCRA Hazardous Waste Operating Permit (NEV HW009) which governs operation of the Hazardous Waste Storage Unit (HWSU) in Area 5, the Explosive Ordnance Disposal Unit (EODU) in Area 11, and the disposal of MW at the Pit 3 Mixed Waste Disposal Unit (P03U) at the Area 5 RWMS. Under Subpart F of RCRA (40 CFR 265.92), groundwater monitoring is required to verify the performance of P03U. The NEV HW009 permit also prescribes post-closure monitoring for five closed waste sites on the NTS that are RCRA Part B-identified Corrective Action Units (CAUs). They include the Area 23 Hazardous Waste Trenches (CAU 112), the Area 3 U3fi Injection Well (CAU 91), the Area 3 U3ax/bl Subsidence Crater (CAU 110), the Area 2 Bitcutter Containment (CAU 90), and the Area 6 Decon Pond Facility (CAU 92).

The NTS has five USTs which are either (1) fully regulated under RCRA and registered with the state (1 tank), (2) regulated under RCRA and registered with the state, but deferred from leak detection requirements (1 tank), or (3) excluded from federal and state regulation (3 tanks). The NTS UST program reports, upgrades, and removes USTs in accordance with regulatory compliance schedules.

RCRA also requires generators of hazardous waste to have a program in place to reduce the volume or quantity and toxicity of such waste. These requirements and NTS compliance with them are addressed under the Pollution Prevention and Waste Minimization sections of this report (Section 2.7, Section 11.0).

The specific Nevada laws which govern hazardous waste management operations under Permit NEV HW009 are Disposal of Hazardous Waste (NRS 459-400 – 459.600), Facilities for Management of Hazardous Waste

(NAC 444.842 – 444.8482), Disposal of Hazardous Waste (NAC 444.850 – 444.8746), and Limitations on Issuance of Permits (NAC 444.960).

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)/ Superfund Amendments and Reauthorization Act (SARA) – Provides 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. No hazardous waste cleanup operations on the NTS are regulated under CERCLA; they are regulated under RCRA instead. The only requirements of CERCLA applicable to NTS operations pertain to an emergency response program for hazardous substance releases to the environment (see discussion of Emergency Planning and Community Right-to-Know Act in Section 2.5).

Federal Facility Compliance Act (FFCA) – Extends the full range of enforcement authorities in federal, state, and local laws for management of hazardous wastes to federal facilities, including the NTS. The FFCA of 1992, signed by NNSA/NSO and the state of Nevada, requires identification of existing quantities for mixed waste, the proposal of methods and/or technologies of mixed waste treatment and management, the creation of enforceable timetables, and tracking and completion of deadlines.

Federal Facilities Agreement and Consent Order (FFACO) – Pursuant to Section 120(a)(4) of CERCLA and to Sections 6001 and 3004(u) of RCRA, the U.S. Department of Energy, U.S. Department of Defense, and the state of Nevada entered into a FFACO in May 1996. This FFACO addresses the environmental restoration of historically contaminated sites at the NTS, parts of Tonopah Test Range (TTR), parts of the Nevada Test and Training Range (NTTR) (formerly known as Nellis Air Force Range), the Central Nevada Test Area (CNTA), and the Project SHOAL Area. Under the FFACO, hundreds of historically contaminated sites on and off the NTS have been identified for cleanup and closure. Individual sites are called Corrective Action Sites (CASs). Multiple CASs are often grouped into CAUs.

40 CFR Subchapter I, Parts 239-299: Solid Wastes – At the NTS, these federal solid waste management regulations are followed through compliance with permits issued by the NDEP.

NAC 444.570-7499 – Solid Waste Disposal Controls – Enforces the federal regulations pertaining to solid wastes (40 CFR Subchapter I, Parts 239-299). This Nevada regulation sets standards for solid waste management systems, including the storage, collection, transportation, processing, recycling, and disposal of solid waste. The NTS has four permitted landfills for solid waste disposal which are regulated and permitted by the state: Area 5 Asbestiform Low-Level Solid Waste Disposal Site (P06U), Area 6 Hydrocarbon Disposal Site, Area 9 U10c Solid Waste Disposal Site, and Area 23 Solid Waste Disposal Site. These landfills are designed, constructed, operated, maintained, and monitored in adherence to the requirements of their state-issued permits.

2.4.1 Compliance Reports

The following reports were prepared in 2004 to comply with environmental regulations for waste management and environmental restoration operations on the NTS. All CAU or CAS reports prepared in 2004 as per the FFACO schedule for environmental restoration of contaminated sites are presented in Table 9-4 of Section 9.4.1.

- *Annual Asbestos Disposal Report* (for the Area 5 Asbestiform Low-Level Solid Waste Disposal Site P06U)
- *Quarterly LLW/MLLW Disposal Reports* (for all active LLW and MW disposal cells)
- *Biannual Neutron Monitoring Report for the Nevada Test Site Area 9 10c and Area 6 Hydrocarbon Landfills*
- *Nevada Test Site 2004 Data Report: Groundwater Monitoring Program Area 5 Radioactive Waste Management Site*
- Post-closure monitoring reports for the five RCRA Part B-identified CAUs
- *January-June 2004 Biannual Solid Waste Disposal Site Report for the Nevada Test Site Area 23 Sanitary Landfill*
- *July-December 2004 Biannual Solid Waste Disposal Site Report for the Nevada Test Site Area 23 Sanitary Landfill*

- *2004 Annual Solid Waste Disposal Site Report for the Nevada Test Site Area 6 Hydrocarbon Landfill and Area 9 U10c Landfills*

2.4.2 Compliance Status

See Table 2-4 for a summary of how NNSA/NSO complied with waste management and environmental restoration regulations at the NTS in 2004.

Table 2-4. NTS compliance status with applicable waste management and environmental restoration regulations

Compliance Measure/Action	Compliance Limit	Compliance Status - 2004	Section Reference(a)
10 CFR 830: Nuclear Facilities			
Completion and maintenance of proper conduct of operations documents required for Class II Nuclear Facility for disposal/characterization/storage of radioactive waste	Six types of guiding documents required	Compliant	9.1.1; Table 9-1
DOE Order 435.1 ***Radioactive Waste Management***			
Establishment of Waste Acceptance Criteria (WAC) for radioactive wastes received for disposal/storage at Area 3 and 5 RWMSs	NA(b)	Compliant	9.1.1; Table 9-1
Vadose zone monitoring at Area 3 and Area 5 RWMSs	Not required by Order - Performed to validate performance assessment criteria of RWMSs	Conducted	9.1.6
Volume of disposed LLW at Area 3 and Area 5 RWMSs (in cubic meters [m^3])	No limit	Area 3: 57,010 m^3 Area 5: 45,863 m^3	9.1.3
Resource Conservation and Recovery Act (as enforced through permits issued by the state of Nevada)			
pH, specific conductance (SC), total organic carbon (TOC), total organic halides (TOX), and tritium (H^3) and 11 general water chemistry parameters in groundwater sampled semi-annually from wells UE5 PW-1, UE5 PW-2, and UE5 PW-3 to verify performance of the Pit 3 Mixed Waste Disposal Unit (P03U)	pH: 7.6 to 9.2 SC: 0.440 mmhos/cm(c) TOC: 1 mg/L TOX: 50 µg/L(d) H^3: 2,000 pCi/L	Compliant	9.1.6; Table 9-2; 4.1.7; Table 4-4;
Volume of stored non-radioactive hazardous waste at the Hazardous Waste Storage Unit	61,600 liters (16,280 gallons)	Compliant	9.2; Table 9-3
Weight of approved explosive ordnance wastes detonated at the Explosive Ordnance Disposal Unit (in kilograms [kg] or pounds [lbs])	45.4 kg (100 lbs) at a time, not to exceed 1 detonation event/hour	Compliant	9.2; Table 9-3
Volume of disposed MW at Pit 3 Mixed Waste Disposal Unit (P03U) (in cubic meters [m^3] or cubic yards [yd^3])	20,000 m^3 (260,159 yd^3)	Compliant	9.2; Table 9-3
Conduct vadose zone monitoring (VZM) for RCRA closure sites: Area 23 Hazardous Waste Trenches, U-3fi Injection Well, and U3ax/bl Subsidence Crater	A23: semi-annually using NL(e) U3fi: quarterly using NL U3ax/bl: continuous using TDR(f)	Compliant	9.4.2

Table 2-4. (continued)

Compliance Measure/Action	Compliance Limit	Compliance Status - 2004	Section Reference[a]
Periodic post-closure inspection of Area 2 Bitcutter Containment and Area 6 Decon Pond	NA	Compliant	9.4.2
Upgrade, remove, and report on underground storage tanks (USTs)	NA	Compliant	9.3
Federal Facilities Agreement and Consent Order			
Adherence to calendar year work scope for site characterization, remediation, and closures	33 CAUs identified for some phase of action; 56 CASs were closed	Compliant All milestones were met	9.4; Table 9-4
Post-closure monitoring and inspections of closed sites	23 Sites required monitoring/ inspecting	Compliant	9.4.2
NAC 444.750-8396 - Solid Waste Disposal Controls			
Track weight and volume of waste disposed each calendar year	Area 5 P06U - No limit Area 6 - No limit Area 9 - No limit Area 23 - 20 tons/d	Compliant	9.5; Table 9-5
Monitor vadose zone for the Area 6 Hydrocarbon and Area 9 U10c Solid Waste disposal sites	Annually using NL[e]	Compliant	9.5.1
Monitor groundwater quality at Well SM-23-1 for the Area 23 Solid Waste Disposal Site	In June 2004, NDEP granted a groundwater monitoring exclusion	NA	9.5.1

(a) The section(s) within this document that describe how compliance summary data were collected
(b) Not applicable
(c) mmhos/cm = milli-mhos per centimeter
(d) µg/L = micrograms per liter
(e) Neutron logging through access tubes
(f) Time domain reflectometry sensors

2.5 Hazardous Materials Control and Management

Toxic Substances Control Act (TSCA) – Requires testing and regulation of chemical substances that enter the consumer market. Since the NTS does not produce chemicals, compliance with TSCA is primarily directed toward management of polychlorinated biphenyls (PCBs). The regulations implementing TSCA for the state of Nevada contain record keeping requirements for PCB activities (NAC 444.9452). At the NTS, remediation activities and maintenance of fluorescent lights can result in the disposal of PCB-contaminated waste and light ballasts. Disposal of these items on the NTS are regulated.

Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) – Sets forth procedures and requirements for pesticide registration, labeling, classification, devices for use, and certification of applicators. The use of certain pesticides (called "restricted-use pesticides") are regulated. The use of non-restricted-use pesticides (as available in consumer products) is not regulated. On the NTS, both restricted-use and non-restricted-use pesticides are applied under the direction of a state of Nevada certified applicator. Pesticide applications in food service facilities are subcontracted to state-certified vendors who provide these services.

Emergency Planning and Community Right-to-Know Act (EPCRA) – This act is a free-standing provision under Title III of the 1986 Superfund Amendments and Reauthorization Act (SARA Title III) amendments to CERCLA. It 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. EO 13148 *Federal Compliance with Right-to-Know Laws and Pollution Prevention Requirements*, requires all federal facilities to comply with the provisions of EPCRA. Under EPCRA, NNSA/NSO is required to submit reports pursuant to Sections 302, 304, 311, 312, and 313 of SARA Title III described below.

> **Section 302-303, Planning Notification** – Requires that the state emergency response commission and the local emergency planning committee be notified when an extremely hazardous substance (EHS) is present at a facility in excess of the threshold planning quantity. An inventory of the location and amounts of all hazardous substances stored on the NTS and its satellite facilities is maintained. Inventory data are included in an annual report called the Nevada Combined Agency (NCA) Report. Also, NNSA/NSO monitors hazardous materials while they are in transit on the NTS through a hazardous materials notification system called HAZTRAK®.
>
> **Section 304, Extremely Hazardous Substances Release Notification** – Requires that the local emergency planning committee and state emergency response agencies be notified immediately of accidental or unplanned releases of an EHS to the environment. Also, the national response center is notified if the release exceeds the CERCLA reportable quantity for the particular hazardous substance.
>
> **Section 311-312, Material Safety Data Sheet (MSDS)/Chemical Inventory** – Requires facilities to provide applicable emergency response agencies with MSDSs, or a list of MSDSs for each hazardous chemical stored on site. This is essentially a one-time reporting unless chemicals or products change. Any new MSDSs are provided annually in the NCA Report. Section 312 requires facilities to report maximum amounts of chemicals onsite at any one time. This report is submitted to the State Emergency Response Commission, the Local Emergency Planning Committee, and the local fire departments.
>
> **Section 313, Toxic Release Inventory (TRI) Reporting** – Requires facilities to submit an annual report entitled "Toxic Chemical Release Inventory, Form R" to the EPA and to the state if annual usage quantities of listed toxic chemicals exceed specified thresholds. Lead releases on the NTS above threshold limits are reported to the EPA and the State Emergency Response Commission in the TRI, Form R report.

NAC 555 – Control of Insects, Pests, and Noxious Weeds – Provides regulatory framework for certification of several classifications of registered pesticide and herbicide applicators in the state of Nevada. The Nevada

Department of Agriculture (NDOA) administers this program and has the primary role to enforce FIFRA in Nevada. Inspections of pesticide/herbicide applicator programs are carried out by NDOA. Restricted-use pesticides are not used by BN at the NTS.

NAC 444 – Polychlorinated Biphenyls – This code incorporates by reference the federal requirements for the handling, storage, and disposal of PCBs at the NTS.

State of Nevada Chemical Catastrophe Prevention Act – This state act directed the NDEP to develop and implement an accident prevention program which was named the Chemical Accident Prevention Program (CAPP). The act requires registration of facilities storing EHSs above listed thresholds. A report is submitted to the NDEP if any storage quantity thresholds are exceeded.

2.5.1 Compliance Reports

The following reports were generated for NNSA/NSO operations in 2004 on the NTS and its satellite facilities in compliance with hazardous materials control and management regulations:

- *Nevada Combined Agency Report - Calendar Year 2004,* submitted to state and local agencies on February 25, 2005
- *Toxic Release Inventory Report, Form R for CY2004 Operations,* submitted to the EPA and to the state on June 22, 2005
- *Calendar Year (CY) 2003 Polychlorinated Biphenyls (PCBs) Report for the Nevada Test Site (NTS)*, submitted to NNSA/NSO on March 22, 2004. (This report is no longer required to be submitted to the EPA).
- *Calendar Year (CY) 2004 Polychlorinated Biphenyls (PCBs) Report for the Nevada Test Site (NTS)*, submitted to NNSA/NSO on March 22, 2005. (This report is no longer required to be submitted to the EPA).

2.5.2 Compliance Status

See Table 2-5 for a summary of how NNSO/NSA complied with regulations for hazardous materials control and management at the NTS and its satellite facilities in 2004.

Table 2-5. NTS compliance status with applicable regulations for hazardous substance control and management

Compliance Measure/Action	Compliance Limit	Compliance Status - 2004	Section Reference[(a)]
Toxic Substances Control Act (TSCA) and NAC 444 - Polychlorinated Biphenyls			
Storage and offsite disposal of PCB materials	Required if >50 ppm[(b)] PCBs	Compliant	10.1
Storage and onsite disposal of PCB materials	Allowed if <50 ppm PCBs	Compliant	10.1
Disposal of bulk product waste (BPW) containing PCBs generated by remediation and site operations	Case-by-case approval by NDEP	Compliant	10.1
Generate report of quantities of PCB liquids and materials disposed offsite during previous calendar year	Due July 1 of following year	Compliant - submitted March 22, 2004 for CY 2003; submitted March 22, 2005 for CY 2004	10.1
Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and NAC 555 - Control of Insects, Pests, and Noxious Weeds			
Application of restricted-use pesticides are conducted under the direct supervision of a state-certified applicator	NA[(c)]	Compliant - no restricted-use pesticides were applied	10.2
Maintain state certification of onsite pesticide and herbicide applicator	NA	Compliant	10.2
Emergency Planning and Community Right-to-Know Act (EPCRA)			
Section 302-303 Planning Notification	NCA Report due in March	Compliant - submitted February 25, 2005; no EHS thresholds exceeded	10.3; B.1.4; B.3.3
Section 304 – EHS Release Notification	Notification Report due immediately after a release	Compliant - no releases occurred	10.3; B.1.4; B.3.3
Section 311-312 – MSDS/Chemical Inventory	NCA Report due in March	Compliant - submitted February 25, 2005	10.3; B.1.4; B.3.3
Section 313 – TRI Reporting	TRI Report, Form R due July 1	Compliant - submitted June 22, 2005 - lead was the only reportable substance	10.3; B.1.4; B.3.3
State of Nevada Chemical Catastrophe Prevention Act			
Registration of NTS with the state if EHSs are stored above listed threshold quantities	NDEP-CAPP[(d)] Report due June 21, 2005	Compliant – no threshold quantities exceeded, no report submitted	10.4

(a) The section(s) within this document that describe how compliance summary data were collected
(b) ppm = parts per million
(c) Not applicable
(d) Chemical Accident Prevention Program

2.6 National Environmental Policy Act

Before any project or activity is initiated at the NTS, it must be evaluated for possible impacts to the environment. Under the National Environmental Policy Act (NEPA), federal agencies are required to consider environmental effects and values and reasonable alternatives before making a decision to implement any major federal action that may have a significant impact on the human environment. NNSA/NSO uses four levels of documentation to demonstrate compliance with NEPA:

- Environmental Impact Statement (EIS) – a full disclosure of the potential environmental effects of proposed actions and the reasonable alternatives to those actions
- Environmental Assessment (EA) – a concise discussion of proposed actions and alternatives and the potential environmental effects to determine if an EIS is necessary
- Supplement Analysis (SA) – a collection and analysis of information for an action already addressed in an existing EIS or EA used to determine whether a supplemental EIS or EA should be prepared, a new EIS or EA should be prepared, or no further NEPA documentation is required
- Categorical Exclusion (CX) – a category of actions which do not have a significant adverse environment impact based on similar previous activities, and for which, therefore, neither an EA nor an EIS is required

A NEPA Environmental Evaluation Checklist (Checklist) is completed for all proposed projects or activities on the NTS, as required under the NNSA/NV Work Acceptance Process Procedural Instructions (Carlson, 2000). The Checklist is reviewed by the NNSA/NSO NEPA Compliance Officer to determine whether the activity's environmental impacts have been addressed in existing NEPA documents. If a proposed project has not been covered under any previous NEPA analysis and it does not qualify as a CX, then a new NEPA analysis is performed. The NEPA analysis may result in preparation of a new EA or a new SA to the existing programmatic NTS EIS (DOE, 1996a). The NEPA Compliance Officer must approve each Checklist before a project proceeds. Table 2-6 presents a summary of how NNSA/NSO complied with NEPA in 2004.

Table 2-6. NTS NEPA compliance activities conducted in 2004

Results of NEPA Checklist Reviews / NEPA Compliance Activities
31 projects were exempted from further NEPA analysis because they were of CX status.
25 projects were exempted from further NEPA analysis due to their inclusion under previous analysis in the NTS EIS (DOE, 1996a) and its Record of Decision.
1 project was exempted from further NEPA analysis due to its inclusion under previous analysis in an SA to the NTS EIS to address the increase in activities associated with the National Center for Combating Terrorism & Counterterrorism Training and related activities (DOE, 2003a).
An EA was initiated in 2003 and completed in June, 2004: *Final Environmental Assessment for Activities Using Biological Simulants and Releases of Chemicals at the Nevada Test Site* (DOE, 2004a). It was initiated in 2003 under a different title (*Environmental Assessment for Tests and Experiments Using Biological Materials and Releases of Chemicals Including Modification of Release Parameters for the Hazardous Materials Spill Center at the Nevada Test Site)*.
3 projects were exempted from further NEPA analysis due to their inclusion under previous analysis in the *Final Environmental Assessment for Activities Using Biological Simulants and Releases of Chemicals at the Nevada Test Site* (DOE, 2004a).
2 projects were reviewed which were not adequately addressed in existing NEPA analysis and resulted in the preparation of two EAs: *Environmental Assessment for Aerial Operations Facility Modifications* (completed October, 2004) (DOE, 2004b) and *Environmental Assessment for the Radiological/Nuclear Countermeasures Test and Evaluation Complex* (completed August, 2004) (DOE, 2004c).

Table 2-6. (continued)

Results of NEPA Checklist Reviews / NEPA Compliance Activities
1 project was exempted from further NEPA analysis due to its inclusion under previous analysis in the *Environmental Assessment for Aerial Operations Facility Modifications* (DOE, 2004b).
1 project was exempted from further NEPA analysis due to its inclusion under previous analysis in the *Environmental Assessment for the Radiological/Nuclear Countermeasures Test and Evaluation Complex* (DOE, 2004c).

2.7 Pollution Prevention and Waste Minimization

Resource Conservation and Recovery Act of 1976 (RCRA) – Through 42 USC 6922 (b) (1) of RCRA, generators of hazardous waste are required to have a program in place to reduce the volume or quantity and toxicity of such waste to the degree determined by the generator to be economically practicable. The EPA was required to develop a list of types of commercially-available products (e.g., copy machine paper, plastic desk top items) and then specify that a certain minimum percentage of the product type's content be comprised of recycled materials if they are to be purchased by a federal agency (e.g., all federally-purchased copy machine paper must be comprised of a minimum of 30 percent recycled paper). It then requires federal facilities to have a procurement process in place to ensure that they purchase product types which satisfy the EPA-designated minimum percentages of recycled material.

EO 13101 ***Greening the Government through Waste Prevention, Recycling and Federal Acquisition*** – Requires federal facilities to incorporate waste prevention and recycling into daily operations. It requires federal facilities to maintain an affirmative procurement process that ensures that 100 percent of products purchased which are found on the EPA-designated product list contain recycled material at the EPA-specified minimum content. The Secretary of Energy's goal is for DOE sites to become 100 percent compliant with this EO by the end of CY 2005.

DOE Order 450.1 ***Environmental Protection Program*** – Requires federal facilities to implement an Environmental Management System (EMS) that includes pollution prevention. The EMS must be fully integrated into the site Integrated Safety Management System (ISMS).

NDEP Hazardous Waste Permit Number NEV HW009 –This state permit requires NNSA/NSO to maintain an Annual Waste Minimization Summary Report in the Facility Operating Records. This report should include a description of the efforts taken during the year to reduce the volume and toxicity of waste generated as per RCRA, 42 USC 6922 (b) (1), as well as a description of the changes in volume and toxicity of waste actually achieved during the year in comparison to previous years to the extent such information is available for the years prior to 1984.

Secretary of Energy's Pollution Prevention and Energy Efficiency Leadership Goals – On November 12, 1999, the Secretary of Energy set numerous pollution prevention and energy efficiency goals that each DOE site is required to meet. They include goals for: (1) reducing wastes, (2) increasing recycling and purchases of recycled materials, and (3) reducing ODS and greenhouse gasses. Table 1-7b presents the status of site compliance with the first two goals.

2.7.1 Compliance Issues

The 1993 baselines for LLW, MW, and TRU waste were all 0 m^3. However, the JASPER project generates TRU waste. As long as this project generates TRU waste, NNSA/NSO will not be able to meet the leadership goals for reducing this waste type.

Before CY 2001, NNSA/NSO was not required to submit a TRI Report, Form R to the EPA. Effective January 1, 2001, the EPA lowered the reporting threshold for lead, a toxic chemical subject to TRI reporting, to 100 pounds (45 kilograms). NNSA/NSO has since reported lead releases from ammunition at the security contractor firing range on the NTS. No reduction in lead releases is anticipated as long as lead ammunition continues to be used.

NNSA/NSO recycled only 12 percent of solid wastes generated by all operations in CY 2004 (the leadership goal is 45 percent). Because of an accelerated cleanup schedule, large volumes of waste were generated and disposed in landfills. Little attempt was made to salvage any of this waste before disposal. As a result, waste generation totals were inflated, lowering the percentage of waste recycled.

In CY 2004, 68 percent of NNSA/NSO purchases of EPA-designated items contained recycled materials. NNSA/NSO is working to improve the procurement process in order to meet the CY 2005 leadership goal of 100 percent.

2.7.2 Compliance Reports

The compliance reports generated in 2004 to comply with pollution prevention and waste minimization (P2/WM) directives are presented in Table 2-7a.

2.7.3 Compliance Status

See Tables 2-7a and 2-7b for a summary of how NNSA/NSO complied with pollution prevention and waste minimization regulations in 2004.

Table 2-7a. NTS compliance status with applicable pollution prevention/waste minimization regulations

Compliance Measure/Action	Compliance Limit/Goal	Compliance Status 2004	Section Reference [a]
Resource Conservation and Recovery Act of 1976 (RCRA)			
Have a program in place to reduce the volume or quantity and toxicity of generated hazardous waste to the degree it is economically practicable	NA[b]	Compliant	11.1
Have a process in place to ensure that EPA-designated List products are purchased containing the minimum content of recycled materials	NA	Compliant	11.1
EO 13101 ***Greening the Government through Waste Prevention, Recycling and Federal Acquisition***			
Incorporate waste prevention and recycling into daily operations	N/A	Compliant	11.1
Percent of all purchased items which contain the minimum content of recycled material as specified on the EPA-designated product list	100%	68%	11.1
Submit a calendar year RCRA/EO 13101 Report to DOE/Headquarters (HQ) by entering the site's data into the DOE/HQ electronic database	Due December 31, 2004	Submitted December 15, 2004	- -
DOE Order 450.1 ***Environmental Protection Program***			
Implement an EMS that includes pollution prevention	Implement by December 31, 2005	On schedule	17.0
Submit a fiscal year Waste Generation and Pollution Prevention Progress Report to DOE/HQ that includes annual recycling totals and waste minimization accomplishments by entering the site's data into the DOE/HQ electronic database	Due December 3, 2004	Submitted November 15, 2004	11.3, 11.4
Submit a calendar year Waste Minimization Summary Report to NDEP	Due by March 1, 2004	Submitted February 14, 2004	11.3, 11.4
Secretary of Energy's P2 Leadership Goals			
See Table 2-7b			

(a) The section(s) within this document that describe how compliance summary data were collected
(b) Not applicable

Table 2-7b. NTS compliance status with the Secretary of Energy's pollution prevention and energy efficiency leadership goals

Leadership Goal	1993 Baseline	CY 2005 Goal	CY 2004 Status	CY 2004 Reduction
Reduce waste from routine operations by the following percentages for each waste type by 2005, using a 1993 baseline:				
Hazardous by 90%	3,724 mtons(a)	372 mtons	18.4 mtons	99.5%
Low Level Radioactive by 80%	0 m^3 (b)	0 m^3	0 m^3	N/A
Low Level Mixed Radioactive by 80%	0 m^3	0 m^3	0 m^3	N/A
Transuranic (TRU) by 80%	0 m^3	0 m^3	0 m^3	N/A
Reduce solid waste from routine operations by 75% by 2005, using a 1993 baseline	13,735 mtons	3,434 mtons	4,502 mtons	68%
Reduce releases of toxic chemicals subject to Toxic Release Inventory (TRI) reporting by 90% by 2005, using a 1993 baseline	0 pounds reported	No reduction possible(c)	5,868.7 pounds	No reduction possible
		Waste Disposed	**Waste Recycled**	**CY 2004 Reduction**
Recycle 45% of solid waste from all operations by 2005 and 50% by 2010		11,875 mtons	1,438 mtons	12%
		Waste Disposed	**Waste Reduced**	**CY 2004 Reduction**
Reduce waste resulting from cleanup, stabilization, and decommissioning activities by 10% on an annual basis		7,556 mtons	839 mtons	11%
			CY 2005 Goal	**CY 2004 Status**
Increase purchases of EPA-designated items with recycled content to 100%, except when not available competitively at a reasonable price or that do not meet performance standards			100%	68%

(a) metric tons, 1 mton = 1.10 ton

(b) cubic meters, 1 m^3 = 1.35 yd^3

(c) No measurable reduction can be reported because no waste of this type was reported on the NTS in 1993

2.8 Historic Preservation and Cultural Resource Protection

National Historic Preservation Act of 1966, as amended – This Act presents the goals of federal participation in historic preservation and delineates the framework for federal activities. Section 106 requires federal agencies to take into account the effects of their undertakings on properties included in, or eligible for inclusion in, the National Register of Historic Places (NRHP) and to consult with interested parties. The Section 106 process involves the agency reviewing background information, identifying eligible properties for the NRHP within the area of potential effect, making a determination of effect (when applicable), and developing a mitigation plan when an adverse effect is unavoidable. Determinations of eligibility, effect, and mitigation are conducted in consultation with the Nevada State Historic Preservation Officer (SHPO) and, in some cases, the federal Advisory Council on Historic Preservation. Section 110 sets out the broad historic preservation responsibilities of federal agencies and is intended to ensure that historic preservation is fully integrated into the ongoing programs of all federal agencies. It 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 archaeological collections and their associated records at professional standards. At the NTS, a long-term management strategy includes: (1) monitoring NRHP-listed and eligible properties to determine if environmental or other actions are negatively affecting the integrity or other aspects of eligibility and (2) taking corrective actions if necessary.

EO 11593 ***Protection and Enhancement of the Cultural Environment*** – Reinforces the obligation of federal agencies to conduct adequate surveys to locate any and all sites of historic value under their jurisdiction.

Archeological Resources and Protection Act of 1979 – The purpose of this act is to secure, for the present and future benefit of the American people, the protection of archaeological resources and sites which are on public and Indian lands, and addresses the irreplaceable heritage of archaeological sites and materials. It requires the issuance of a federal archaeology permit to qualified archaeologists for any work that involves excavation or removal of archaeological resources on federal and Indian lands and notification to Indian tribes of these activities. Unauthorized excavation, removal, damage, alteration, or defacement of archaeological resources is prohibited, as is the sale, purchase, exchange, transport, receipt of, or offer for sale of, such resources. Criminal and civil penalties apply to such actions. Information concerning the nature and location of any archaeological resource may not be made available to the public unless the federal land manager determines that the disclosure would not create a risk of harm to the resources or site. The Secretary of Interior is required to submit an annual report at the end of each fiscal year to Congress which reports the scope and effectiveness of all federal agencies' efforts on the protection of archaeological resources, specific projects surveyed, resources excavated or removed, damage or alterations to sites, criminal and civil violations, the results of permitted archaeological activities, and the costs incurred by the federal government to conduct this work. All archaeologists working at the NTS must have qualifications that meet federal standards and must work under a permit issued by NNSA/NSO. In the event of vandalism, NNSA/NSO would need to investigate the actions.

American Indian Religious Freedom Act of 1978 – 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 ceremonials and traditional rites. Locations exist on the NTS that have religious significance to Western Shoshone and Southern Paiute; visits to these places involve prayer and other activities. Access is provided by NNSA/NSO as long as there are no safety or health hazards.

Native American Graves Protection and Repatriation Act of 1990 (NAGPRA) – This act requires federal agencies to identify Native American human remains, funerary objects, sacred objects, and objects of cultural patrimony in their possession. Agencies are required to prepare an inventory of human remains and associated funerary objects, as well as a summary with a general description of sacred objects, objects of cultural patrimony, and unassociated funerary objects. Through consultation with Native American tribes, the affiliation of the remains and objects are determined and the tribes can request repatriation of their cultural items. The agency is required to publish a notice of inventory completion in the Federal Register. The law also protects the physical location where human remains are placed during a death rite or ceremony. The NTS artifact collection is subject to NAGPRA and the locations of American Indian human remains at the NTS must to be protected from NTS activities.

2.8.1 *Reporting Requirements*

NNSA/NSO submits Section 106 cultural resources survey reports and historical evaluations to the Nevada SHPO for review and concurrence. Mitigation plans and mitigation documents also are submitted to the Nevada SHPO and some types of documents go to the Advisory Council on Historic Preservation and the National Park Service. Reports containing restricted data on site locations are not available to the public. Some technical reports, however, are available to the public upon request and can be obtained from the National Technical Information Service. The 2004 reports submitted to agencies are discussed in Chapter 12.

2.8.2 *Compliance Status*

See Table 2-8 for a summary of how NNSA/NSO complied with historic preservation and cultural resource protection regulations on the NTS in 2004.

Table 2-8. NTS compliance status with historic preservation regulations

Compliance Action	**Compliance Status - 2004**	**Section Reference**[a]
National Historic Preservation Act of 1966 and EO 11593 *Protection and Enhancement of the Cultural Environment*		
Maintain and implement NTS Cultural Resources Management Plan	Compliant	--
Conduct cultural resources pre-activity surveys, inventories and evaluations of historic structures	Conducted for 8 projects	12.1; Table 12-1
Make determinations of eligibility to the National Register	Determined 8 properties eligible	12.1.3; Table 12-1
Make assessments of impact to eligible properties	All eligible sites are avoided by NTS activities	12.1.3
Manage artifact collection as per required professional standards	Compliant	12.2
Archaeological Resources and Protection Act of 1979		
Conduct archaeological work by qualified permittees	Compliant	--
Determine if archaeological sites have been damaged	None damaged	12.1.4.1
Complete and submit Secretary of the Interior Archaeology Questionnaire	Completed	12.1.4.3
American Indian Religious Freedom Act of 1978		
Allow American Indians access to NTS locations for ceremonies and traditional use	Access provided	12.3

Table 2-8. (continued)

Compliance Action	Compliance Status - 2004	Section Reference[(a)]
Native American Graves Protection and Repatriation Act		
Consult with affiliated American Indian tribes regarding repatriation of cultural items	Completed	12.2
Protect American Indian burial locations on NTS	Compliant	12.2
Overall Requirement		
Consult with tribes regarding various cultural resources issues	Compliant	12.3

(a) The section(s) within this document that describe how compliance summary data were collected

2.9 Conservation and Protection of Biota and Wildlife Habitat

Endangered Species Act (ESA) – Section 7 of this act requires federal agencies to ensure that their actions do not jeopardize the continued existence of federally listed endangered or threatened species or their critical habitat. The threatened desert tortoise is the only animal protected under the ESA which may be impacted by NTS operations. NTS activities within tortoise habitat are conducted so as to comply with the terms and conditions of a Biological Opinion issued by the U.S. Fish and Wildlife Service (FWS).

Migratory Bird Treaty Act (MBTA) – Prohibits the harming of any migratory bird, their nest, or eggs without authorization by the Secretary of the Interior. All but five of the 239 bird species observed on the NTS (Wills and Ostler, 2001) are protected under this act. Biological surveys are conducted for projects to prevent direct harm to protected birds, nests, and eggs.

Bald Eagle Protection Act – Prohibits the capture or harming of bald and golden eagles without special authorization. Both bald and golden eagles occur on the NTS. Biological surveys are conducted for projects to prevent direct harm to eagles and their nests and eggs.

Clean Water Act (CWA), Section 404, Wetlands Regulations – Regulates land development affecting wetlands by requiring a permit obtained from the U.S. Army Corps of Engineers (USACE) to discharge dredged or fill material into waters of the United States, which includes most wetlands on public and private land. NTS projects are evaluated for their potential to disturb wetlands and their need for a Section 404 permit application. Based on recent rulings, no natural NTS wetland may meet the criteria of a "jurisdictional" wetland subject to Section 404 regulations. However, final determination from the USACE regarding the status of NTS wetlands has yet to be received.

National Wildlife Refuge Administration Act – Forbids a person to knowingly disturb or injure vegetation or kill vertebrate or invertebrate animals or their nests or eggs on any National Wildlife Refuge lands unless permitted by the Secretary of the Interior. The boundary of the Desert National Wildlife Refuge (DNWR), land administered within this System, is approximately 5 km (3.1 mi) downwind of the NPTEC in Area 5. Biological monitoring is conducted to verify that approved tests conducted at the NPTEC do not disperse toxic chemicals that could harm biota on the DNWR.

EO 11990 *Protection of Wetlands* – Requires governmental agencies to minimize the destruction, loss, or degradation of wetlands and to preserve and enhance the natural and beneficial values of wetlands in carrying out the agency's responsibilities, including managing federal lands and facilities. Projects are evaluated for their potential to disturb the more than 20 natural water sources on the NTS. NTS wetlands are monitored to document their status and use by wildlife, even though they may not meet the criteria for "jurisdictional" status under the CWA.

EO 11988 *Floodplain Management* – Ensures protection of property and human wellbeing within a floodplain and protection of floodplains themselves. The Federal Emergency Management Agency (FEMA) publishes guidelines and specifications for assessing alluvial fan flooding. NNSA/NSO generally satisfies EO 11988 through DOE Order 420.1, *Facility Safety*, and invoked standards. DOE Order 420.1 and the associated implementation guide for mitigation of natural phenomena hazards call for a graded approach to assessing risk to all facilities (structures, systems, and components [SSC]) from potential natural hazards. Chapter 4 of DOE Standard 1020 (DOE-STD-1020-2002) provides flood design and evaluation criteria for SSC. Evaluations of flood hazards at the NTS are generally conducted to ensure protection of property and human wellbeing.

EO 13186 *Responsibilities of Federal Agencies to Protect Migratory Birds* – Directs federal agencies to take certain actions to further implement the MBTA if agencies have, or are likely to have, a measurable negative effect on migratory bird populations. It also directs federal agencies to support the conservation intent of the MBTA and conduct actions, as practicable, to benefit the health of migratory bird populations. NTS projects are evaluated for their potential to impact such bird populations.

EO 13112 *Invasive Species* – 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 NTS 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.

Wild Free-Roaming Horse and Burro Act – Requires the protection, management, and control of wild horses and burros on public lands and calls for the management and protection of these animals in a manner that is designed to achieve and maintain a thriving natural ecological balance. Wild horses on the NTS may wander off the NTS onto public lands and therefore are protected under this act. This act makes it unlawful to harm wild horses and burros.

Five-Party Cooperative Agreement – Agreement between NNSA/NSO, NTTR, FWS, Bureau of Land Management (BLM), and the state of Nevada Clearinghouse that calls for cooperation in conducting resource inventories and developing resource management plans for wild horses and burros and to maintain favorable habitat on federally withdrawn lands for these animals. BLM considers NTS a zero herd-size management area. NNSA/NSO consults with BLM regarding any issue of NTS horse management.

NAC 503.010-503.104 - Protection of Wildlife – Identifies Nevada animal species, both protected and unprotected, and prohibits the harm of protected species without special permit. Over 200 bird species and 1 bat species on the NTS are State-protected. Biological surveys are conducted for projects to prevent direct harm to protected birds, nests, eggs, and protected bats.

NAC 527.270 - Protection of Flora – Requires that the State Forester Firewarden determine the protective status of Nevada plants and prohibits removal or destruction of protected plants without special permit. Currently, no State-protected plant species are known to occur on the NTS. Annual reviews of the protection status of NTS plants are conducted.

2.9.1 Out-of-Compliance Incidents

Sixteen of 19 reports of mortality among migratory birds recorded in 2004 were related to NTS activities (see Table 13-5). They included eight species of migratory birds. The major cause of mortality was being hit by vehicles on roads (eight road kills). The electrocutions and road-kills in 2004 occurred at different locations. No feasible mitigation actions were identified or taken to reduce future bird mortality from these causes.

2.9.2 Compliance Reports

The following reports were prepared in 2004 to meet requirements of the regulations or to document compliance activities:

- *Annual Report of Actions Taken Under Authorization of the Biological Opinion on Nevada Test Site Activities (File No. 1-5-96-F-33) – January 1, 2004 Through December 31, 2004,* submitted to the FWS Southern Nevada Field Office in January 2005
- *Annual Report for Handling Permit S23391 for 2004*, submitted via email to Nevada Division of Wildlife on December 15, 2004
- *Annual Report for Federal Migratory Bird Scientific Collecting Permit MB008695-0*, submitted via FAX to FWS Portland Office in December 2004
- *Ecological Monitoring and Compliance Program Fiscal/Calendar Year 2004 Report,* DOE/NV/11718-985, March 2005

2.9.3 Compliance Status

See Table 2-9 for a summary of how NNSA/NSO complied with regulations related to the conservation and protection of biota and wildlife habitat on the NTS in 2004.

Table 2-9. NTS compliance status with applicable biota and wildlife habitat regulations

Compliance Measure/Action	Compliance Limit	Compliance Status - 2004	Section Reference[(a)]
Endangered Species Act			
Number of tortoises accidentally injured or killed due to NTS activities, per year	3	0	13.1
Number of tortoises captured and displaced from project sites, per year	10	0	13.1
Number of tortoises taken since 1992 by way of injury or mortality on NTS paved roads by vehicles other than those in use during a project	Unlimited	5	13.1
Number of total acres of desert tortoise habitat disturbed during NTS project construction since 1992	3,015	240.01	13.1
Follow the 23 terms and conditions of the Biological Opinion during construction and operation of NTS projects	NA[(b)]	Compliant	13.1
Conduct biological surveys at proposed project sites to assess presence of protected species	NA	Compliant 145 surveys conducted for 40 projects	13.2
Migratory Bird Treaty Act; Bald Eagle Protection Act and EO 13186 *Responsibilities of Federal Agencies to Protect Migratory Birds*			
Number of birds/nests/eggs harmed by NTS project activities	0	6 bird nests removed from buildings, 16 bird deaths	13.2; Table 13-4; 13.3.4; Table 13-5
National Wildlife Refuge System Administration Act			
Number of animals, their nests, or eggs killed and amount of vegetation disturbed or injured on System lands (the Desert National Wildlife Range) as a result of NTS activities	0	0	13.5
Wild Free-Roaming Horse and Burro Act and Five-Party Cooperative Agreement			
Number of horses harassed or killed due to NTS activities	0	0	13.3.3
Cooperation in conducting resource inventories and developing resource management plans for horses on NTS, NTTR, and the Desert National Wildlife Range	NA	NTS annual horse inventory conducted	13.3.3; Figure 13-6

Table 2-9. (continued)

Compliance Measure/Action	Compliance Limit	Compliance Status - 2004	Section Reference[(a)]
EO 11988 *Floodplain Management*			
Conduct flood hazard evaluations	NA	Evaluations were conducted for: (1) Corrective Action Unit 482, Area 15 U15a/e muckpiles and ponds (2) DHS Training Facility, Area 6 (3) Radioactive Waste Management Sites, Area 3 and Area 5	--
Clean Water Act, Section 404-Wetlands Regulations and EO 11990 *Protection of Wetlands*			
Number of wetlands disturbed by NTS activity	NA	18 natural wetlands surveyed –none disturbed by NTS activity	13.3.5
EO 13112 *Invasive Species*			
Disturbed habitat is revegetated with native plant species on occasion to mitigate for loss of tortoise habitat (in lieu of payment), to stabilize soil, and to prevent invasion of non-native plants	NA	No revegetation conducted, previously revegetated Egg Point Fire area was monitored	13.4
NAC 503.010-503.104 and NAC 527.270 - Nevada Protective Measures for Wildlife and Flora			
Number of state-protected animals harmed or killed and number of state-protected plants collected or harmed due to NTS activities	0	16 bird deaths recorded	13.3; Table 13-5

(a) The sections within this document that describe how compliance summary data were collected

(b) Not applicable

2.10 Environmental Management System

EO 13148 ***Greening the Government through Leadership in Environmental Management*** – Requires federal facilities to have an EMS that considers potential environmental impacts in all aspects of its work. This is especially important in the work planning and budgeting stages. Pollution prevention, eliminating potential wastes, and recycling materials must always be addressed when planning work. The EO requires that the EMS be in place by December 31, 2005.

DOE Order 450.1 ***Environmental Protection Program*** – Requires each DOE facility to implement an EMS which is a continuing cycle of planning, implementing, evaluating, and improving processes and actions undertaken to achieve environmental goals. The objectives are to implement sound stewardship practices that are protective of the air, water, land, and other natural and cultural resources impacted by DOE operations, by which DOE cost-effectively meets or exceeds compliance with applicable environmental, public health, and resource protection laws, regulations, and DOE requirements. The EMS must be fully integrated into each DOE site's ISMS by December 31, 2005.

2.10.1 Compliance Reports

NNSA/NSO submitted quarterly reports to DOE Headquarters (HQ) in 2004 regarding progress towards meeting interim goals that were established to help facilities meet the December 31, 2005 deadline.

2.10.2 Compliance Status

See Table 2-10 for a summary of how NNSA/NSO complied with EMS regulations.

Table 2-10. NTS compliance status with Environmental Management System regulations

Compliance Measure/Action	Compliance Limit	Compliance Status - 2003	Section Reference[(a)]
Executive Order (EO) 13148 ***Greening the Government through Leadership in Environmental Management***			
Have an EMS in place	December 31, 2005	On schedule	17.0
Have measurable environmental Objectives and Targets established	December 31, 2004	Compliant	17.0
Have environmental programs established to achieve EMS Objectives and Targets	December 31, 2004	Compliant	17.0
Establish awareness training program	December 31, 2004	Compliant	17.0
DOE Order 450.1 ***Environmental Protection Program***			
Incorporate the EMS into the site's ISMS	December 31, 2005	On schedule	17.0

(a) The section(s) within this document that describe compliance summary data

2.11 Occurrences, Unplanned Releases, and Continuous Releases

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) – Continuous release reporting under Section 103 requires that a non-permitted hazardous substance release that is equal to or greater than its reportable quantity be reported to the National Response Center. The EPA requires all facilities that release a hazardous substance meeting the Section 103(f) requirements to report annually to EPA and perform an annual evaluation of releases. CERCLA requirements applicable to NTS operations also pertain to an emergency response program for hazardous substance releases to the environment (see discussion of Emergency Planning and Community Right-to-Know Act in Section 2.5).

Emergency Planning and Community Right-to-Know Act (EPCRA) – This act is described in Section 2.5. See Table 2-5 for summary of compliance to EPCRA pertaining to unplanned environmental releases of hazardous substances.

40 CFR 302.1 – 302.8: Designation, Reportable Quantities, and Notification – Requires facilities to notify federal authorities of spills or releases of certain hazardous substances designated under CERCLA and the CWA. It specifies what quantities of hazardous substance spills/releases must be reported to authorities and delineates the notification procedures for a release that equals or exceeds the reportable quantities.

DOE Order 231.1A *Environment, Safety, and Health Reporting* – This Order includes the requirement for reporting environmental occurrences. Along with DOE M 231.1-1 *Environment, Safety and Health Reporting Manual*, it requires the establishment and maintenance of a system for reporting operations information related to DOE-owned and leased facilities, for processing that information to identify the root causes of environmental occurrences, and for providing appropriate corrective action for such occurrences.

NAC 445A.345–445.348 - Notification of Release of Pollutant – Requires state notification for the unplanned or accidental releases of specified quantities of pollutants, hazardous wastes, and contaminants.

Water Pollution Control General Permit GNEV93001 – This general wastewater discharge permit issued by the state to the NTS specifies that no petroleum products will be discharged into treatment works without first being processed through an oil/water separator or other approved methods. It also specifies how NNSA/NSO shall report each bypass, spill, upset, overflow, or release of treated or untreated sewage.

Other NTS Permits/Agreements – As with General Permit GNEV93001, there are other state permits and agreements cited in previous subsections of this chapter (e.g., FFACO) that specify that accidents or events of non-compliance must be reported. These include events that may create an environmental hazard.

2.11.1 Compliance Status

There are no continuous releases on the NTS or at its satellite facilities.

One reportable environmental occurrence happened on the NTS in 2004 and involved the release of used motor oil onto soil. This occurrence is described in Table 2-11.

One reportable environmental occurrence happened at the NLVF in 2004 and is discussed in Appendix B.

Accidental spills or releases which are less than federal or state-designated reportable quantities are not presented in this report. The direct, contributing, and root causes of all occurrences are determined and are described within occurrence reports prepared for each occurrence. Occurrence reports are submitted to NNSA/NSO by BN Environmental Services.

Table 2-11. Environmental occurrences on the NTS in 2004

Occurrence Report Number and Date	Type of Occurrence
NVOO-BN-NTS-2004-0006, November 17, 2004	**Waste Oil Release** A BN lubrication truck leaked used oil from a 650-gallon oil holding tank. The truck was parked on a hard packed dirt surface near the Generator Shop (Building 6-621) in Area 6. A piece of tubing attached to the oil holding tank broke during non-work hours over a weekend, resulting in the release of what was first estimated to be 210 gallons of oil. The surface stain on the ground measured approximately 20 x 20 ft. A review of the truck's log sheets resulted in a revised estimate of approximately 75 gallons of oil spilled. The leak exceeded the NDEP limit of 25 gallons. The oil release was controlled. Notifications were made to NDEP. Contaminated soils were excavated to meet NDEP clean up levels. The truck was taken out of service for repairs. The cause of tubing failure was determined to be exposure to the environment. New ultraviolet light resistant tubing was used for replacement tubing. Approximately 12 – 15 cubic yards of contaminated soil was disposed of in the Area 6 Hydrocarbon Landfill. The excavation was backfilled with clean fill.

2.12 Summary of Permits

Table 2-12 presents the complete list of all federal and state permits active in 2004 that have been issued to NNSA/NSO and to BN for NTS, NLVF, and RSL operations and which have been referenced in previous subsections of this chapter. The table includes those pertaining to air quality monitoring, operation of drinking water and sewage systems, hazardous materials and hazardous waste management and disposal, and endangered species protection. Reports associated with these permits are submitted to the appropriate designated state or federal office. Copies of reports may be obtained upon request.

Table 2-12. Environmental permits required for NTS and NTS site facility operations

Permit Number	Description	Expiration Date	Reporting
Air Quality	**NTS**		
AP9711-0549.01	NTS Class II Air Quality Operating Permit	June 25, 2009	Annually
AP1442-1429	Temporary Sand and Gravel Processing, Hot Mix Asphalt, and Concrete Batch Facilities	June 29, 2009	Annually
04-121	Area 27 Burn Variance (LLNL)	March 31, 2005	None
04-27	NTS Burn Variance (Training Fires)	March 12, 2005	None
	NLVF		
A38701	A-16 Spray Paint Booth	None	Annually
A38703	A-5/B-5 Emergency Generators	None	Annually
A06503	Emergency Generator	None	Annually
A06505	B-1 Aluminum Sander	None	Annually
A06507	Tinco Dry Blaster	None	Annually
	RSL		
A34801	Boiler, Columbia, WL-180	None	March, June
A34802	Boiler, Columbia, WL-90	None	March, June
A34803	Water Heater, #2 Natl. BD	None	March, June
A34804(a)	Emergency Fire Control Pump Engine	None	June
A34804(b)	Emergency Generator, Cummins	None	June
A34805	Spray Paint Booth	None	June
NTS Drinking Water			
NY-0360-12NTNC	Areas 6 and 23	September 30, 2005	None
NY-4098-12NTNC	Area 25	September 30, 2005	None
NY-4099-12NTNC	Area 12	September 30, 2005	None
NY-0835-12NP	NTS Water Hauler #84846	September 30, 2005	None
NY-0836-12NP	NTS Water Hauler #84847	September 30, 2005	None
NTS Septic Systems and Pumpers			
NY-1076	Septic System, Area 6 (Airborne Response Team Hangar)	None	None
NY-1077	Septic System, Area 27 (Baker Compound)	None	None
NY-1106	Septic System, Area 5 (Building 05-08)	None	None
NY-1079	Septic System, Area 12 (U12g Tunnel)	None	None
NY-1080	Septic System, Area 23 (Building 1103)	None	None
NY-1081	Septic System, Area 6 (CP-170)	None	None
NY-1082	Septic System, Area 22 (Building 22-01)	None	None
NY-1083	Septic System, Area 5 Radioactive Material Management Site	None	None
NY-1084	Septic System, Area 6 (Device Assembly Facility)	None	None

Table 2-12. (continued)

Permit Number	Description	Expiration Date	Reporting
NTS Septic Systems and Pumpers (cont.)			
NY-1085	Septic System, Area 25 (Central Support Area)	None	None
NY-1086	Septic System, Area 25 (Reactor Control Point)	None	None
NY-1087	Septic System, Area 27 (Able Compound)	None	None
NY-1089	Septic System, Area 12 (Camp)	None	None
NY-1090	Septic System, Area 6 (LANL Construction Camp Site)	None	None
NY-1091	Septic System, Area 23 (Gate 100)	None	None
NY-1103	Septic System, Area 22 (Desert Rock Airport)	None	None
NY-1110-HAA-A	Individual Sewage Disposal System, A-12, Bldg. 12-910	None	None
NY-1112	Commercial Sewage Disposal System, U1a, Area 1	None	None
NY-1113	Commercial Sewage Disposal System, Area 1, Building 121	None	None
NY-17-03313	Septic Tank Pumper E 106785	November 30, 2005	None
NY-17-03315	Septic Tank Pumper E 107105	November 30, 2005	None
NY-17-03317	Septic Tank Pumper E-105918	November 30, 2005	None
NY-17-03318	Septic Tank Pumping Contractor (one unit)	November 30, 2005	None
NY-17-06838	Septic Tank Pumper E-105919	November 30, 2005	None
NY-17-06839	Septic Tank Pumper E-107103	November 30, 2005	None
Wastewater Discharge	**NTS**		
GNEV93001	Water Pollution Control General Permit	May 7, 2005	Quarterly
NEV96021	Water Pollution Control for E-Tunnel Waste Water Disposal System and Monitoring Well ER-12-1	September 25, 2007	Quarterly
	NLVF		
VEH-112	NLVF Wastewater Contribution Permit	December 31, 2006	Annually
TNEV2003461	NLVF Temporary Well Test/Discharge Permit	May 21, 2004	Monthly
TNEV2004348	NLVF Temporary Well Test/Discharge Permit	November 21, 2004	Monthly
TNEV2004364	NLVF Temporary Well Test/Discharge Permit	May 21, 2005	Monthly
	RSL		
CCWRD-080	Industrial Wastewater Discharge Permit	June 30, 2005	Quarterly
Hazardous Materials	**NTS**		
2287-5146	NTS Hazardous Materials	February 28, 2005	Annually
2287-5147	Non-Proliferation Test and Evaluation Complex (formerly known as the Hazardous Materials Spill Center)	February 28, 2005	Annually
	NLVF		
2287-5144	NLVF Hazardous Materials Permit	February 28, 2005	Annually
	RSL		
2287-5145	RSL Hazardous Materials Permit	February 28, 2005	Annually
NTS Hazardous Waste			
NEV-HW009	NTS Hazardous Waste Management (RCRA)	November 17, 2005	Biennially

Table 2-12. (continued)

Permit Number	Description	Expiration Date	Reporting
NTS Disposal Sites			
SW 13 000 01	Area 5 Asbestiform Low-Level Solid Waste Disposal Site	Postclosure[(a)]	Annually
SW 13 097 02	Area 6 Hydrocarbon Disposal Site	Postclosure	Annually
SW 13 097 03	Area 9 U10c Solid Waste Disposal Site	Postclosure	Annually
SW 13 097 04	Area 23 Solid Waste Disposal Site	Postclosure	Annually
Endangered Species/Wildlife			
File No. 1-5-96-F-33	U.S. Fish and Wildlife Service - Desert Tortoise Incidental Take Authorization	December 31, 2006	Annually
MB008695-0	U.S. Fish and Wildlife Service – Migratory Bird Scientific Collecting Permit	December 31, 2004	Annually
S23391	Nevada Division of Wildlife - Scientific Collection of Wildlife Samples	December 31, 2004	Annually

(a) Permit expires 30 years after closure of the landfill

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3.0 Radiological and Non-Radiological Air Monitoring

Section 3.1 of this chapter presents the results of radiological air monitoring conducted on and off the NTS to ensure compliance with radioactive air emission standards (see Section 2.1). Sources of radioactive air emissions from the NTS include evaporation of tritiated water from containment ponds, diffusion of tritiated water vapor from the soil at Area 3 and Area 5 Radioactive Waste Management Sites (RWMSs)s, Sedan crater, and Schooner crater, release of tritium gas during equipment calibrations at Building 650 in Area 23, and resuspension of plutonium and americium from contaminated soil at historical nuclear device safety test locations and atmospheric test locations. Radiological monitoring is conducted by Bechtel Nevada (BN) Environmental Technical Services (ETS).

The concentrations of radioactivity in air samples are presented in Section 3.1. These data are then used to assess radiological dose to the general public in the vicinity of the NTS. The calculated doses are presented in Section 8.0 (Radiological Dose Assessment). The calculated doses are based on the air sampling data presented in Section 3.1, the water sampling data presented in Section 4.1, and the direct radiation exposure data presented in Section 5.0.

An oversight monitoring program has been established by the NNSA/NSO to monitor radionuclide contamination of air within communities adjacent to the NTS. This independent oversight program is managed by the University of Nevada's Desert Research Institute (DRI). DRI's 2004 air monitoring results are presented in Section 6.0.

Section 3.2 of this chapter presents the results of non-radiological air quality assessments conducted on the NTS to ensure compliance with current air quality permits (see Section 2.1). NTS operations which are potential sources of non-radiological 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, and releases of various chemicals during testing at the Non-Proliferation Test and Evaluation Complex (NPTEC). Air quality assessments are conducted by BN Environmental Services (ES).

3.1 Radiological Air Monitoring

DOE Order 5400.5 *Radiation Protection of the Public and the Environment*, and the Clean Air Act (CAA) National Emission Standards for Hazardous Air Pollutants (NESHAP) require air monitoring for radiological emissions at the NTS. Radiological air monitoring is conducted to ensure that no significant emission source that contributes to calculable offsite exposures is ignored and that the NTS is in full compliance with the requirements of DOE Order 5400.5 and the CAA. To accomplish this, an air surveillance network comprised of air particulate samplers and samplers for tritium in atmospheric moisture has been established. The objectives and design of the network are described in detail in the *Routine Radiological Environmental Monitoring Plan* (RREMP) (DOE, 2003b). The network monitors airborne radioactivity near NTS sites at which radioactivity from past nuclear testing was deposited on and in the soil, at NTS operating facilities that may produce radioactive air emissions, and along the boundaries of the NTS. Data from all sampling stations are analyzed to meet the specific goals listed below. The dose measures which are calculated to show compliance with federal radiation protection regulations are defined and presented in Section 8.0.

Also listed below are the monitored analytes that comprise the base data needed to perform dose assessments. They are concentrations of the radionuclides or radioactivity which are most likely to be present in the air as a result of past or current NTS operations. These analytes were selected based on the results of NTS inventories of radionuclides in surface soil (McArthur, 1991), and upon their volatility and availability for resuspension. Uranium is included on this list because depleted uranium (see Glossary, Appendix D) ordinances are used during exercises in Areas 20 and 25. It is analyzed for in air samples only from selected sampling locations in the vicinity of these areas. Gross alpha and gross beta readings are also used in air monitoring as a rapid screening measure and for looking at trends in gross radioactivity concentrations.

Radiological Air Monitoring Goals	*Analytes Monitored*	
Measure radionuclide concentrations in air at or near historic or current operation sites which have the potential to release airborne radioactivity to: (1) detect and identify local and site-wide trends, (2) identify radionuclides emitted to air, and (3) detect accidental and unplanned releases	Americium-241 (^{241}Am)	Uranium-233+234 ($^{233+234}$U)
Determine if radioactive air emissions from past or present NTS activities result in a radiation dose to any member of the public that exceeds the NESHAP standard of 10 millirem per year (mrem/yr) (0.1 millisievert per year [mSv/yr])	Cesium-137 (^{137}Cs)	Uranium-235+236 ($^{235+236}$U)
	Tritium (^{3}H)	Uranium-238 (^{238}U)
Provide point source operational monitoring as required under NESHAP for any facility that has the potential to emit radionuclides into the air which could cause a dose greater than 0.1 mrem/yr (0.001 mSv/yr) to any member of the public	Plutonium-238 (^{238}Pu)	Gross alpha radioactivity
Provide data to determine if radioactive air emissions from past or present NTS activities result in a radiation dose to any member of the public from all pathways (air, water, food) that exceeds the DOE Order 5400.5 standard of 100 mrem/yr (1 mSv/yr)	Plutonium-239+240 ($^{239+240}$Pu)	Gross beta radioactivity

3.1.1 Monitoring System Design

Environmental Samplers – There are 19 sampling stations referred to as environmental samplers. They include 3 stations which have only low-volume air particulate samplers, 1 which has only a tritium sampler, and 15 which have both air particulate and tritium samplers (Figure 3-1). The 6 critical receptor samplers described below are included in this count. With the exception of the 6 critical receptor samplers, they are located throughout the NTS in or near diffuse radiation sources. The sources include areas with (1) radioactivity in surface soil that can be resuspended by the wind, (2) tritium that transpires or evaporates from plants and soil at the sites of past nuclear cratering tests, and (3) tritium that evaporates from ponds receiving tritiated water either pumped from contaminated wells or directed from tunnels that cannot be sealed shut. Sampling and analysis of air particulates and tritium was performed at these stations as described in Section 3.1.2. Radionuclide concentrations measured at these stations are used for trending, determining ambient background concentrations in the environment, and monitoring for unplanned releases of radioactivity. Air concentrations approaching 10 percent of the NESHAP Concentration Levels for Environmental Compliance (CLs) (second column of Table 3-1) are investigated for causes so that they may be mitigated to avoid exceeding regulatory dose limits.

Critical Receptor Samplers – Six air particulate and tritium sampling stations located near the boundaries and the center of the NTS are approved by EPA Region IX as critical receptor samplers (Figure 3-1). Radionuclide concentrations measured at these six stations are used to assess compliance with the NESHAP dose limit to the public of 10 mrem/yr (0.1 mSv/yr). Analysis of air particulate and tritium data obtained at these six stations was performed as described in Section 3.1.2 below. The annual average concentrations from each station were then compared with the concentration limits listed in Table 3-1. To be in compliance with NESHAP, the annual average concentrations must be less than the concentration limits in Table 3-1. 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 concentration limit and then adding the fractions together, is less than 1.0.

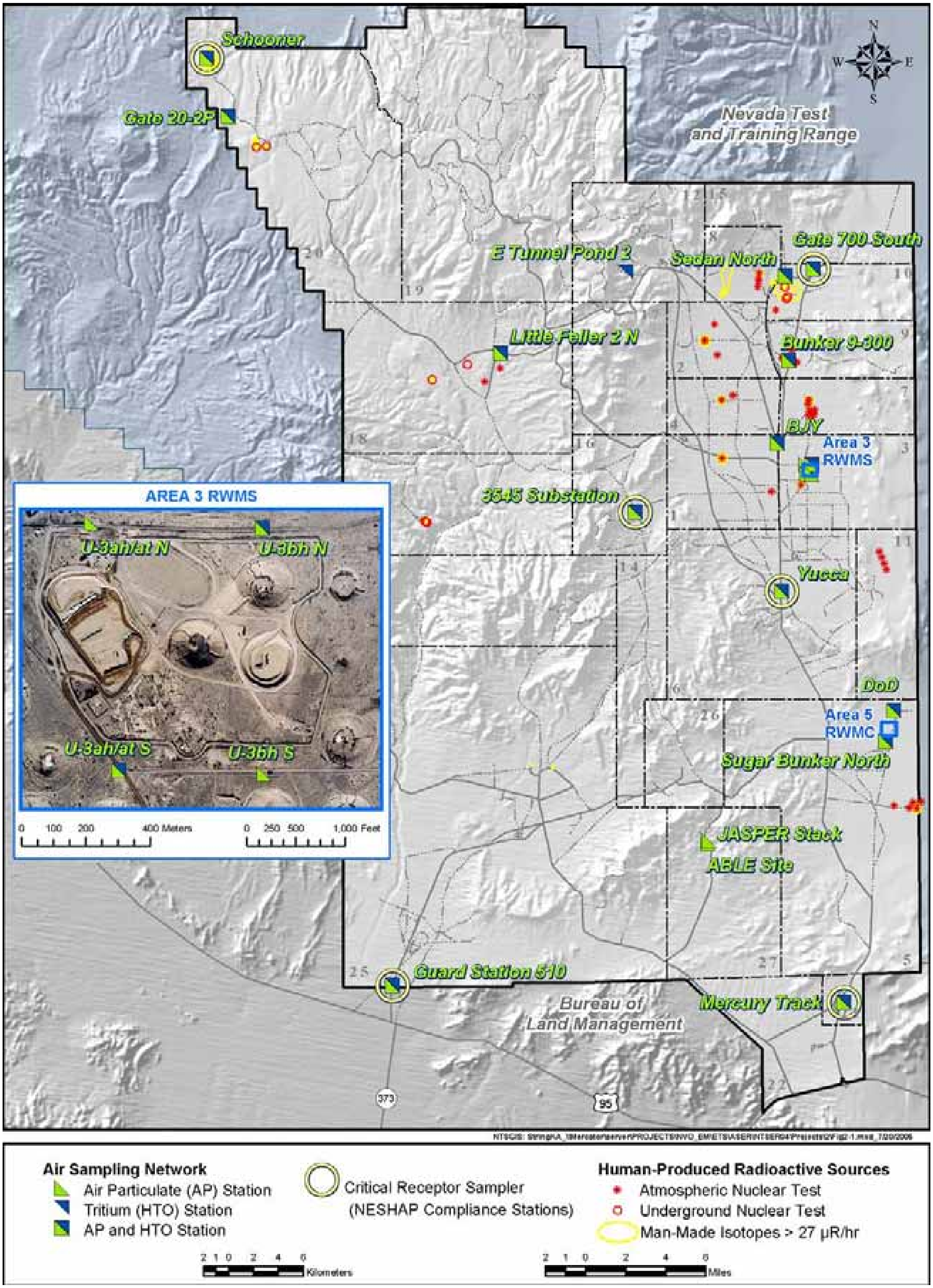

Figure 3-1. Radiological air sampling network on the NTS in 2004

Table 3-1. Regulatory concentration limits for radionuclides in air

Radionuclide	Concentration (x 10^{-15} microcuries/milliliter [µCi/mL]) NESHAP Concentration Level for Environmental Compliance (CL)[a]	Derived Concentration Guide (DCG)[b]
^{241}Am	1.9	2
^{137}Cs	19	40,000
^{3}H	1,500,000	10,000,000
^{238}Pu	2.1	3
^{239}Pu	2	2
^{233}U	7.1	9
^{234}U	7.7	9
^{235}U	7.1	10
^{236}U	7.7	10
^{238}U	8.3	10

Note: Both the CL and DCG values represent the annual average concentration which would result in a committed effective dose equivalent (CEDE) of 10 mrem/yr which is the federal dose limit to the public from all radioactive air emissions. When they differ, the CLs are more conservative than the DCGs. They are computed using different dose models.

(a) From Table 2, Appendix E of 40 CFR 61, NESHAP, 1999

(b) From Chapter 3 of DOE Order 5400.5, 1990, see Glossary, Appendix D for definition

Point–Source (Stack) Sampler – Only one facility on the NTS, the JASPER facility in Area 27 (Figure 3-1), requires stack monitoring because it has the potential to emit airborne radionuclides that could result in an offsite radiation dose ≥ 0.1 mrem/yr. Air emissions from the facility are filtered through a high efficiency particulate air (HEPA) filter, and Lawrence Livermore National Laboratory (LLNL) performs stack monitoring down-stream of the filter. Environmental sampling of air particulates adjacent to the facility is performed as stated in Section 3.1.2. If air concentrations of any man-made radionuclide were found above the minimum detectable concentration (MDC), (see Glossary, Appendix D) then an assessment of offsite dose to the public would be performed to determine NESHAP compliance and LLNL would investigate the cause of the emission and implement corrective actions.

3.1.2 *Air Particulate and Tritium Sampling Methods*

A weekly sample of airborne particulates was collected from each air sampling station by drawing air through a 10-centimeter (cm) (4-inch [in]) diameter glass-fiber filter at a constant flow rate of 85 liters per minute (L/min) (3 cubic feet per minute [cfm]). 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 run-time clock measures the operating time. The run time, multiplied by 85 L/min yields the volume of air sampled, which is about 860 cubic meters (m^3) (30,000 cubic feet [ft^3]) during a typical seven-day sampling period. The air sampling rates were measured at the start and end of each sampling period with a mass-flow meter, which measured the rates at existing temperature and barometric pressure.

The 10-cm diameter filters were analyzed for gross alpha and gross beta radioactivity after a five-day holding time to allow for the decay of the progeny of naturally-occurring radon and thoron. The filters from four weeks of sampling were composited, analyzed by gamma spectroscopy, and then analyzed for $^{239+240}$Pu and ^{241}Am by alpha spectroscopy after radiochemical separation. To monitor for any potential emissions from tests using depleted uranium, the filter composites from Yucca (Area 6), Substation 3545 (Area 16), Gate 20-2p (Area 20), Guard Station 510 (Area 25), and Able Site (Area 27) were also analyzed for uranium isotopes by alpha spectroscopy.

Tritiated water vapor in the form of $^3H^3HO$ or ^3HHO (collectively referred to as HTO) was sampled continuously over two-week periods at each tritium sampling station. Tritium samplers were operated at a constant flow rate of 566 cubic centimeters per minute (cc/min) (1.2 cubic feet per hour [ft^3/hr]) by microprocessors that summed the total volume sampled (about 11 m^3 [14.4 yd^3] over a two-week sampling period). Due to failures in aging components, the microprocessor controls were replaced by the end of the year with mechanical controls which simplified repairs and reduced maintenance costs. The HTO was removed from the air stream by two molecular sieve columns connected in series (one for routine collection and a second one to indicate if breakthrough occurred during collection). These columns were exchanged biweekly. An aliquot of the total moisture collected was extracted from the first column and analyzed for tritium by liquid scintillation counting.

Routine quality control air samples (e.g., duplicates, blanks, and spikes) are also incorporated into the analytical suites on a frequent basis. The reader is directed to Section 18.0 for a discussion of quality assurance/quality control protocols and procedures utilized for radiological air monitoring.

3.1.3 Presentation of Air Sampling Data

The annual average concentration for each radionuclide at each sampling location is presented in data tables in the following results sections. The annual average concentration for each radionuclide was calculated from the uncensored analytical results for individual samples; i.e., values less than the sample-specific MDC were included in the calculation. A column is included in each table indicating the percentage of the analytical results that were greater than their analysis-specific MDCs.

Annual average concentrations are also expressed in the tables as percentages of the CL (the second column of Table 3-1). In graphs of concentration data, the CL or some percentage of the CL is included as a green horizontal line. The CL for each radionuclide was used instead of the DCG, as it was always the lesser of the two for those radionuclides for which these limits differed. The CL (or fraction thereof) is shown in graphs for reference only and not to demonstrate compliance with NESHAP dose limits; assessment of compliance is based upon annual average concentrations, not upon the single measurement results shown in the graphs.

For convenience in reporting, values shown in the tables in the following results sections are formatted to a greater number of digits (three or more) than can be justified by the accuracy of the measurements, which is typically two significant figures (e.g., 2500, 25, 2.5, or 0.025).

3.1.4 Air Sampling Results from Environmental Samplers

No radioactive emissions were detected from current NTS operations in 2004. All radionuclide concentrations in the 2004 air samples shown in the tables and graphs are attributed to the resuspension of legacy contamination in surface soils and to the evaporation and transpiration of tritium from the soil and plants at the sites of past nuclear tests and of low-level radioactive waste burial.

3.1.4.1 Americium-241

During 2004, 41 percent of all the air samples contained detectable concentrations of ^{241}Am (Table 3-2). The average concentration of ^{241}Am across all environmental sampler sites was 9.7×10^{-18} μCi/mL (0.36 microbecquerel per cubic meter [μBq/m^3]). The highest mean concentration occurred at Bunker 9-300 (48.1×10^{-18} μCi/mL [1.8 μBq/m^3]), which is only 2.5 percent of the CL. Peaks in ^{241}Am concentrations throughout the year occurred predominately at Bunker 9-300 (Figure 3-2).

Table 3-2. Concentrations of ^{241}Am in air samples collected in 2004

			^{241}Am (x 10^{-18} µCi/mL)							
NTS Area	**Location**	**Number of Samples**	**Mean**	**% of CL [a]**	**Median**	**SD[b]**	**Min [c]**	**Max [d]**	**Mean MDC**	**% > MDC**
1	BJY	12	7.95	0.4	5.48	9.88	0.00	35.34	7.49	50.0
3	U-3ah/at N	12	12.79	0.7	11.62	7.83	2.25	28.83	7.48	75.0
3	U-3ah/at S	12	20.58	1.1	19.04	11.38	0.70	34.95	6.76	83.3
3	U-3bh N	12	14.05	0.7	7.79	20.06	-2.89	73.51	7.89	66.7
3	U-3bh S	12	8.57	0.5	8.96	3.33	2.61	13.28	7.70	50.0
5	DoD	12	4.11	0.2	3.69	5.22	-1.44	18.62	7.92	41.7
5	Sugar Bunker N	12	3.89	0.2	3.55	2.78	0.40	8.63	7.38	33.3
6	Yucca	12	3.57	0.2	3.59	4.15	-1.30	13.94	8.54	33.3
9	Bunker 9-300	12	48.07	2.5	24.27	50.04	5.26	169.66	7.93	66.7
10	Gate 700 S	12	5.54	0.3	2.82	7.37	1.13	27.46	8.38	25.0
10	Sedan N	12	17.89	0.9	5.98	19.98	0.06	59.00	7.63	50.0
16	3545 Substation	12	2.74	0.1	2.88	2.41	-0.95	6.44	7.83	29.2
18	Little Feller 2 N	12	4.85	0.3	4.41	4.16	-2.37	13.90	8.21	33.3
20	Gate 20-2P	12	0.88	0.0	1.45	2.21	-3.89	3.97	9.36	8.3
20	Schooner	12	2.18	0.1	1.79	4.05	-4.52	12.95	8.28	16.7
23	Mercury Track	12	2.96	0.2	3.04	2.26	-1.50	5.74	7.05	20.8
25	Guard Station 510	12	4.69	0.2	3.03	8.29	-0.37	30.56	7.40	16.7
27	ABLE Site	12	8.99	0.5	1.86	17.56	-0.60	62.85	8.45	33.3
All Environmental Samplers		**216**	**9.68**	**0.5**	**4.18**	**18.12**	**-4.52**	**169.66**	**7.87**	**40.7**
27	JASPER Stack	10	19.01	1.0	5.10	29.89	-0.20	93.51	78.40	0.0

Blue-shaded locations are EPA-approved critical receptor sampler stations

The orange-shaded location is a point-source sampler station

Non-shaded locations are environmental sampler stations

Green shading indicates that some percentage of samples had concentrations above the sample-specific MDC

(a) CL is the NESHAP Concentration Level for Environmental Compliance (see Table 3-1)

(b) Standard deviation

(c) Minimum

(d) Maximum

Note: The CL for ^{241}Am is 1,900 x 10^{-18} µCi/mL when expressed in the same scale as the data in this table.

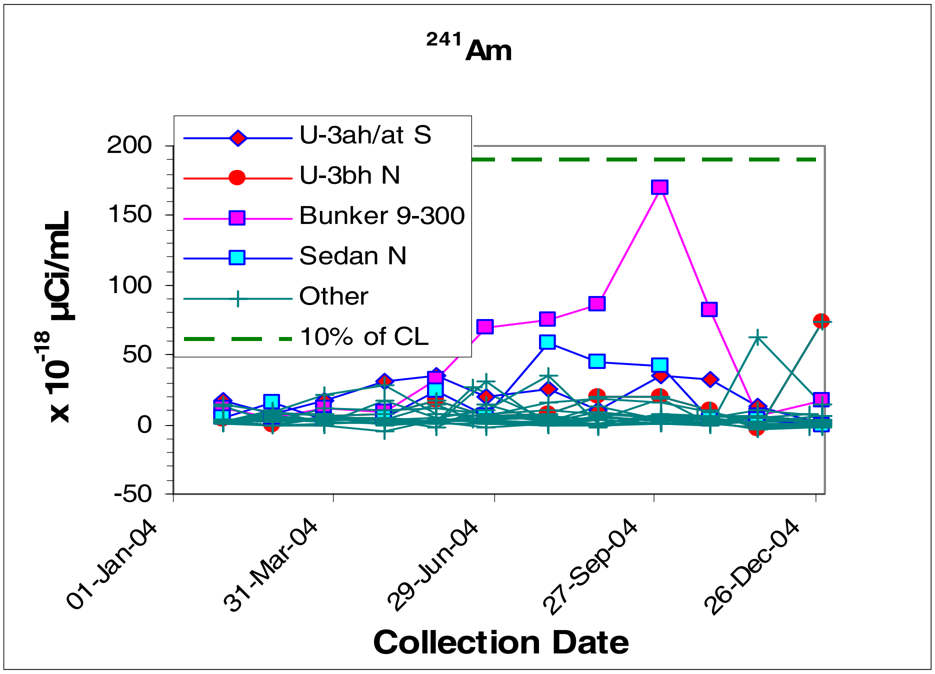

Figure 3-2. Concentrations of ^{241}Am in air samples collected in 2004

3.1.4.2 *Cesium-137*

Cs-137 was measured above the MDC in samples from only one location, Gate 700 S in Area 10 (Table 3-3), which is near known legacy deposits of radionuclides from past nuclear tests. As in previous years, ^{137}Cs is only occasionally detected in the monthly air sample composites. All concentration means were below or near zero, similar to past years. No graph for ^{137}Cs concentrations is included because the majority of values were below detection levels.

3.1.4.3 *Plutonium Isotopes*

Pu-238 was detected above the MDC in at least one sample from each of 13 locations (Table 3-4). The proportion of samples with concentrations above their MDCs was approximately the same as that in the last three years. The U-3ah/at S and Bunker 9-300 locations had the highest proportion of samples above their MDCs (27 and 36 percent, respectively) and also the highest mean concentrations which were only 0.2 percent and 0.3 percent, respectively, of the CL. No graph for ^{238}Pu concentrations is included because the majority of the sample concentrations were below their MDCs.

The proportion of $^{239+240}$Pu results above their MDCs in 2004 (50 percent, Table 3-5) was slightly lower than in 2003 but slightly higher than in 2002 (54 and 48 percent, respectively). In 2004, the only location at which 100 percent of the air samples contained $^{239+240}$Pu above detection was Bunker 9-300. In 2003, this occurred at U-3ah/at N, U-3ah/at S, U-3bh N, U-3bh S, and Bunker 9-300. Generally, the proportion of $^{239+240}$Pu results above their MDCs is greater than 50 percent at those air sampling locations that are in areas where $^{239+240}$Pu is in the surface soil (see Figure 3-1 and Table 3-5). The $^{239+240}$Pu continues to be detected while most other radionuclides are not, due to their more rapid radioactive decay and absorption into the soil. Due to the long half-life of ^{239}Pu (~24,000 years) and its insolubility in water, its presence in soil and resuspension into the air will continue to decrease slowly with time.

Table 3-3. Concentrations of ^{137}Cs in air samples collected in 2004

			^{137}Cs (x 10^{-15} μCi/mL)							
NTS Area	**Location**	**Number of Samples**	**Mean**	**% of CL** [(a)]	**Median**	**SD** [(b)]	**Min** [(c)]	**Max** [(d)]	**Mean MDC**	**% > MDC**
1	BJY	11	-0.78	-0.4	-1.00	3.74	-9.33	5.23	6.42	0.0
3	U-3ah/at N	11	0.54	0.3	0.02	2.49	-4.89	3.74	6.67	0.0
3	U-3ah/at Ss	11	-0.60	-0.3	0.21	4.92	-14.57	3.79	6.45	0.0
3	U-3bh N	10	-1.89	-1.0	-0.71	4.97	-13.70	4.32	7.01	0.0
3	U-3bh S	11	-0.81	-0.4	0.07	2.92	-5.96	3.68	6.17	0.0
5	DoD	12	-1.39	-0.7	-0.70	4.42	-14.31	2.55	6.55	0.0
5	Sugar Bunker N	11	-0.98	-0.5	-1.13	2.01	-4.98	2.48	6.65	0.0
6	Yucca	12	-2.11	-1.1	-0.75	4.90	-16.98	1.74	6.64	0.0
9	Bunker 9-300	12	-0.97	-0.5	-0.90	2.42	-5.40	2.32	6.07	0.0
10	Gate 700 S	12	-0.21	-0.1	-0.88	2.19	-2.85	5.04	6.56	8.3
10	Sedan N	11	-1.66	-0.9	-0.53	7.11	-21.37	4.43	6.64	0.0
16	3545 Substation	12	-0.55	-0.3	-0.52	2.03	-4.58	2.43	6.17	0.0
18	Little Feller 2 N	11	-2.03	-1.1	-0.18	5.88	-17.88	4.69	6.50	0.0
20	Gate 20-2P	11	-1.88	-1.0	-0.42	5.56	-18.30	1.89	6.89	0.0
20	Schooner	10	0.56	0.3	0.73	2.50	-3.79	4.82	6.99	0.0
23	Mercury Track	11	0.86	0.5	0.60	1.76	-2.14	4.56	6.30	0.0
25	Guard Station 510	12	-1.84	-1.0	-0.72	4.49	-14.92	2.40	7.11	0.0
27	ABLE Site	12	0.13	0.1	-0.09	2.33	-3.20	5.44	6.47	0.0
All Environmental Samplers		**203**	**-0.87**	**-0.5**	**-0.42**	**3.94**	**-21.37**	**5.44**	**6.56**	**0.5**
27	JASPER Stack	11	-5.13	-2.7	-0.54	14.34	-37.21	9.61	58.18	0.0

Blue-shaded locations are EPA-approved critical receptor sampler stations

The orange-shaded location is a point-source sampler station

Non-shaded locations are environmental sampler stations

Green shading indicates that some percentage of samples had concentrations above the sample-specific MDC

(a) CL is the NESHAP Concentration Level for Environmental Compliance (see Table 3-1)

(b) Standard deviation

(c) Minimum

(d) Maximum

Table 3-4. Concentrations of ^{238}Pu in air samples collected in 2004

			^{238}Pu (x 10^{-18} µCi/mL)							
NTS Area	Location	Number of Samples	Mean	% of CL [(a)]	Median	SD [(b)]	Min [(c)]	Max [(d)]	Mean MDC	% > MDC
1	BJY	11	1.87	0.1	0.27	2.84	-0.78	7.44	9.08	9.1
3	U-3ah/at N	11	2.87	0.1	2.11	3.89	-2.87	11.21	9.49	9.1
3	U-3ah/at S	11	4.68	0.2	2.70	5.57	-1.98	17.55	8.73	27.3
3	U-3bh N	10	3.34	0.2	1.55	4.91	-1.91	10.83	9.49	10.0
3	U-3bh S	11	2.89	0.1	2.10	3.80	-1.96	12.06	9.28	18.2
5	DoD	11	1.12	0.1	0.00	2.85	-3.02	5.83	10.10	0.0
5	Sugar Bunker N	11	0.98	0.0	0.18	3.63	-2.92	10.22	10.68	9.1
6	Yucca	11	1.68	0.1	0.81	3.12	-2.10	9.92	10.38	18.2
9	Bunker 9-300	11	5.61	0.3	5.25	4.18	0.00	13.21	9.51	36.4
10	Gate 700 S	11	2.21	0.1	1.78	3.49	-1.83	9.04	8.64	18.2
10	Sedan N	11	4.10	0.2	2.75	5.12	-1.98	14.05	9.36	18.2
16	3545 Substation	9	3.08	0.1	0.12	5.11	-0.14	14.92	8.27	11.1
18	Little Feller 2 N	11	1.03	0.0	0.43	3.28	-4.32	7.64	10.30	0.0
20	Gate 20-2P	12	0.20	0.0	-0.29	1.38	-1.23	2.57	8.48	0.0
20	Schooner	11	2.07	0.1	1.57	2.87	-1.04	9.17	9.31	0.0
23	Mercury Track	11	1.17	0.1	0.85	2.00	-1.19	4.96	7.82	0.0
25	Guard Station 510	11	1.76	0.1	0.00	4.67	-2.18	14.04	8.07	9.1
27	ABLE Site	12	1.61	0.1	1.11	2.79	-2.11	8.17	9.78	8.3
All Environmental Samplers		**197**	**2.32**	**0.1**	**1.26**	**3.85**	**-4.32**	**17.55**	**9.27**	**11.2**
27	JASPER Stack	11	-1.35	-0.1	-4.69	16.11	-23.70	36.22	89.50	0.0

Blue-shaded locations are EPA-approved critical receptor sampler stations

The orange-shaded location is a point-source sampler station

Non-shaded locations are environmental sampler stations

Green shading indicates that some percentage of samples had concentrations above the sample-specific MDC

(a) CL is the NESHAP Concentration Level for Environmental Compliance (see Table 3-1)

(b) Standard deviation

(c) Minimum

(d) Maximum

Note: The CL for ^{238}Pu is 2,100 x 10^{-18} µCi/mL when expressed in the same scale as the data in this table.

The annual mean $^{239+240}$Pu concentrations for most locations were slightly greater than last year, as reflected in the site-wide mean of 48 x 10^{-18} µCi/mL (1.8 µBq/m^3) in 2004 compared to 38 x 10^{-18} µCi/mL (1.4 µBq/m^3) for 2003. The location with the highest mean concentration (290 x 10^{-18} µCi/m^3 [11 µBq/m^3]), at Bunker 9-300, was only 15 percent of the CL.

The highest concentrations of $^{239+240}$Pu in 2004 occurred at the following five locations: U-3ah/at N, U-3ah/at S, U-3bh N, Bunker 9-300, and Sedan N (Table 3-5 and Figure 3-3). The peaks in $^{239+240}$Pu concentrations and the peaks for ^{241}Am occurred on the same dates for most of these locations. This is expected because ^{241}Am is the daughter-product of ^{241}Pu which is present with the $^{239+240}$Pu used in past nuclear tests. Due to the differences in half-lives between ^{241}Pu (14.4 years) and ^{241}Am (433 years), concentrations of ^{241}Am in NTS soils will increase gradually with time for about 80 years, after which they will begin decreasing.

Table 3-5. Concentrations of $^{239+240}$Pu in air samples collected in 2004

			$^{239+240}$Pu (x 10^{-18} µCi/mL)							
NTS Area	**Location**	**Number of Samples**	**Mean**	**% of CL (a)**	**Median**	**SD (b)**	**Min (c)**	**Max (d)**	**Mean MDC**	**% > MDC**
1	BJY	11	56.15	2.8	30.97	69.81	5.76	241.83	7.71	81.8
3	U-3ah/at N	11	89.47	4.5	79.65	69.38	11.47	267.41	7.17	90.9
3	U-3ah/at S	12	119.52	6.0	132.48	66.85	8.89	213.06	7.06	91.7
3	U-3bh N	11	83.73	4.2	59.75	119.31	0.00	431.06	17.24	81.8
3	U-3bh S	11	40.79	2.0	38.14	31.95	1.42	101.09	7.24	81.8
5	DoD	11	16.55	0.8	3.97	35.83	-3.02	121.30	5.83	45.5
5	Sugar Bunker N	11	6.44	0.3	5.92	4.27	1.95	17.18	8.67	36.4
6	Yucca	11	15.96	0.8	9.58	16.86	1.63	56.24	8.76	36.4
9	Bunker 9-300	12	294.12	14.7	196.88	310.83	17.83	1048.71	17.55	100.0
10	Gate 700 S	11	20.52	1.0	6.63	43.80	1.21	151.58	8.03	50.0
10	Sedan N	11	77.39	3.9	29.41	115.92	2.39	366.98	7.49	81.8
16	3545 Substation	9	3.38	0.2	4.14	1.95	0.25	5.60	6.37	27.8
18	Little Feller 2 N	11	7.71	0.4	4.50	7.64	-1.44	20.46	7.10	54.5
20	Gate 20-2P	12	1.62	0.1	1.15	1.90	-1.07	5.90	9.65	8.3
20	Schooner	11	0.24	0.0	0.00	4.26	-7.25	6.88	10.26	9.1
23	Mercury Track	11	1.84	0.1	1.27	1.58	0.09	5.31	7.60	0.0
25	Guard Station 510	11	3.07	0.2	2.63	3.43	-1.70	9.18	8.32	13.6
27	ABLE Site	11	1.31	0.1	0.75	3.16	-1.70	10.12	10.96	9.1
All Environmental Samplers		**199**	**48.25**	**2.4**	**6.88**	**113.82**	**-7.25**	**1048.71**	**9.52**	**50.0**
27	JASPER Stack	12	31.73	1.6	9.85	40.74	-4.47	118.39	80.74	0.0

Blue-shaded locations are EPA-approved critical receptor sampler stations

The orange-shaded location is a point-source sampler station

Non-shaded locations are environmental sampler stations

Green shading indicates that some percentage of samples had concentrations above the sample-specific MDC

(a) CL is the NESHAP Concentration Level for Environmental Compliance (see Table 3-1)

(b) Standard deviation

(c) Minimum

(d) Maximum

Note: The CL for $^{239+240}$Pu is 2,000 x 10^{-18} µCi/mL when expressed in the same scale as the data in this table.

Figure 3-4 shows the long-term trends in the highest annual mean for $^{239+240}$Pu among sampling locations that have been grouped into one of nine NTS Area Groups and which have at least 14 years of sampling data. The concentration lines for each air sampling station are color-coded by the station's geographical location within an area group. Fluctuations in the highest mean concentrations occur throughout the years within each area group, but within most area groups, a general decline in the highest annual mean concentrations occurs over time. No annual mean $^{239+240}$Pu concentration from any area group has exceeded the CL in over a decade. Figure 3-5 shows the long-term trends in the average (rather than the highest) mean concentration for $^{239+240}$Pu from air sampling stations within each area group. This plot shows a steady decrease in air-borne $^{239+240}$Pu over the past three decades at most locations. The area groups with the slightest long-term decreases are those with the highest means in 2004.

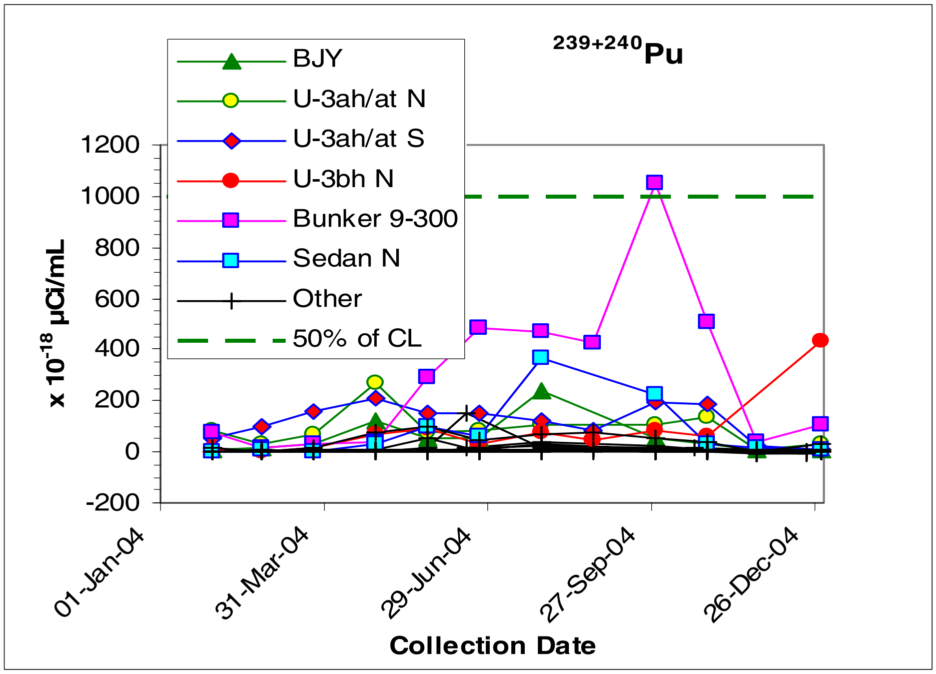

Figure 3-3. Concentrations of $^{239+240}$Pu in air samples collected in 2004

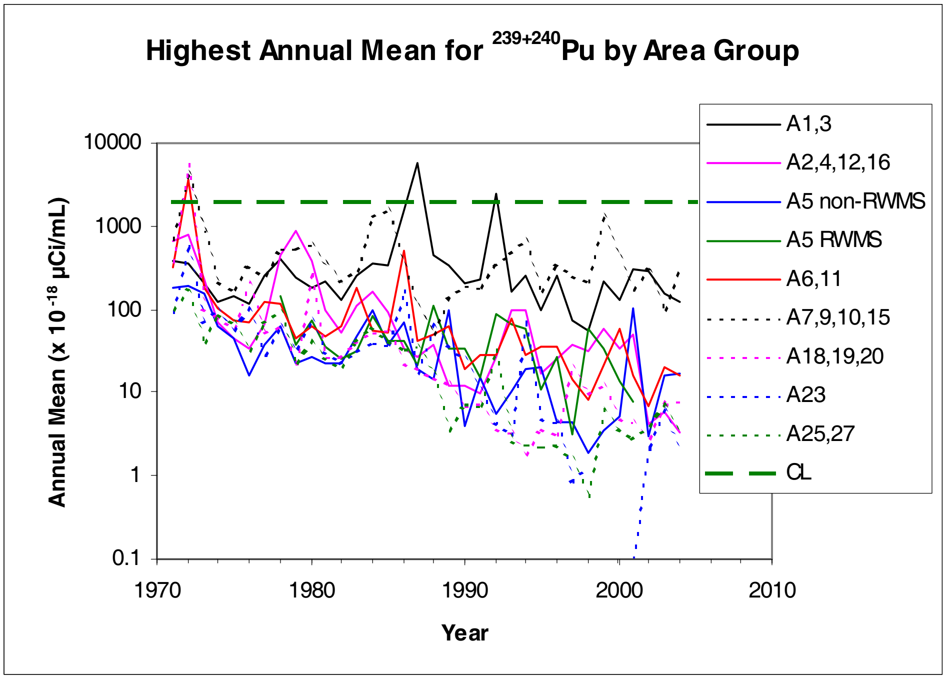

Figure 3-4. Long-term trends in highest annual mean $^{239+240}$Pu for NTS area groups

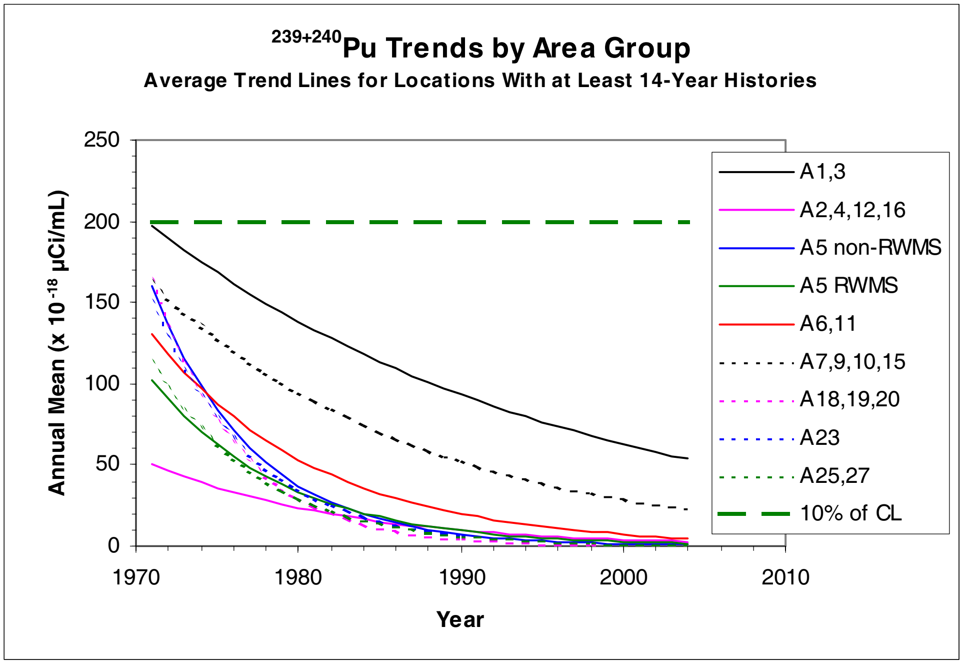

Figure 3-5. Long-term trends in average annual mean $^{239+240}$Pu for NTS area groups

3.1.4.4 *Uranium Isotopes*

Uranium analyses were performed for samples from only those locations in Areas 20 and 25 where depleted uranium ordinances have been used during exercises. The annual mean concentrations for uranium isotopes, measured in air samples collected at these locations and analyzed by radiochemistry, are shown in Table 3-6. The concentrations show little change from those of previous years. All of the air samples (100 percent) contained uranium at levels above detection for $^{233+234}$U and ^{238}U, whereas the detection rate ranged from 38 to 67 percent for $^{235+236}$U.

The uranium isotopes measured are attributed to naturally-occurring uranium in soils which have become resuspended. This was determined by calculating the ratio of the annual average concentration of ^{238}U to that of the other uranium isotopes for all sampling locations and then comparing these ratios to those expected from various uranium sources (Table 3-7). Isotope ratios calculated from samples with very low values of $^{235+236}$U are expected to be somewhat unreliable. Therefore, in estimating the mean ratio of ^{238}U / $^{235+236}$U, only those samples in which $^{235+236}$U was more than half its MDC were used; therefore it is expected that the actual mean of the ^{238}U / $^{235+236}$U ratio is underestimated.

Table 3-6. Concentrations of uranium isotopes in air samples collected in 2004

			$^{233+234}$U (x 10^{-17} µCi/mL)							
NTS Area	**Location**	**Number of Samples**	**Mean**	**% of CL (a)**	**Median**	**SD (b)**	**Min (c)**	**Max (d)**	**Mean MDC**	**% > MDC**
6	Yucca	11	18.02	2.5	19.27	3.99	12.00	22.84	2.53	100.0
16	3545 Substation	12	18.33	2.6	17.99	1.94	15.62	22.08	2.68	100.0
20	Gate 20-2P	11	17.59	2.5	17.22	3.53	11.50	24.87	1.93	100.0
25	Guard Station 510	12	21.02	3.0	18.37	8.06	15.40	45.15	1.98	100.0
27	ABLE Site	12	19.79	2.8	19.20	3.81	14.36	29.44	1.81	100.0
	All Locations	**58**	**18.99**	**2.7**	**18.50**	**4.77**	**11.50**	**45.15**	**2.19**	**100.0**

Table 3-6. (continued)

			$^{235+236}$U (x 10^{-18} µCi/mL)							
NTS Area	**Location**	**Number of Samples**	**Mean**	**% of CL [(a)]**	**Median**	**Std [(b)]**	**Min [(c)]**	**Max [(d)]**	**Mean MDC**	**% > MDC**
6	Yucca	12	22.05	0.3	14.67	20.62	0.58	66.78	23.90	45.8
16	3545 Substation	12	17.23	0.2	12.14	13.82	0.00	46.87	15.94	62.5
20	Gate 20-2P	11	14.80	0.2	15.85	8.20	-4.01	25.41	14.44	54.5
25	Guard Station 510	12	13.38	0.2	11.82	10.28	-2.63	34.01	14.19	37.5
27	ABLE Site	12	19.25	0.3	13.87	21.78	5.16	84.25	15.06	66.7
	All Locations	**59**	**17.39**	**0.2**	**13.33**	**15.75**	**-4.01**	**84.25**	**16.74**	**53.4**
			^{238}U (x 10^{-17} µCi/mL)							
6	Yucca	11	18.47	2.2	18.70	2.98	14.14	24.65	2.16	100.0
16	3545 Substation	12	18.05	2.2	17.14	3.31	14.94	25.12	2.04	100.0
20	Gate 20-2P	11	17.73	2.1	17.51	1.83	14.79	20.16	1.46	100.0
25	Guard Station 510	12	21.18	2.6	18.63	9.65	14.32	50.87	1.47	100.0
27	ABLE Site	12	18.05	2.2	17.97	3.55	12.42	26.51	1.58	100.0
	All Locations	**58**	**18.71**	**2.3**	**18.26**	**5.13**	**12.42**	**50.87**	**1.74**	**100.0**

Blue-shaded locations are EPA-approved critical receptor sampler stations

Non-shaded locations are environmental sampler stations

Green shading indicates that some percentage of samples had concentrations above the sample specific MDC

(a) CL is the NESHAP Concentration Level for Environmental Compliance (see Table 3-1)

(b) Standard deviation

(c) Minimum

(d) Maximum

Note: The CL for $^{233+234}$U is about 710 x 10^{-17} µCi/mL when expressed in the same scale as the data in this table.

Note: The CL for $^{235+236}$U is about 7,100 x 10^{-18} µCi/mL when expressed in the same scale as the data in this table.

Note: The CL for ^{238}U is 830 x 10^{-17} µCi/mL when expressed in the same scale as the data in this table.

Table 3-7. Expected ratios of uranium isotopes by type of source

Source	**Expected Isotope Ratios** ^{238}U / $^{233+234}$U	 ^{238}U / $^{235+236}$U
Natural	1	21
Enriched	0.1	5
Depleted	1	62

Table 3-8 shows the estimated isotope ratios from the 2004 data. As previously mentioned, the estimates of the mean ^{238}U / $^{235+236}$U ratio obtained from the censored data are expected to underestimate the true mean ratio. Therefore, the overall average ratio for data from these locations should be somewhat higher than 15, perhaps around 17. This is close to the expected value for uranium from natural sources (21) and far below the expected value for depleted uranium (62). It is also well above the expected value for enriched uranium (5).

Table 3-8. Mean uranium isotope ratios from air samples collected in 2004

NTS Area	Location	Estimated Mean Isotope Ratios	
		^{238}U / $^{233+234}U$	^{238}U / $^{235+236}U$
6	Yucca	1.050	> 12.44
16	3545 Substation	0.983	> 14.02
20	Gate 20-2P	1.035	> 12.40
25	Guard Station 510	0.999	> 19.16
27	ABLE Site	0.922	> 16.35
	All Locations	0.998	> 14.97

3.1.4.5 *Tritium*

Detectable tritium was observed in all air samples collected at Schooner crater and E Tunnel Pond 2 and in 92 percent of the Sedan samples (Table 3-9). The tritium found at these locations comes primarily from tritium used in nuclear testing devices. During the detonations, the tritium was oxidized forming tritiated water which was entrained in the ejecta from the cratering experiments at Sedan and Schooner and in the rubble formed in the various shafts of E Tunnel. At Sedan and Schooner, the tritiated moisture evaporates and transpires from the soil and vegetation in these areas. At the E Tunnel ponds, the tritiated water continues to flow out of the tunnel and evaporates into the air. Figure 3-6 shows the variation of measured tritium concentrations in air throughout the year.

The highest annual mean concentration of tritium was at Schooner (360×10^{-6} picocuries [pCi]/mL [13 Bq/m^3]), where the sampler is located only 269 m (882 ft) from the crater and is surrounded by ejecta from the crater. This concentration is only 24 percent of the CL. The data for Schooner are plotted in Figure 3-6 at one-tenth their actual values so that the details at other locations may be seen. Sedan crater was the other location with relatively higher concentrations, as in past years. The concentrations at all locations followed the same pattern observed in past years, increasing during the summer months and decreasing in the fall. This lags somewhat the rise and fall of the temperature. The influence of rainfall events in suppressing tritium releases is also seen in Figure 3-6.

Figure 3-7 shows the annual means for nineteen air sample locations with at least a seven-year history between 1988 and 2004. The data from 1982 through 1987 (dotted lines), taken from previous annual reports, were in some cases reported as "< xxx", in which xxx was an average of values that included the "less than" values as well as actual measurements above the MDCs. Beginning with the 1988 data (solid lines) actual measurements were reported, whether above or below their MDCs. Locations are color-coded into Area Groups consisting of adjacent NTS Areas. As shown by this figure, the annual concentration averages of tritium in air decreased during the years 1982 to 1992 and continued the decrease more gradually from then to the present time. Sampling at Schooner (in Area 20) began in 1998 when a solar photovoltaic system was available to provide electrical power to operate the sampler.

Table 3-9. Concentrations of tritium in air samples collected in 2004

			^{3}H Concentration (x 10^{-6} pCi/mL)							
NTS Area	Location	Number of Samples	Mean	% of CL [(a)]	Median	SD [(b)]	Min [(c)]	Max [(d)]	Mean MDC	% > MDC
1	BJY	26	1.32	0.1	1.06	1.17	-0.13	5.16	1.02	53.8
3	U-3ah/at S	4	0.54	0.0	0.72	0.40	-0.06	0.79	0.78	25.0
3	U-3bh N	4	0.50	0.0	0.59	0.43	-0.10	0.92	0.78	25.0
5	DoD	26	0.43	0.0	0.60	0.83	-1.28	2.46	1.02	21.2
5	Sugar Bunker N	25	0.78	0.1	0.74	0.85	-0.88	2.46	1.03	40.0
6	Yucca	23	0.76	0.1	0.60	1.15	-1.15	4.22	1.03	30.4
9	Bunker 9-300	26	3.41	0.2	2.52	2.91	-0.21	12.11	1.02	76.9
10	Gate 700 S	26	1.02	0.1	0.91	1.27	-0.97	5.79	0.92	57.7
10	Sedan N	26	10.33	0.7	4.66	10.08	0.44	28.80	1.00	92.3
12	E Tunnel Pond 2	25	3.61	0.2	2.92	2.35	0.74	9.57	0.90	100.0
16	3545 Substation	26	0.62	0.0	0.48	1.15	-1.65	4.34	0.98	25.0
18	Little Feller 2 N	24	0.56	0.0	0.40	1.06	-1.46	3.90	0.94	25.0
20	Gate 20-2P	25	0.81	0.1	0.63	0.93	-1.22	2.94	0.95	35.3
20	Schooner	25	364.69	24.3	177.58	360.03	15.34	1064.66	0.94	100.0
23	Mercury Track	26	0.51	0.0	0.37	1.11	-1.24	3.74	1.05	15.4
25	Guard Station 510	26	0.73	0.0	0.28	2.27	-1.12	11.03	1.03	19.2
All Environmental Samplers		**363**	**26.89**	**1.8**	**0.86**	**130.66**	**-1.65**	**1064.66**	**0.98**	**49.0**

Blue-shaded locations are EPA-approved critical receptor sampler stations

Non-shaded locations are environmental sampler stations

Green shading indicates that some percentage of samples had concentrations above the sample-specific MDC

(a) CL is the NESHAP Concentration Level for Environmental Compliance (see Table 3-1)

(b) Standard deviation (c) Minimum (d) Maximum

Note: The CL for ^{3}H is 1,500 x 10^{-6} pCi/mL when expressed in the same scale as the data in this table.

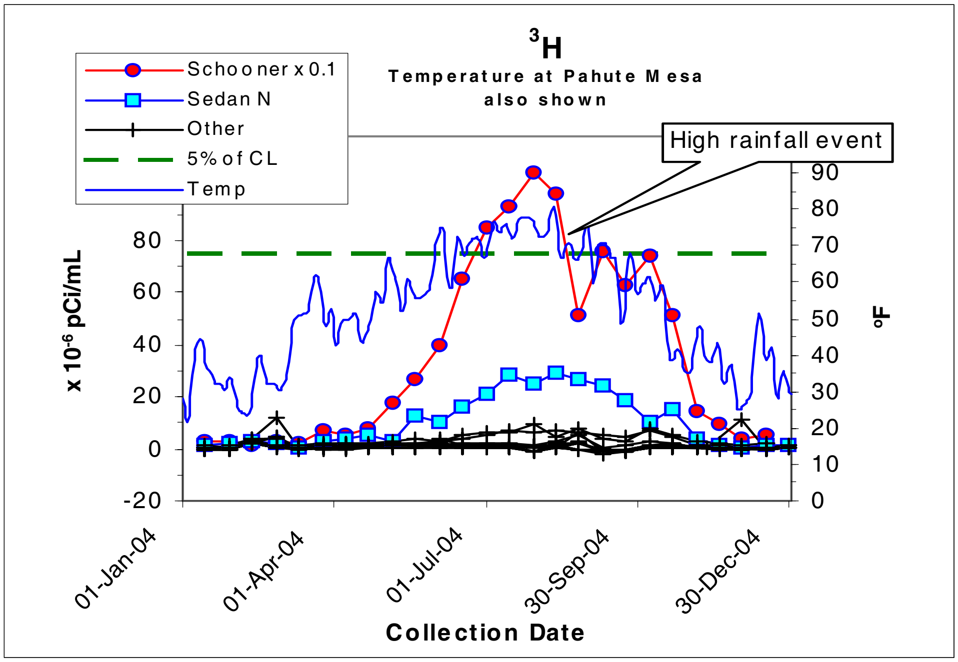

Figure 3-6. Concentrations of tritium in air samples collected in 2004

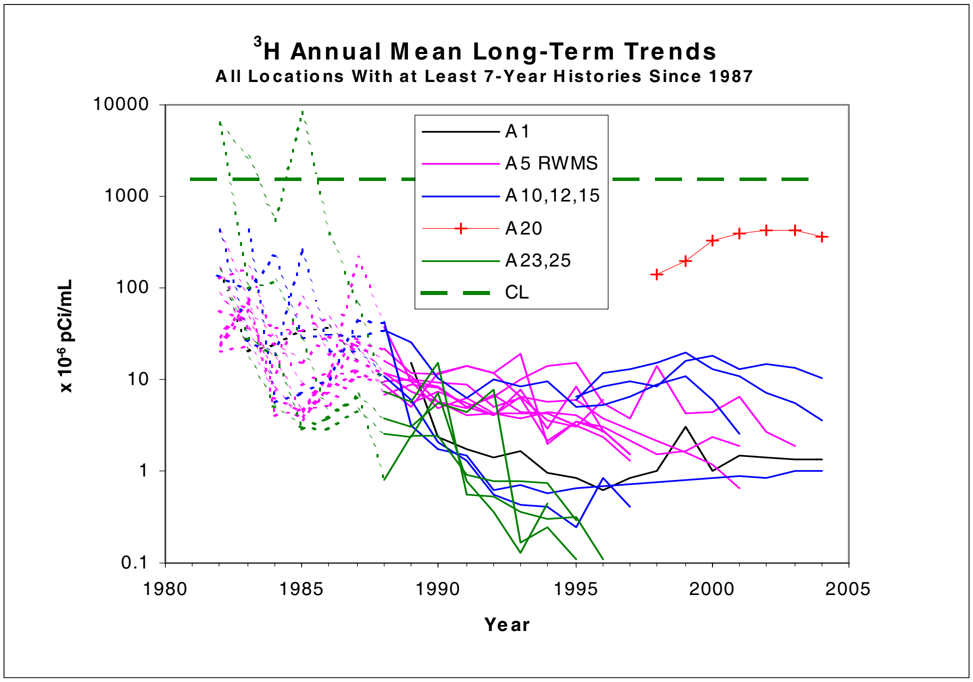

Figure 3-7. Average long-term trends in tritium at locations on the NTS having at least 7 years of data

3.1.4.6 *Gross Alpha and Gross Beta*

The concentrations of gross alpha and gross beta radioactivity in air samples collected from all environmental samplers in 2004 are shown in Tables 3-10 and 3-11 and Figures 3-8 and 3-9. Since these radioactivities include naturally-occurring ^{40}K, ^{7}Be, uranium, thorium, and the daughter isotopes of uranium and thorium, no reference to a CL is appropriate. These analyses are useful in that they can be performed by BN personnel at NTS five days after collection to identify any increases requiring investigation.

As shown in Figures 3-8 and 3-9, the concentrations of both gross alpha and gross beta have a parallel variation common to all locations similar to what has been observed in the past. The locations of peak values at U-3ah/at N, U-3bh N, Sugar Bunker N, and Bunker 9-300, identified on the figures, are at locations near or in areas of legacy deposits of radionuclides in and on the soil. Peak values occurred at these five locations during previous years as well. No increasing trend in gross alpha or beta radioactivity was observed for any location.

Table 3-10. Gross alpha radioactivity in air samples collected in 2004

			Gross Alpha (x 10^{-15} μCi/mL)						
NTS Area	Location	Number of Samples	Mean	Median	SD [(a)]	Min [(b)]	Max [(c)]	Mean MDC	% > MDC
1	BJY	52	2.39	2.13	1.62	-1.90	5.06	3.42	33.7
3	U-3ah/at N	52	3.49	3.48	2.24	-1.35	9.83	3.57	51.9
3	U-3ah/at S	52	3.07	2.95	1.98	-1.15	8.67	3.45	46.2
3	U-3bh N	51	2.85	3.00	1.95	-0.82	6.79	3.41	37.3
3	U-3bh S	52	2.34	2.29	1.86	-1.68	6.07	3.40	32.7
5	DoD	52	2.11	1.76	1.79	-1.01	7.85	3.47	28.8
5	Sugar Bunker N	51	3.80	4.04	2.11	-0.51	8.58	3.47	60.8
6	Yucca	50	2.44	2.44	1.49	-0.79	5.91	3.43	21.0
9	Bunker 9-300	52	2.83	2.49	2.93	-1.04	15.41	3.39	36.5
10	Gate 700 S	49	2.10	2.08	1.66	-1.49	5.82	3.44	25.5
10	Sedan N	51	2.41	2.18	1.72	-0.96	6.11	3.58	31.4
16	3545 Substation	52	1.85	1.89	1.43	-1.22	4.61	3.40	19.2
18	Little Feller 2 N	50	1.57	1.78	1.53	-2.01	5.22	3.37	16.0
20	Gate 20-2P	50	2.03	2.09	1.24	-0.19	4.79	3.45	17.0
20	Schooner	49	1.97	2.04	1.28	-0.31	4.71	3.37	20.4
23	Mercury Track	52	1.77	1.68	1.25	-0.47	5.49	3.42	13.5
25	Guard Station 510	51	1.93	2.03	1.54	-0.77	5.17	3.42	20.6
27	ABLE Site	51	1.80	1.71	1.52	-1.67	5.90	3.45	19.6
All Environmental Samplers		**919**	**2.38**	**2.24**	**1.86**	**-2.01**	**15.41**	**3.44**	**29.7**
27	JASPER Stack	49	-0.38	0.00	11.59	-51.26	29.43	24.83	2.0

Blue-shaded locations are EPA-approved critical receptor sampler stations

The orange-shaded location is a point-source sampler station

Non-shaded locations are environmental sampler stations

Green shading indicates that some percentage of samples had concentrations above the sample-specific MDC

(a) Standard deviation

(b) Minimum

(c) Maximum

Table 3-11. Gross beta radioactivity in air samples collected in 2004

			Gross Beta (x 10^{-14} µCi/mL)						
NTS Area	Location	Number of Samples	Mean	Median	SD [(a)]	Min [(b)]	Max [(c)]	Mean MDC	% > MDC
1	BJY	52	1.85	1.85	0.61	0.55	4.00	0.34	100.0
3	U-3ah/at N	52	1.98	1.98	0.66	0.69	4.48	0.36	98.1
3	U-3ah/at S	52	1.99	2.01	0.65	0.48	4.35	0.34	100.0
3	U-3bh N	51	1.89	1.96	0.63	0.39	4.21	0.34	100.0
3	U-3bh S	52	1.95	1.98	0.63	0.49	3.85	0.34	100.0
5	DoD	52	2.03	2.02	0.69	0.52	4.56	0.35	100.0
5	Sugar Bunker N	51	2.12	2.15	0.69	0.19	4.45	0.35	98.0
6	Yucca	50	1.98	2.00	0.66	0.61	4.41	0.34	100.0
9	Bunker 9-300	52	1.85	1.94	0.56	0.58	3.73	0.34	100.0
10	Gate 700 S	49	1.83	1.84	0.62	0.40	3.67	0.34	100.0
10	Sedan N	51	1.85	1.86	0.60	0.65	3.68	0.36	100.0
16	3545 Substation	52	1.75	1.79	0.58	0.51	3.24	0.34	100.0
18	Little Feller 2 N	50	1.76	1.74	0.57	0.34	3.53	0.34	100.0
20	Gate 20-2P	50	1.84	1.81	0.61	0.37	4.06	0.34	100.0
20	Schooner	49	1.86	1.85	0.59	0.41	4.29	0.34	100.0
23	Mercury Track	52	1.91	1.96	0.66	0.49	4.61	0.34	100.0
25	Guard Station 510	51	1.93	1.91	0.64	0.57	4.49	0.34	100.0
27	ABLE Site	51	1.87	1.90	0.61	0.46	4.13	0.34	100.0
All Environmental Samplers		**919**	**1.90**	**1.91**	**0.63**	**0.19**	**4.61**	**0.34**	**99.8**
27	JASPER Stack	49	-0.18	0.08	1.16	-3.72	2.66	2.48	2.0

Blue-shaded locations are EPA-approved critical receptor sampler stations

The orange-shaded location is a point-source sampler station

Non-shaded locations are environmental sampler stations

Green shading indicates that some percentage of samples had concentrations above the sample-specific MDC

(a) Standard deviation

(b) Minimum

(c) Maximum

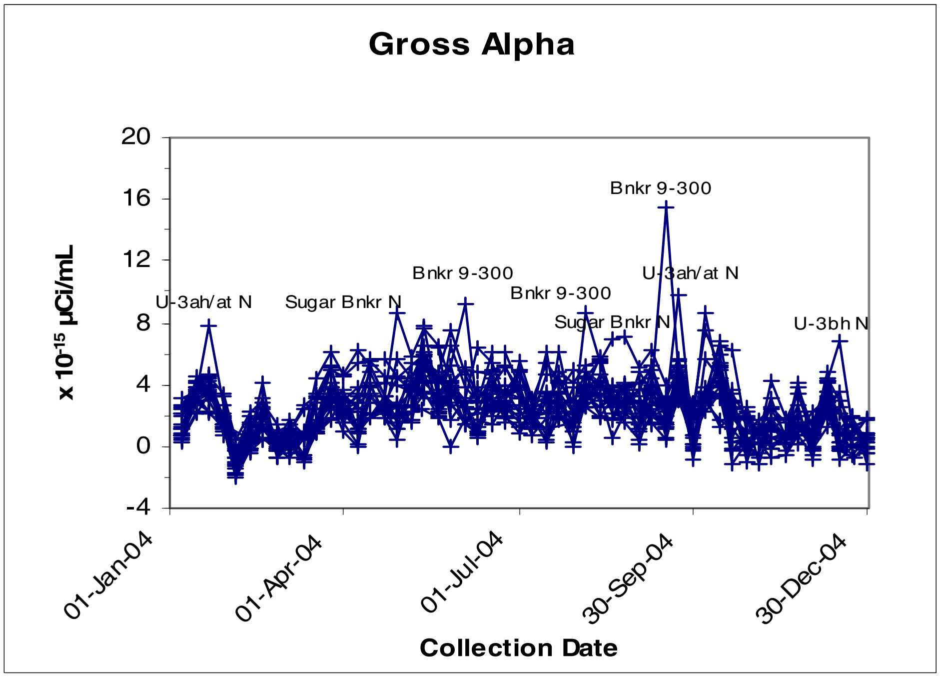

Figure 3-8. Gross alpha radioactivity in air samples collected in 2004

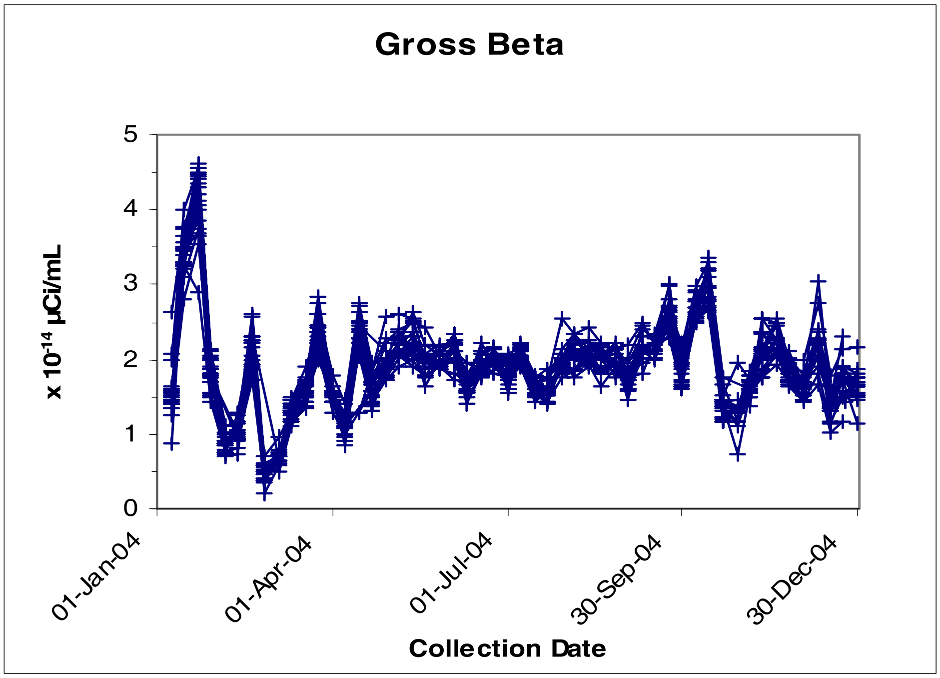

Figure 3-9. Gross beta radioactivity in air samples collected in 2004

3.1.5 Air Sampling Results from Critical Receptor Samplers

The following radionuclides were detected at three or more of the critical receptor samplers: ^{241}Am, ^{238}Pu, $^{239+240}$Pu, $^{233+234}$U, $^{235+236}$U, ^{238}U, and ^{3}H (tritium) (see Tables 3-2, 3-4, 3-5, 3-6, and 3-9, respectively). All concentrations of these radionuclides were well below their CLs. The uranium isotopes are attributed to naturally-occurring uranium (see Section 3.1.4.4). The concentration of each measured radionuclide (excluding uranium, since it has been determined to be of natural origin) at each of the six critical receptor samplers was divided by its respective CL (see Table 3-1) to obtain a "fraction of CL". These fractions were then summed for each location. The sum of these fractions at each critical receptor sampler is less than 1.0 (Table 3-12) and shows that the NESHAP dose limit to the public of 10 mrem/yr was not exceeded. A hypothetical individual residing at Schooner would receive a CEDE of 2.5 mrem/yr.

Table 3-12. Sum of percents of compliance levels for radionuclides detected at critical receptor samplers

Radionuclides Included in Sum of Percents[(a)]	NTS Area	Location	Sum of Fractions of Compliance Levels (CLs)
^{241}Am, ^{238}Pu, $^{239+240}$Pu, ^{3}H	6	Yucca	0.010
	10	Gate 700 S	0.014
	16	3545 Substation	0.005
	20	Schooner	0.245[(b)]
	23	Mercury	0.003
	25	Guard Station 510	0.005

(a) $^{233+234}$U, $^{235+236}$U, and ^{238}U are not included in sum of percents. All uranium detected in air particulate samples was determined to be naturally-occurring, based on the isotopic ratios.

(b) This equates to a hypothetical receptor at this location receiving a CEDE of 2.5 mrem/yr.

3.1.6 Air Sampling Results from Point-Source (Stack) Sampler

The 2004 air samples from the stack sampler at the JASPER facility contained no man-made radionuclides above their MDCs (see Tables 3-2 through 3-5). The HEPA filters at the facility appeared to function as intended, therefore, no radionuclide emission rate or offsite dose was calculated for this potential NTS radiation source (see Section 8.0).

3.1.7 Radiological Atmospheric Releases used for Estimating Dose to the Maximally Exposed Individual

Selected air sampling data gathered from the network of 19 environmental samplers are used to estimate the radiological dose to the hypothetical maximally exposed individual (MEI) residing near the NTS that is attributable to NTS emissions. Certain factors must be identified and quantified to estimate the dose to the MEI using the EPA-approved atmospheric diffusion model, called the Clean Air Package 1988, Version 2.0 (CAP88-PC). One of these factors is the quantity of radionuclides released from potential NTS sources, in Ci/yr. The following are measured or calculated to obtain the quantity of radiological atmospheric releases:

- The quantity of tritium gas released during the calibration of laboratory equipment
- The quantity of tritium released through evaporation from containment ponds or open tanks, estimated from the measured tritium concentrations in water discharged into them and assuming that all water completely evaporated during the year

- The quantity of tritium released from the Area 3 and Area 5 RWMSs and from Schooner and Sedan crater sites, estimated from calculations with CAP88-PC software and annual mean concentration of tritium in air measured by environmental air samplers at locations near these sources
- The quantity of other radionuclides resuspended in air from areas of known soil contamination, calculated from an inventory of radionuclides in surface soil determined by the Radionuclide Inventory and Distribution Program (DOE, 1991), a re-suspension model (NRC, 1983), and equation parameters derived at the NTS (DOE, 1992)

Table 3-13 summarizes the quantity of 2004 NTS radiological air emissions used in the CAP88-PC computer model to compute dose to the MEI. The calculated dose to the hypothetical MEI is 0.12 mrem/yr (0.0012 mSv/yr), and the MEI resides in Cactus Springs, Nevada (see Section 8.1.3). This is well below the NESHAP limit of 10 mrem/yr (0.1 mSv/yr).

Table 3-13. NTS radiological atmospheric releases for calendar year 2004 (in Curies)

^{3}H	^{85}Kr	Noble Gases ($T_{1/2}$<40 days)	Short-Lived Fission and Activation Products ($T_{1/2}$<3 hr)	Fission and Activation Products ($T_{1/2}$>3 hr)	Total Radio-iodine	Total Radio-strontium	Total Uranium	Plutonium	Other Actinides	Other
560	0	0	0	0	0	0	0	0.29 ($^{239+240}$Pu)	0.047 (^{241}Am)	0

3.1.8 Environmental Impact

The concentrations of man-made radionuclides in air on the NTS were all less than the regulatory concentration limits specified by federal regulations. Long-term trends of $^{239+240}$Pu and tritium in air continue to show a decline with time. All radionuclides detected by environmental monitoring appear to be from legacy deposits of radioactivity on and in the soil from past nuclear tests. There was no significant contribution to radioactive air emissions from NTS operational facilities in 2004.

3.2 Non-Radiological Air Quality Assessment

Non-radiological air quality assessments[1] are conducted to document compliance with current state of Nevada air quality permits that regulate specific operations or facilities on the NTS. The state of Nevada has adopted the CAA standards which include National Emissions Standard for Hazardous Air Pollutants (NESHAP), National Ambient Air Quality Standards (NAAQS), and New Source Performance Standards (NSPS) (see Section 2.1). Therefore, requirements set forth in the NTS air permits issued by the state are in compliance with these national standards. Specifically omitted from this section is NESHAP compliance for radionuclide emissions, as these are presented in Section 3.1. Assessments, facility/equipment monitoring, record-keeping, and reporting activities related to air quality on the NTS are conducted by BN ES personnel to meet the program goals shown in the table below. BN ES personnel collect and track the compliance measures shown in the table below.

Air Quality Assessment Program Goals	*Compliance Measures*
Ensure that NTS operations comply with all the requirements of current air quality permits issued by the state of Nevada for NTS operations	Tons of emissions of criteria pollutants produced annually
	Gallons of fuel burned annually
Ensure that air emissions of criteria pollutants (sulfur dioxide [SO_2]), nitrogen oxides[NO_x], carbon monoxide [CO], volatile organic compounds ([VOCs], and particulate matter [PM]) do not exceed limits established under NAAQS	Hours of operation of equipment per year
	Rate at which aggregate and concrete is produced
Ensure that NTS operations comply with the asbestos abatement reporting requirements under NESHAP	Quarterly opacity readings
	Pounds of chemicals released from NPTEC facilities
Document usage of ozone-depleting substances (ODS) to comply with Title VI of the CAA	Amount of asbestos in existing structures removed or scheduled for removal

There are two current NTS air quality permits. They are listed below along with the facilities they cover on the NTS.

NTS Class II Air Quality Operating Permit AP9711-0549.01

- Over 30 facilities/pieces of equipment in Areas 1, 3, 5, 6, 12, and 23
- Non-Proliferation Test and Evaluation Complex (NPTEC) in Area 5
- NPTEC in Area 25 (Test Cell C Facility)
- Big Explosives Experimental Facility (BEEF)
- Explosives Ordnance Disposal Unit (EODU)
- Tactical Demilitarization Development Project (TaDD) Facility in Area 11

Class II/Temporary General Air Quality Operating Permit AP1442-1429

- Portable screen and crushing plant in Area 6

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[1] The word "assessment" versus "monitoring" is used in this section. Adherence to most non-radiological air quality standards on the NTS does not require field collection and analysis of air samples (activities called "monitoring" in this report). Instead, adherence to NTS air quality permits for non-radiological emissions usually involves the review of records, gathering of operational information, and calculation of emissions.

The NTS Class II Air Quality Operating Permit that regulates operations and emissions generated by aggregate-producing facilities, fuel-burning equipment, and fuel storage tanks was renewed in June 2004. The new permit is a consolidation of all of the existing NTS Class II air permits into a single site-wide permit. Its issuance resulted in some new requirements, including quarterly reporting of emissions from certain sources, performance testing of point source emissions units, and installation of monitors at NPTEC and BEEF to measure airborne particulate matter equal to or less than 10 microns in diameter (PM10). The BEEF facility is scheduled to start operation in April 2005.

In June, 2004, the Class II/Temporary General Air Quality Operating Permit was issued for the placement of a screening and crushing plant in Area 6 at the NTS. The plant may be operated for up to one year at this location and if it remains, must be transferred to the NTS Class II Air Quality Operating Permit. As of this writing, the plant is still on location and plans are being made to include it in the NTS Class II Air Quality Operating Permit.

NTS facilities regulated by these permits must adhere to the recordkeeping and operational requirements specified in the permits. Compliance is verified by conducting periodic site walk-downs, observations of equipment while in operation, and a review of the records associated with each permitted facility. A description of the various activities performed or measures tracked in order to meet permit requirements and the results of 2004 air quality activities are described below.

3.2.1 Emissions of Criteria Air Pollutants and Hazardous Air Pollutants

Along with each air quality permit issued, there is an *Air Emissions Inventory* which lists all permitted facilities and equipment and the quantities of criteria pollutants (see Glossary, Appendix D) as well as Hazardous Air Pollutants (HAPs) that each facility/piece of equipment would emit annually if it were operated for the maximum number of hours specified in the air permit. These quantities are known as the “Potential to Emit” (PTE). Lead is considered a HAP as well as a criteria pollutant. Emissions from lead are reported as part of the total HAPs emissions rather than as a separate criteria pollutant. Compliance with permits involves documenting that the PTE for all facilities or equipment is not exceeded. Quantities of emissions of criteria pollutants and non-radiological HAPs produced by each permitted facility are determined through calculations that take into account the number of operating hours, number of gallons of fuel burned, number of tons of material that were produced, and emission factors. Emission factors are representative values that relate the quantity of a pollutant released to the atmosphere to an activity associated with the release of that pollutant. These factors are generally expressed as the weight of the pollutant divided by a unit weight, volume, distance, or duration of the activity emitting the pollutant, e.g., pounds of particulates emitted per ton of aggregate material produced. Emission factors have been developed for many different types of industries and activities and are published by the EPA in a document titled *Compilation of Air Pollutant Emission Factors* (EPA, 1995). The emission factors that were used in the NTS air quality operating permits are derived from this source.

Each year, the state issues *Actual Production/Emissions Reporting Forms* for the NTS air permit to NNSA/NSO. These forms are used to report the actual hours of operation, gallons of fuel burned, etc. for each permitted facility/piece of equipment. Using this data and emission factors furnished by the state, emissions of the criteria pollutants are calculated and reported along with the other required information mentioned above. The forms are completed by BN ES personnel and returned to NNSA/NSO for submittal to the state. The state uses the submitted information to determine annual maintenance and emissions fees and to document compliance with emission limits.

Quantities of criteria pollutants produced by open burns are not required to be calculated. However, submittal of an Open Burn Variance form is required by the state prior to each burn. An exception to this is the Open Burn Variance for fire extinguisher training, which is valid for one year and covers approximately 60 fire extinguisher training sessions conducted throughout the year.

In 2004, examination of records for permitted facilities and equipment indicated that all operational parameters were being properly tracked. Table 3-14 presents the calculated tons of emissions of criteria pollutants from NTS facilities that were operational during 2004. The PTEs for each facility are shown in Table 3-14 and were derived from the limits set forth in the NTS air quality permits. Approximately 6.91 tons (6.27 mtons) of criteria pollutants were emitted from NTS facilities and equipment during 2004. The majority of these emissions were volatile organic compounds (VOCs) from the NPTEC facilities. The PTE for VOCs from NPTEC facilities was 100 tons under its permit which expired in June 2004. This limit was lowered to 3.01 tons under the renewed Class II NTS air quality

Table 3-14. Tons of criteria air pollutant emissions released on the NTS in 2004

	Calculated Tons(a) of Emissions									
	Particulate Matter (PM10)(b)		Carbon Monoxide (CO)		Nitrogen Oxides (NOx)		Sulfur Dioxide (SO_2)		Volatile Organic Compounds (VOC)	
Facility	**Actual**	**PTE(c)**	**Actual**	**PTE**	**Actual**	**PTE**	**Actual**	**PTE**	**Actual**	**PTE**
Wet Aggregate Plant	0.49	6.14	NA(d)	NA	NA	NA	NA	NA	NA	NA
Area 1 Concrete Batch Plant	0.07	2.04	NA	NA	NA	NA	NA	NA	NA	NA
Cementing Equipment	0.33	18.54	NA	NA	NA	NA	NA	NA	NA	NA
Portable Cement Bins	0	3.06	NA	NA	NA	NA	NA	NA	NA	NA
Boilers	0.02	0.61	0.04	1.35	0.15	5.41	0.01	1.15	0.01	0.06
Incinerator (propane fired)	0	0.03	0	0	0	0.02	0	0	0	0
Diesel Fired Compressors	0	0.54	0	1.66	0	7.72	0	0.51	0	0.61
Diesel Fired Generators	0.03	3.34	0.20	10.24	0.86	17.87	0.01	3.13	0.03	2.16
Laboratory Hoods	NA	NA	NA	NA	NA	NA	NA	NA	0	2.0
Bulk Gasoline Storage Tank	NA	NA	NA	NA	NA	NA	NA	NA	1.39	3.92
Bulk Diesel Fuel Storage Tank	NA	NA	NA	NA	NA	NA	NA	NA	0.02	0.02
NPTEC Facilities	0	3.00(e))	0	3.26(e)	0	3.02(e)	0.10	3.00(e)	3.15	100 and 3.01(e)
Area 1 Miscellaneous Conveyors	0	0.21	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total	**0.94**	**37.51**	**0.24**	**16.51**	**1.01**	**34.04**	**0.12**	**7.79**	**4.60**	**11.78**
Total 2004 Actual Emissions	**6.91**									

(a) For mtons, multiply tons by 0.9072

(b) Particulate matter equal to or less than 10 microns in diameter

(c) Potential to Emit - the quantity of criteria 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 in the air permit

(d) Not applicable because the permit does not regulate the emissions of this pollutant for this facility

(e) PTE under Permit AP9711-0814, which expired in June 2004, was 100 tons. PTE under Permit AP9711-0549.01, renewed in June 2004, is 3.01 tons. Most tests were conducted at NPTEC facilities prior to June.

permit. The renewed permit was then modified in May 2005 to increase the VOC limits at these facilities to 10 tons based on better projections of future operations.

Table 3-15 and Figure 3-10 show the tons of air pollutants released on the NTS since 1995. These numbers were derived from the Actual Production/Emissions Reporting Forms that are required to be submitted to the state annually. Prior to calendar year (CY) 2000, HAPS were not included in the Reporting Forms. HAPs are now reported, but for only a few of the facilities. Specific HAPs are not identified in the Reporting Forms. The quantity of HAPs released in 2004, as calculated in the Reporting Forms, was 0.41 tons (Table 3-15). Total air emissions of lead from the NTS, as reported in the Toxic Release Inventory (TRI) Report, Form R (see Section 10.3) was 10.4 pounds.

The *Calendar Year 2004 Actual Production/Emissions Reporting Form,* containing the calculated emission totals for 2004 was submitted to the Nevada Division of Environmental Protection (NDEP) on February 28, 2005, prior to its due date of March 1.

Table 3-15. Criteria air pollutants and HAPS released on the NTS since 1995

	Total Emissions (tons/yr)(a)									
Pollutant	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Particulate Matter (PM10)(b)	4.53	2.89	1.67	1.11	1.7	1.46	2.05	3.61	2.39	0.94
Carbon Monoxide (CO)	0.21	0.04	5.28	1.85	1.87	2.76	4.84	4.6	1.79	0.24
Nitrogen Oxides (NO$_x$)	1.56	0.16	19.79	7.57	8.07	12.75	22.23	21.09	8.11	1.01
Sulfur Dioxide (SO$_2$)	1.47	0.3	0.85	0.37	0.42	0.98	1.68	1.62	0.76	0.12
Volatile Organic Compounds (VOC)	19.87	2.82	0.94	11.76	1.99	1.89	2.01	2.1	1.21	4.60
Hazardous Air Pollutants (HAPs)	NR(c)	NR	NR	NR	NR	0.01	0.03	0.01	0	0.41

(a) For mtons, multiply tons by 0.9072
(b) Particulate matter equal to or less than 10 microns in diameter
(c) Not reported

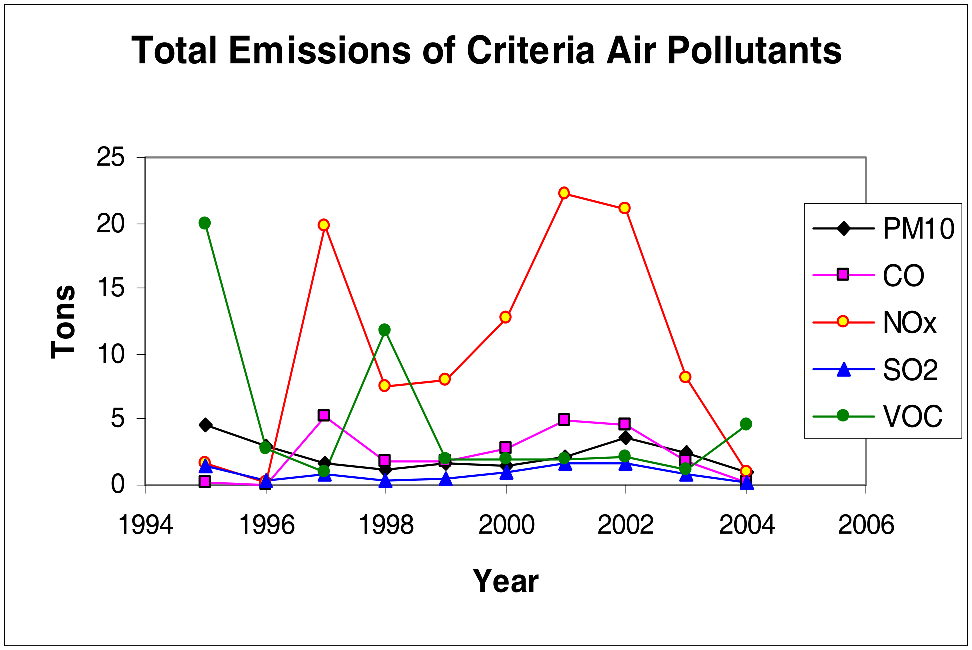

Figure 3-10. Criteria air pollutants released on the NTS since 1995

3.2.2 Production Rates/Hours of Operation

Compliance with operational parameters such as production rates and hours of operation is verified through an examination of the data generated by each facility owner for the annual report to the state. The number of hours that equipment operates throughout a year is determined by reading meters that are located on each piece of equipment. Permit requirements specific to each piece of equipment dictate the frequency in which readings are obtained. Production rates for construction facilities such as the aggregate-producing plant are calculated using the hours of operation and amount of material produced. Logbooks are maintained to record this information. Gallons of fuel used are calculated using industry standards and the hours of operation, or simply by recording tank levels each time that the tank is filled.

Production rates and hours of operation were computed for all permitted facilities as an interim step in order to calculate the tons of air pollutants emitted in 2004, as shown in Table 3-14 above. The records examined for all permitted equipment and facilities indicated that the production rates, hours of operation, and gallons of fuel used by each were within the specified permit limits.

3.2.3 Opacity Readings

Under Title 40 CFR Part 60, personnel that conduct visible emissions evaluations to satisfy the opacity requirements for a facility or piece of equipment must be certified semi-annually by a qualified organization. A form similar to one appearing in Title 40 CFR Part 60 for conducting visible emissions evaluations is used to record and document the readings. The form requires that weather conditions, wind speeds, and other factors that could affect the readings be recorded. Visual readings are taken every 15 seconds. A minimum of 24 consecutive readings is required for a valid reading. The average of the 24 readings must not exceed the permit-specified limit (20 percent for NAAQS, 10 percent for NSPS) to remain in compliance. Readings must be obtained only once during the month that the equipment is used. No readings are required during months that the equipment is not used.

The opacity reading requirement was revised from monthly to quarterly when the renewed air permit was issued in June 2004. During 2004, four BN personnel were certified by Carl Koontz Associates to conduct visible emissions evaluations (opacity readings). Opacity readings were obtained for the following NTS permitted facilities regulated under the NAAQS opacity limit of 20 percent: Area 23 Incinerator, Area 1 Concrete Batch Plant, Area 1 Wet Aggregate Plant, Area 23 Boiler, Area 1 Storage Silos, and the Portable Field Bins. Readings for these facilities ranged from 0 to 10 percent, all below the air quality permit limits of 20 percent.

Opacity readings were obtained for a portion of the Area 1 Wet Aggregate Plant which is regulated under the stricter NSPS opacity limit of 10 percent. Opacities were found to be within the 10 percent limit.

3.2.4 NPTEC Reporting

The NTS air quality operating permit for both the Area 5 NPTEC and the Area 25 Test Cell C facility requires, in addition to annual reporting, the submittal of test plans and final analysis reports to the state for each chemical release. Test plans provide detailed information regarding the types and quantities of chemicals to be released, a description of how they will be released, and environmental and chemical hazards. The Area 5 and Area 25 Test Cell C NPTEC facilities, by their nature as research facilities, provide no air quality controls. The impact of the chemical releases at both facilities is minimized by controlling the amount and duration of each release. When chemical release tests are conducted, plumes pass through an instrument array and impacts are confined to a defined area. Predictions of impacts for each test are reliable because of extensive meteorological data that is available on wind direction, wind speed, standard deviation of wind direction, vertical turbulence, temperature, humidity, and barometric pressure. In turn, post-release monitoring is used to document the degree of actual impact. Following each release, a completion report is submitted that documents the test dates, chemicals, and quantities that were actually released.

In 2004, 5 chemical tests consisting of 25 releases were conducted at the Area 5 NPTEC and the Area 25 Test Cell C facility. They included:

- Divine Invader 55-63 Project at Area 5 (4 releases)

- Divine Invader 53-54 Project at Area 5 (3 releases)
- Rattler Project at Area 5 (5 releases)
- Roadrunner III Test at Frenchman Lake Bed (Area 5) (8 releases)
- Roadrunner III Test at Area 25 Test Cell C (5 releases)

A completion report was submitted to NNSA/NSO for transmittal to NDEP's Bureau of Air Pollution Control at the conclusion of each test. Table 3-16 summarizes the total quantities of all chemicals released during tests in 2004.

Table 3-16. Chemicals released during tests conducted at the Area 5 NPTEC in 2004

Chemical	Total Amount Released (lbs)[a]
2-Diisopropylamino ethanol	2.8
2-Diethylaminoethanol	4.6
3,3-dimethyl-2-butanol	12.9
Dimethyl methylphosphonate	2768.2
Ammonia	127.9
Boron Trichloride	2100
Butanol	40
Butyl nitrate	17.5
Carbon tetrachloride	12
Chlorobenzene	41
Cyclohexanol	12.9
Chlorobenzene	41
DC (Methyl phosphonic dichloride)	9
Deuterium oxide	2.2
Diethanolamine	4.2
Diethyl ethylphosphonate	37.4
Diethylamine	2.6
Diisopropylamine	2.2
Dimethyl ether	18.6
Dipropylene glycol methyl ether	2610
DV methyl ester	13.2
Ethylene	12
Freon 134A	41
Freon R414b	400
Isobar E fluid	11.2
Isopropyl alcohol	29
Methanol	544.3
Methyl chloride	213
Methylamine	3
m-Phenoxybenzyl alcohol	11.2
Permethrin	5.5
Pinacolone	13.2
Propane	1
Propylene	5.3
Sulfur dioxide	208
Thionyl chloride	12
Triethyl phosphate	98.6
Triethyl phosphorothioate	33.2

(a) 1lb = 0.456 kilograms

Table 3-17. Chemicals released during tests conducted at the Area 25 Test Cell C facility in 2004

Chemical	Total Amount Released (lbs)[(a)]
Ethyl formate	6.4
Methanol	56.2
1,1,1-Trichloroethane	11.5
Dimethyl methylphosphonate	28
Trimethyl phosphite	22.3
Ammonia	0.7
Dimethyl ether	2.2
Ethylene	20.5
Methylamine	8.3
Freon R134a	3.5

(a) 1lb = 0.456 kilograms

3.2.5 TaDD Reporting

The TaDD is located in Area 11 at the NTS. This facility was developed as a prototype of a portable burn facility to dispose of unneeded Shillelagh tactical military rocket motors. As such, TaDD was added to the NTS air quality operating permit because of the emissions generated during each burn. Emissions are controlled by a baghouse, HEPA, and ultra high efficiency filters. Permit requirements include annual reporting of hours of operation and emissions and an opacity limit of 20 percent.

The TaDD facility has not been used due to lack of funding. It is listed in the renewed air permit with 0 allowable operating hours and is expected to be removed from the air permit during 2005.

3.2.6 ODS Recordkeeping

ODS recordkeeping requirements applicable to NTS operations include maintaining, for a minimum of three years, evidence of technician certification, recycling/recovery equipment approval, and servicing records for appliances containing 22.7 kilograms (50 pounds) or more of refrigerant. Compliance with recordkeeping and certification requirements for the use and disposition of ODS is verified through periodic assessments. The assessments include a records review and interviews with managers and technicians associated with the use, disposition, and purchase of refrigerants. Under Section 608 of the CAA, EPA may conduct random inspections to determine compliance.

From an assessment conducted in CY 2002, it was determined that the regulatory requirements of Title VI (Section 608) of the CAA for the protection of stratospheric ozone were generally being met. No assessment was conducted in CY 2004. An ODS Management Plan is scheduled to be written in 2005 to develop and implement a program and procedures to maximize the use of safe alternatives to ODS due to their required phase-out.

3.2.7 Asbestos Abatement

A NESHAP notification is submitted annually to the EPA for the next calendar year. This notification provides an estimate of the quantities of asbestos-containing materials that are expected to be removed from small projects: removal of less than 79.2 linear meters [260 linear feet] or less than 14.9 square meters (m^2) (160 square feet [ft^2]). These projections are submitted to EPA in an Annual Asbestos Abatement Notification Form. A Notification of Demolition and Renovation Form is also submitted to EPA at least 10 working days prior to the start of each project if either (1) no asbestos is present in a facility scheduled for demolition, or (2) if quantities of asbestos-containing materials to be removed are estimated to exceed 79.2 linear meters or 14.9 m^2. The recordkeeping requirements for asbestos abatement activities on the NTS include maintaining the following records for the following number of years:

- Asbestos air and bulk sampling data records (collected during asbestos removal projects) up to 75 years
- Asbestos abatement plans up to 25 years
- Operations and Maintenance activity records up to 75 years
- Location-specific records of asbestos-containing materials for a minimum of 75 years

Compliance with recordkeeping requirements is verified through periodic assessments. The assessments include a records review and interviews with managers and technicians associated with asbestos abatement. State assessments/audits are performed periodically.

An Annual Asbestos Abatement Notification Form was submitted to the EPA in February 2004 which projected that 45.7 linear meters (150 linear feet) and 23.2 m^2 (250 ft^2) of asbestos-containing material would be removed from small projects from NTS facilities in 2004. During 2004, all asbestos abatement activities throughout the NTS complex were minor in scope, involving the removal of amounts below the reporting threshold. Asbestos abatement records continued to be maintained as required.

3.2.8 Fugitive Dust Control

Section VII of the NTS Class II Air Quality Operating Permit, No. AP9711-0549.01, *Surface Area Disturbance Conditions* states that "Permittee may not cause or permit the construction, repair, demolition, or use of unpaved or untreated areas without first putting into effect an ongoing program using the best practical methods to prevent particulate matter from becoming airborne”. Methods that are typically used to control fugitive dust include presoaking, using water sprays, using dust palliatives, gravelling or paving haul routes, revegetating, reducing vehicle speeds, and either covering stockpiles or watering them. At the NTS, the main method of dust control is the use of water sprays.

During the summer of 2004, NNSA/NSO personnel observed an excess of fugitive dust resulting from an operation at the Area 5 RWMS. NNSA/NSO determined that BN was failing to monitor operations sufficiently to prevent excessive fugitive dust. In response to this finding, BN ES finalized a fugitive dust control policy in November (Organization Instruction, OI-0442.002 *Fugitive Dust Monitoring*). This policy establishes periodic monitoring of non-permitted dust-producing activities and operations.

3.2.9 State Inspections

On May 12, 2004, the state of Nevada conducted an inspection of some facilities regulated by the NTS air quality permit. These facilities included the Area 1 Aggregate Plant, Area 1 Batch Plant, and the NPTEC. There were no findings or exceedances of permit limits.

3.2.10 Environmental Impact

In order to be considered a Class II or “minor” source of pollutants for air permitting purposes, a facility’s annual emissions must not exceed 100 tons of any one criteria pollutant, or 10 tons of any one HAP, or 25 tons of any combination of HAPS. During 2004, NTS activities produced a total of only 6.91 tons of criteria pollutants and 0.41 tons of hazardous air pollutants (see Table 3-14). These small quantities had little, if any, impact to air quality on the NTS and at offsite locations. Emissions of pollutants for CY 2004 were significantly less than those generated during the heightened activity that occurred in the years prior to the nuclear weapons testing moratorium.

Impacts of the chemical releases during tests at the NPTEC are minimized by controlling the amount and duration of each release. Biological monitoring at the NPTEC is performed whenever there is a risk of significant exposure to downwind plants and animals from the planned tests (see Section 13.5). BN biologists review all chemical release test plans to determine the level of field monitoring needed for each test. To date, chemical releases at the NPTEC 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.

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4.0 Radiological and Non-Radiological Water Monitoring

This chapter presents radiological and non-radiological monitoring results for surface water and groundwater conducted by Bechtel Nevada (BN) on and off the Nevada Test Site (NTS). Surface water and groundwater includes natural springs, drinking water, non-potable groundwater, and water discharged into domestic and wastewater systems on the NTS. Several BN programs or projects are involved with water monitoring. These include: (1) routine radiological monitoring conducted by BN Environmental Technical Services (ETS) under the *Routine Radiological Environmental Monitoring Plan* (RREMP) (DOE, 2003b), (2) water quality assessments of permitted water systems conducted by BN ES, and (3) water sampling and analysis conducted by the Underground Test Area (UGTA) Project. Water quality assessments are driven by the need to comply with applicable state and federal regulations (see Section 2.2) as well as by the desire to address the concerns of stakeholders who reside within the vicinity of the NTS.

Section 4.1 presents the concentrations of radioactivity in water samples. These data are used to calculate radiological dose to the general public residing near the NTS via drinking water; these results are provided in Section 8.0 (Radiological Dose Assessment).

The Community Environmental Monitoring Program (CEMP) has been established by the U. S. Department of Energy, National Nuclear Security Administration Nevada Site Office (NNSA/NSO) to independently monitor radionuclide contamination of offsite springs and water supply systems. This independent oversight program is managed by the Desert Research Institute (DRI). DRI's 2004 monitoring results for surface and groundwater are presented in Section 6.2.

Section 4.2 of this chapter presents the results of non-radiological monitoring of drinking water and domestic and industrial wastewaters on the NTS.

4.1 Radiological Surface Water and Groundwater Monitoring

There have been 828 underground nuclear tests conducted at the NTS. Approximately one third of these tests were detonated near or below the water table (DOE, 1996; DOE, 2000a). This legacy of nuclear testing has resulted in the contamination of groundwater in some areas. The Federal Facility Agreement and Consent Order (FFACO) established Corrective Action Units (CAUs) that delineated and defined areas of concern for groundwater contamination on the NTS (DOE, 1996). Figure 4-1 shows the locations of underground nuclear tests and areas of potential groundwater contamination. To safeguard the public's health and safety and comply with applicable federal, state, and local environmental protection regulations as well as DOE directives, groundwater on and near the NTS is monitored for radioactivity. Monitoring in the past was conducted by the U.S. Public Health Service, U.S. Geological Survey (USGS), the U.S. Environmental Protection Agency (EPA), and others. In 1998, BN was tasked by NNSA/NSO to establish and manage an NTS integrated and comprehensive radiological environmental monitoring program. The RREMP (DOE, 2003b) describes groundwater monitoring objectives, regulatory drivers, and quality assurance protocols.

The purpose of radiological water monitoring is to determine whether concentrations of radionuclides in groundwater and surface water bodies at the NTS and its vicinity pose a threat to public health or the environment. Toward this end, the monitoring program collects and analyses water samples to meet the goals shown below.

In addition to RREMP-driven monitoring, the UGTA Project (see Section 14.0) collects data from wells to define groundwater flow rates and directions to determine the nature and location of aquifers. Data from these studies are used to determine whether radionuclides from nuclear testing have moved appreciable distances from original test locations. Groundwater sampling and radiological analysis results for 2004 from UGTA wells are also presented in this section along with RREMP monitoring results (see Section 4.1.10).

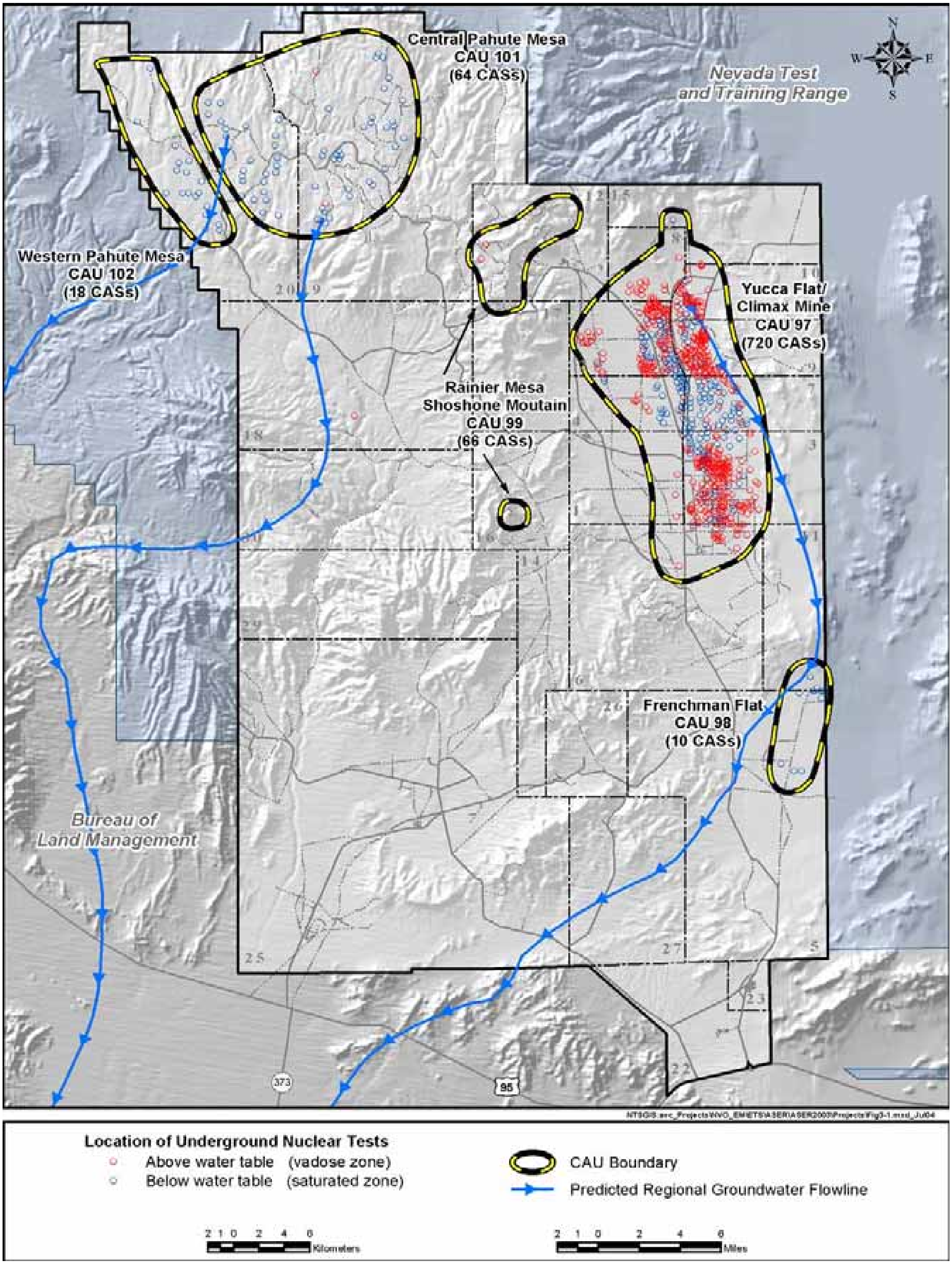

Figure 4-1. Areas of potential groundwater contamination on the NTS

Radiological Surface Water and Groundwater Monitoring Program Goals	Analytes Monitored
Determine if radionuclide concentrations of offsite and onsite water supply wells exceed the safe drinking water standards established by the EPA under the Safe Drinking Water Act or the dose limits to the general public set by DOE Order 5400.5.	Tritium (^{3}H)
	Gross alpha radioactivity
Determine if radionuclide concentrations in surface waters on the NTS expose terrestrial and aquatic animals to doses which exceed those set by DOE (DOE-STD-1153-2002) to protect wildlife populations.	Gross beta radioactivity
	Gamma-emitting radionuclides
Determine if permitted facilities on the NTS are in compliance with permit discharge limits for radionuclides.	Plutonium-238 (^{238}Pu)
	Plutonium-239+240 ($^{239+240}$Pu)
Determine if radionuclide concentrations in offsite natural springs and from onsite and offsite non-potable water wells (monitoring wells), including those within CAUs, indicate that NNSA/NSO activities have had an impact on the environment. Strict drinking water standards are often used as a monitoring action level for this determination.	Carbon-14 (^{14}C)
	Strontium-90 (^{90}Sr)
	Technetium-99 (^{99}Tc)

The selection of analytes for groundwater monitoring shown above is based on the radiological source term from historical nuclear testing, regulatory/permit requirements, and characterization needs. The isotopic inventory remaining from nuclear testing is presented in the most recent environmental impact statement for NTS activities (DOE, 1996a) and in a recent Lawrence Livermore National Laboratory (LLNL) document (Smith, 2001). Many of the radioactive species generated from subsurface testing have very short half-lives, sorb strongly onto the solid phase, or are bound into what is termed “melt glass” and are not available for groundwater transport in the near term (Smith, 1993; Smith et al., 1995). Tritium (^{3}H) is the radioactive species created in the greatest quantities and is widely believed to be the most mobile. Tritium is therefore the primary target analyte; it represents the greatest concern to users of groundwater on and around the NTS for at least the next 100 years due to its high mobility and concentration (DOE, 1996a; International Technology [IT], 1997).

Tritium analyses are done on all water samples. Analyses for gross alpha, gross beta, and gamma-emitting radionuclides are also conducted on all water samples as rapid screening measures. Gross alpha and gross beta radioactivity can include activity from both natural and man-made radionuclides, if any are present. Naturally-occurring deposits of certain minerals in water can contribute to both alpha (e.g., isotopes of uranium and ^{226}Ra) and beta (e.g., ^{228}Ra and ^{40}K) radiation. The analyses for gamma-emitting radionuclides by gamma spectroscopy can identify the presence of specific man-made radionuclides (e.g., ^{241}Am, ^{137}Cs, ^{60}Co, ^{152}Eu, and ^{154}Eu), as well as natural radionuclides (e.g., ^{228}Ac, ^{212}Pb, ^{40}K, ^{235}U, and ^{234}Th). Specific analyses for ^{238}Pu, $^{239+240}$Pu, ^{226}Ra, ^{228}Ra, ^{14}C, ^{90}Sr, ^{99}Tc, ^{241}Am, and uranium isotopes are performed on selected water samples to help characterize sampled locations. Water analyses also include chemical parameters to characterize the groundwater chemistry and hydrology, but these measures are not presented in this report.

4.1.1 Water Monitoring Locations

The NTS groundwater and surface water monitoring network consists of a variety of monitoring locations that include onsite supply wells, domestic offsite wells, wells specifically designed to monitor groundwater, onsite and offsite natural springs, onsite containment ponds, and point-of-opportunity locations. The monitoring network is located in a complex hydrogeologic setting as described in Appendix A. The RREMP (DOE, 2003b) identifies a groundwater monitoring network of 78 wells to be sampled at frequencies which range from once every three months to once every three years. There are also eight additional wells (five offsite and three onsite) not identified in the RREMP which have been added to the network and which are sampled opportunistically or under the suggestion of NNSA/NSO. Of all these 86 wells, 63 have been sampled at least once since 1999. These 63 include 26 offsite wells, 10 onsite potable water supply wells, and 27 onsite monitoring wells (Figure 4-2). Those wells not sampled since 1999, but identified in the RREMP, include 14 onsite monitoring wells and 1 offsite well that have not been sampled because they are either not accessible, are used for other purposes, are blocked, provide water samples that are of poor quality or are contaminated (disqualifying them from monitoring), or contain waters with known high levels of radiological contamination which are not expected to change.

A network of 36 groundwater locations was sampled in 2004 (Figure 4-2). The 36 sampled wells include:

- 14 offsite wells
- 10 onsite potable water supply wells (9 of which are permitted)
- 12 onsite monitoring wells (3 are compliance wells for the Area 5 RWMS and 1 is a compliance well for the Area 23 sewage lagoon)

The RREMP identifies seven offsite springs that have been sampled over the years at intervals which range from once a year to once every three years (Figure 4-3). The RREMP also identifies one containment pond system and three sewage lagoons that are sampled at intervals of once every three months to once a year. Only two of the three sewage lagoons are currently active (Yucca and A23). Those surface water monitoring locations sampled in 2004 on and off the NTS (Figure 4-4) include:

- 2 offsite springs
- 1 NTS operations-related containment pond system (E Tunnel ponds)
- 2 onsite sewage lagoons

Several UGTA wells were sampled and analyzed for radionuclides in 2004 under the UGTA program (see Section 14.0). These wells do not comprise the RREMP network of groundwater wells, but they are briefly discussed in Section 4.1.10 below.

4.1.2 *Water Sampling/Analysis Methods*

Water sampling methods are based, in part, on the characteristics and configurations of the 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 via a wireline bailer or a portable pumping system. Grab samples are typically obtained from the springs.

Some of the monitoring program wells are constructed with multiple strings of casing/tubing or multiple completion zones comprised of discrete intervals of slotted casing which access different horizons of the penetrated hydrostratigraphic units. Multiple-depth samples were obtained from three wells with such configurations in 2004:

- 590, 622, 649, and 701 m (1,935, 2,040, 2,130, and 2,300 ft) below ground surface (bgs) in HTH #1
- 518 and 649 m (1,700 and 2,130 ft) bgs in UE-18r
- 475 and 608 m (1,560 and 1,994 ft) bgs in PM-3

Sampling frequencies and requisite analyses for routine radiological water monitoring are based on the location and type of the sampling point as defined in the RREMP (DOE, 2003b). During each monitoring year, not every water sample is analyzed for every analyte, per the design criteria of the RREMP. In 2004, tritium analyses were performed on all samples. Analyses for the other analytes listed were performed only on specific subsets of groundwater, spring, onsite containment pond, and sewage lagoon samples based on the probability of their detection at the sampled location or on whether they had been screened for previously at that location.

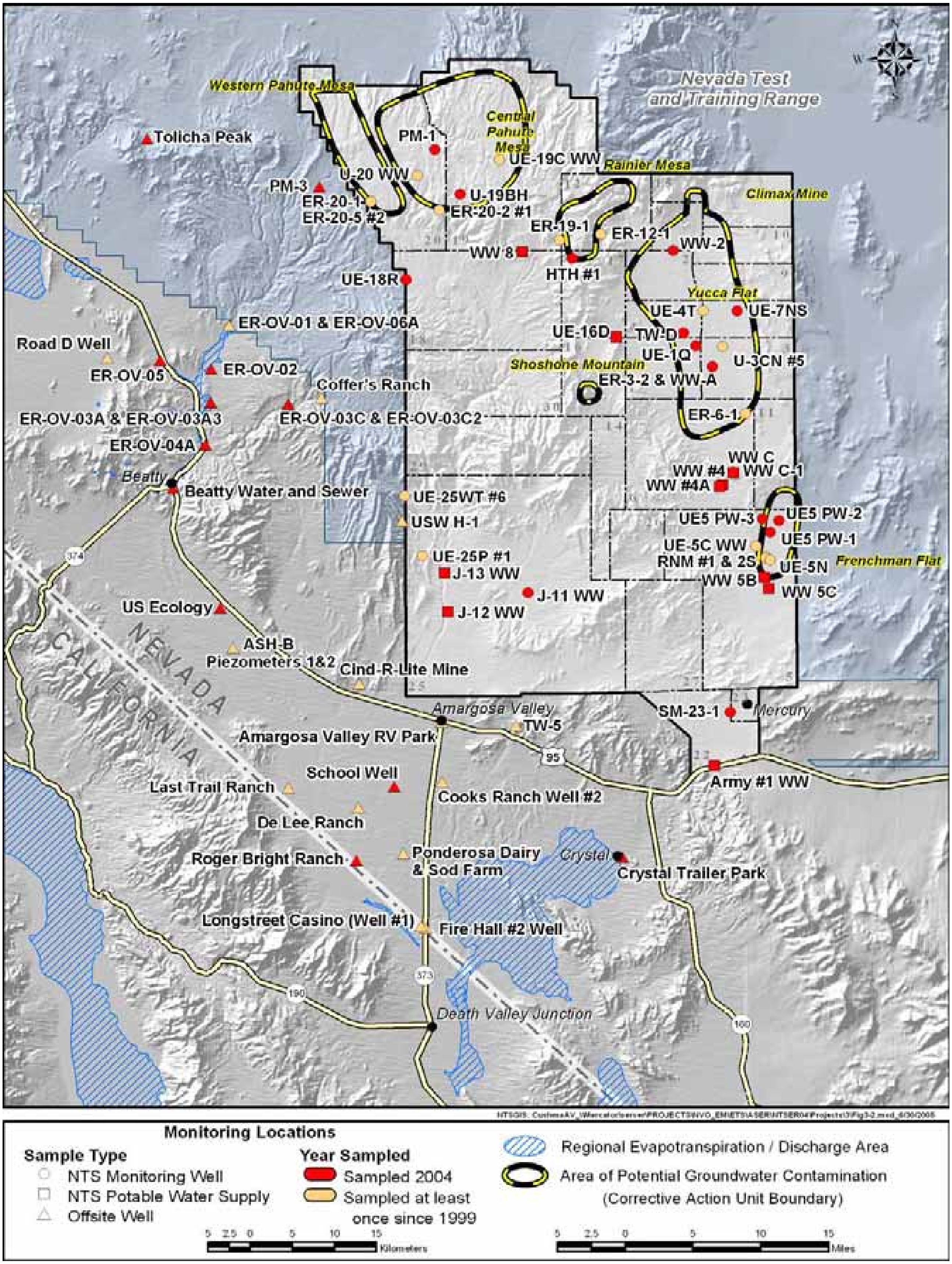

Figure 4-2. RREMP well monitoring locations sampled on and off the NTS in 2004

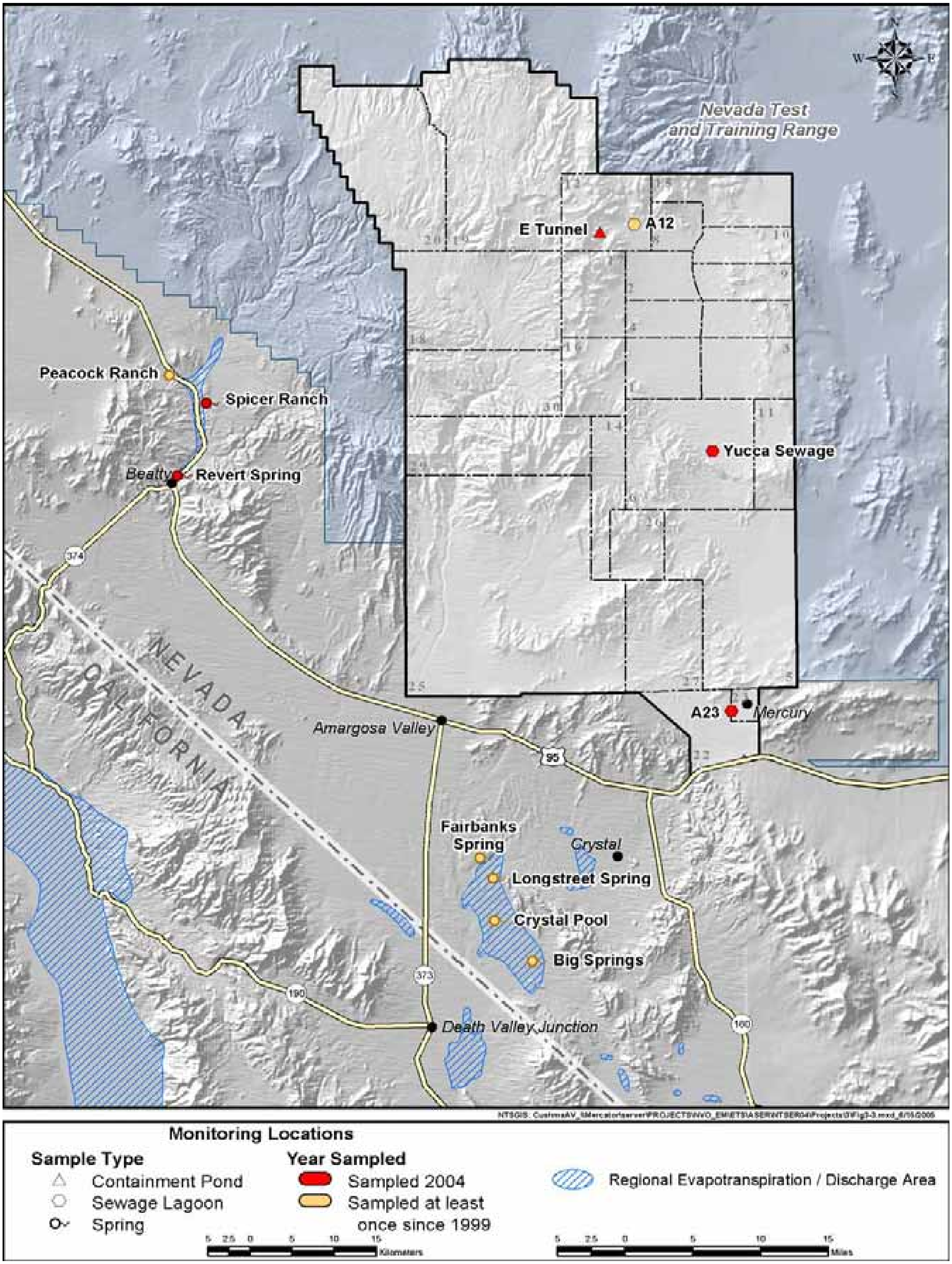

Figure 4-3. RREMP spring and surface water monitoring locations sampled on and off the NTS in 2004

To achieve a sufficiently low detection limit, most tritium analyses were conducted after the samples underwent an enrichment process. The enrichment process concentrates tritium in a sample to provide an effective minimum detectable concentration (MDC) (see Glossary, Appendix D) of approximately 25 picocuries per liter (pCi/L). Sample-specific MDCs, reported in each results table, ranged from 17 to 26 pCi/L. The MDC for standard (non-enriched) tritium analyses typically ranges from 200-400 pCi/L.

Routine quality control samples (e.g., duplicates, blanks, and spikes) are also incorporated into the analytical streams on a frequent basis. The reader is directed to Section 18.0 for a thorough discussion of quality assurance/quality control protocols and procedures utilized for radiological water monitoring.

4.1.3 Presentation of Water Sampling Data

Each water sample is analyzed for a potentially very large suite of radionuclides based on the analyses listed above. The following section presents only concentrations that were above the MDC for gamma-emitting radionuclides, plutonium, ^{14}C, ^{90}Sr, and ^{99}Tc. Concentration values of gross alpha, gross beta, tritium, ^{226}Ra, and ^{228}Ra, whether they are below or above the sample-specific MDCs, are presented for all water samples in the data tables.

The uncertainty values presented in the data tables of this chapter represent the counting uncertainty ("error") of the analytical method. This does not include the uncertainty associated with the preparation and concentration of tritium, which is estimated to be up to 20 percent. Therefore, it is important to note that the total or system error associated with the enrichment and analysis process for tritium samples is somewhat higher than the uncertainty values presented in the data tables.

All values shown in the tables in the following results sections are formatted to two significant figures based on the accuracy of the measurements (e.g., 2500, 25, 2.5, or 0.025).

4.1.4 Results from Offsite Wells

The 14 offsite locations sampled in 2004 include private domestic wells, community wells, and NNSA/NSO wells related to NTS activities. The 2004 data indicate that groundwater at the offsite locations has not been impacted by NTS nuclear testing operations. All of the tritium results for the offsite wells were less than the MDC except for one sample from well PM-3, which was slightly above the sample-specific MDC (Table 4-1). A duplicate sample from PM-3 collected on the same date was below the sample-specific MDC (Table 4-1).

The radiological analytes that were most often detected in 2004 are gross alpha and gross beta. ER-OV-02 had gross alpha levels above the EPA 15 pCi/L maximum contaminant level (MCL) in drinking water, and similar levels have been measured in previously from this well. This offsite monitoring well does not supply drinking water. It produces water from a volcanic aquifer that may have relatively higher quantities of natural alpha-yielding elements in the host rock. The gross alpha levels are attributed to the decay of naturally occurring uranium and local variation in mineralogy due to hydrothermal alteration in the volcanic host rock. ^{226}Ra and ^{228}Ra measurements indicate that radium is not a significant contributor to the gross alpha activity. No man-made radionuclides were detected by gamma spectroscopy in any of the water samples.

Among the 26 offsite wells which have been sampled at least once since 1999, there are no detectable trends in gross alpha or gross beta activity (Figure 4-4), or in tritium concentrations (Figure 4-5) from 2000 to 2004. Alpha and beta levels have mostly been below the EPA MCL for drinking water, and tritium concentrations have mostly been below their MDCs.

Table 4-1. Gross alpha, gross beta, tritium, and radium analysis results for offsite wells in 2004

Monitoring Location	Date Sampled	Gross α ± Uncertainty[a] (MDC) (pCi/L)[b]	Gross β ± Uncertainty (MDC) (pCi/L)[c]	^{3}H ± Uncertainty (MDC) (pCi/L)[d]	^{226}Ra ± Uncertainty (MDC) (pCi/L)[e]	^{228}Ra ± Uncertainty (MDC) (pCi/L)[e]
Beatty Water And Sewer	12/1/2004	15 ± 2.7 (1.2)	9.9 ± 2.1 (2.1)	5.9 ± 15 (25)	0.018 ± 0.12 (0.24)	-0.068 ± 0.40 (0.87)
Beatty Water And Sewer FD[f]	12/1/2004	14 ± 2.6 (1.1)	11 ± 2.2 (2.2)	6.1 ± 15 (25)	-0.032 ± 0.11 (0.24)	0.32 ± 0.41 (0.81)
Crystal Trailer Park	12/1/2004	2.8 ± 0.90 (1.1)	6.8 ± 1.6 (1.8)	11 ± 15 (25)	0.038 ± 0.15 (0.29)	0.34 ± 0.40 (0.80)
ER-OV-02	9/27/2004	45 ± 7.7 (1.6)	48 ± 8.1 (3.4)	-5.9 ± 11 (19)	NA	NA
ER-OV-02 FD	9/27/2004	51 ± 8.7 (1.9)	40 ± 7.0 (3.7)	NA[g]	NA	NA
ER-OV-03A	9/28/2004	6.9 ± 1.4 (0.78)	7.1 ± 1.5 (1.4)	-6.9 ± 12 (21)	NA	NA
ER-OV-03A FD	9/28/2004	7.4 ± 1.5 (0.73)	7.2 ± 1.6 (1.7)	NA	NA	NA
ER-OV-03A3	9/29/2004	8.3 ± 1.6 (0.85)	7.8 ± 1.6 (1.5)	-9.0 ± 12 (21)	NA	NA
ER-OV-03C	9/28/2004	8.4 ± 1.6 (0.64)	7.4 ± 1.4 (1.1)	-7.2 ± 13 (22)	NA	NA
ER-OV-03C2	9/28/2004	5.7 ± 1.1 (0.62)	4.6 ± 1.0 (1.1)	7.8 ± 13 (21)	NA	NA
ER-OV-04A	9/27/2004	7.9 ± 1.6 (1.0)	17 ± 3.0 (1.9)	-11 ± 12 (22)	NA	NA
ER-OV-05	9/27/2004	6.1 ± 1.4 (1.1)	15 ± 2.9 (2.2)	-4.8 ± 13 (22)	NA	NA
PM-3	5/25/2004	3.3 ± 0.85 (0.78)	17 ± 2.9 (1.5)	20 ± 12 (18)	NA	NA
PM-3 FD	5/25/2004	NA	NA	17 ± 12 (18)	NA	NA
Roger Bright Ranch	12/1/2004	2.5 ± 1.0 (1.4)	14 ± 2.9 (2.6)	8.9 ± 15 (24)	0.10 ± 0.12 (0.18)	0.49 ± 0.45 (0.87)
School Well	12/1/2004	1.6 ± 0.53 (0.58)	8.6 ± 1.7 (1.4)	3.0 ± 15 (25)	0.036 ± 0.090 (0.17)	0.18 ± 0.43 (0.90)
Tolicha Peak	12/1/2004	2.6 ± 0.68 (0.67)	5.0 ± 1.1 (1.2)	10 ± 15 (25)	0.19 ± 0.15 (0.16)	0.22 ± 0.43 (0.89)
U.S. Ecology	12/1/2004	4.4 ± 1.2 (1.1)	11 ± 2.5 (2.8)	11 ± 16 (26)	0.063 ± 0.13 (0.23)	0.20 ± 0.38 (0.78)

Green shaded results are considered detected (result is greater than the sample specific MDC)

Yellow shaded results are any which are equal to or greater than the EPA-designated levels shown below for each analyte:

(a) ±2 standard deviations

(b) The EPA established MCL in drinking water for gross alpha (α) is 15 pCi/L

(c) The EPA "Level of Concern" in drinking water for gross beta (β) is 50 pCi/L

(d) The EPA established MCL in drinking water for tritium (^{3}H) is 20,000 pCi/L

(e) The EPA established MCL in drinking water for ^{226}Ra and ^{228}Ra combined is 5 pCi/L

(f) FD = field duplicate sample

(g) NA = Specific analysis was not run on the sample

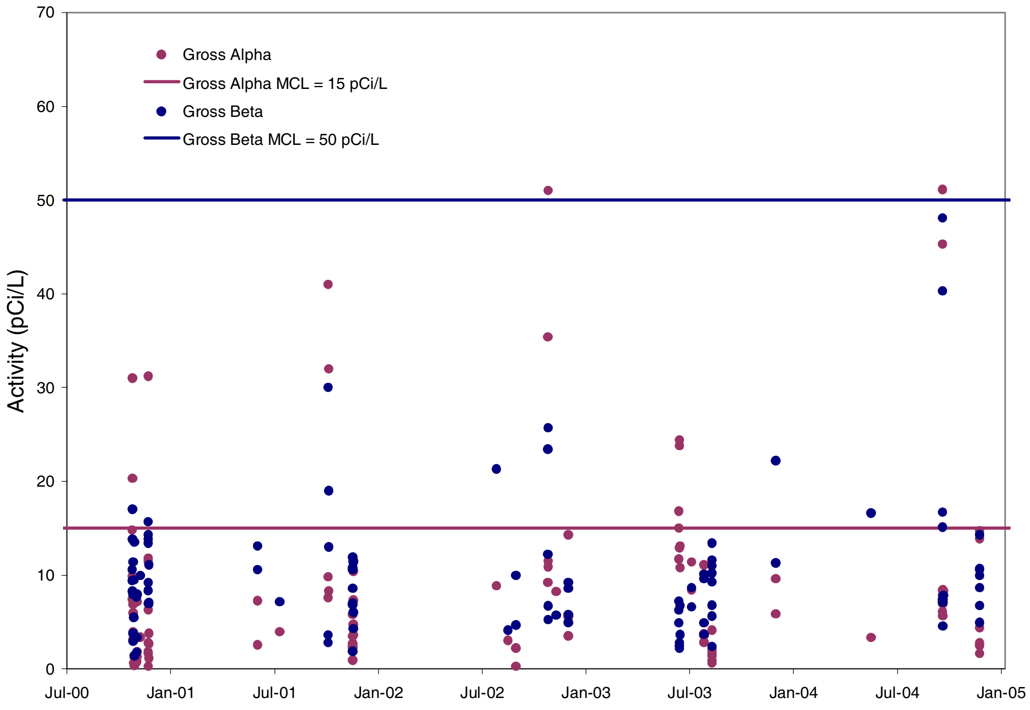

Figure 4-4. Gross alpha and gross beta levels in offsite wells from 2000 to 2004

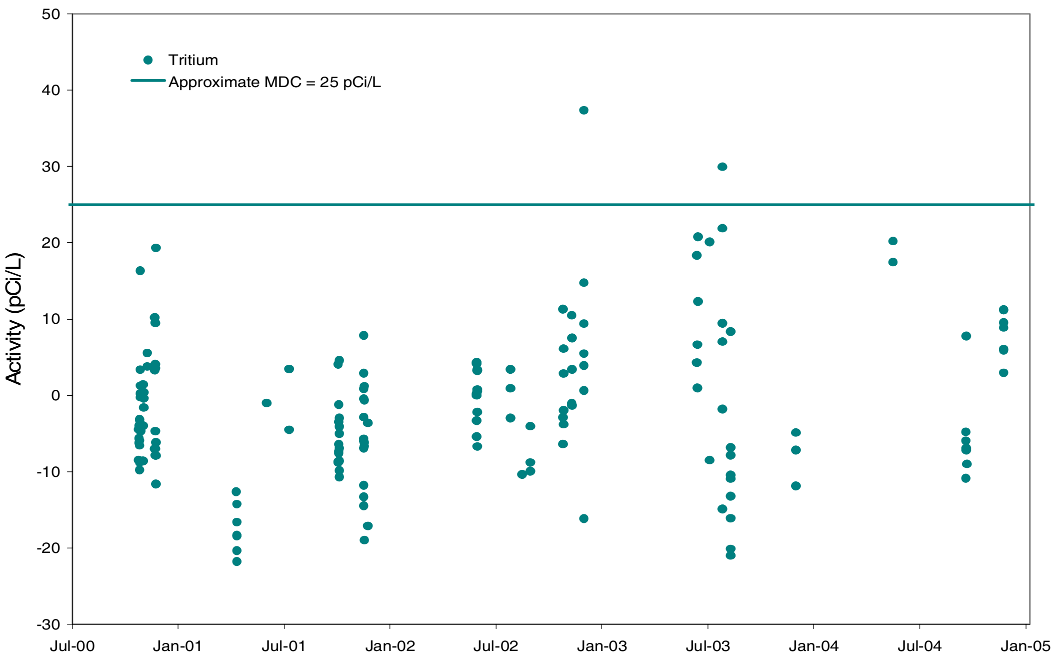

Figure 4-5. Tritium concentrations in offsite wells from 2000 to 2004

4.1.5 Results from Offsite Springs

Two offsite springs, Spicer Ranch Spring and Revert Spring, were sampled in 2004. Both springs are near Beatty, Nevada. Detectable concentrations of gross alpha and gross beta were present in water collected from the springs, although their concentrations were below the EPA MCL for drinking water (Table 4-2). The measurable gross alpha and gross beta radioactivity is likely from natural sources.

No detectable concentrations of tritium were found in any of the samples (Table 4-2). ^{226}Ra and ^{228}Ra measurements indicate that radium is not a significant contributor to the gross alpha activity.

No man-made gamma-emitting radionuclides were detected.

Among the seven offsite springs that have been sampled at least once since 1999, there are no detectable trends in gross alpha or gross beta activity (Figure 4-6), or in tritium concentrations (Figure 4-7) from 2000 to 2004. Alpha and beta levels have all been below the EPA MCL for drinking water, and tritium concentrations have all been below the MDC.

Table 4-2. Gross alpha, gross beta, tritium, and radium analysis results for offsite springs in 2004

Monitoring Location	Date Sampled	Gross α ± Uncertainty (MDC)(a) (pCi/L)(b)	Gross β ± Uncertainty (MDC) (pCi/L)(c)	^{3}H ± Uncertainty (MDC) (pCi/L)(d)	^{226}Ra ± Uncertainty (MDC) (pCi/L)(e)	^{228}Ra ± Uncertainty (MDC) (pCi/L)(e)
Revert Spring	12/1/2004	4.1 ± 1.0 (0.87)	4.8 ± 1.5 (2.1)	-7.8 ± 14 (25)	0.71 ± 0.30 (0.21)	0.15 ± 0.46 (0.96)
Revert Spring FD(f)	12/1/2004	NA(g)	NA	5.7 ± 15 (24)	NA	NA
Spicer Ranch	12/1/2004	6.2 ± 1.4 (1.1)	8.3 ± 1.9 (2.0)	6.7 ± 15 (25)	0.92 ± 0.40 (0.36)	-0.050 ± 0.40 (0.86)

Green shaded results are considered detected (result is greater than the sample specific MDC)

(a) ±2 standard deviations

(b) The EPA established MCL in drinking water for gross alpha (α) is 15 pCi/L

(c) The EPA "Level of Concern" in drinking water for gross beta (β) is 50 pCi/L

(d) The EPA established MCL in drinking water for tritium (^{3}H) is 20,000 pCi/L

(e) The EPA established MCL in drinking water for ^{226}Ra and ^{228}Ra combined is 5 pCi/L

(f) FD = field duplicate sample

(g) NA = Specific analysis was not run on the sample

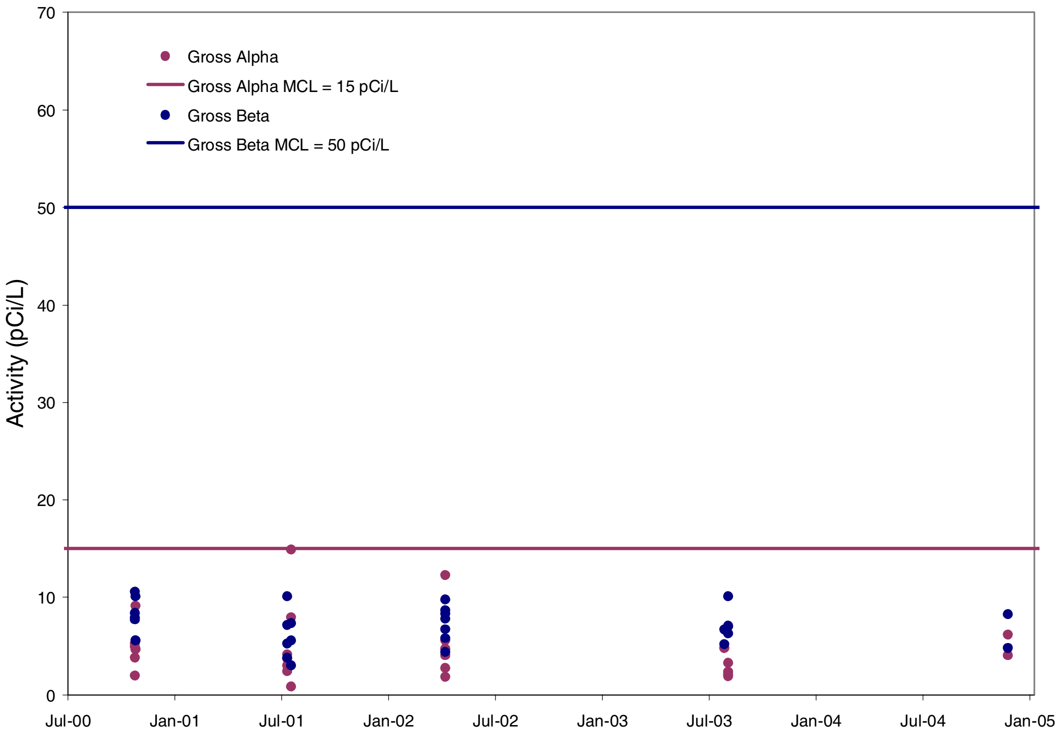

Figure 4-6. Gross alpha and gross beta levels in offsite springs from 2000 to 2004

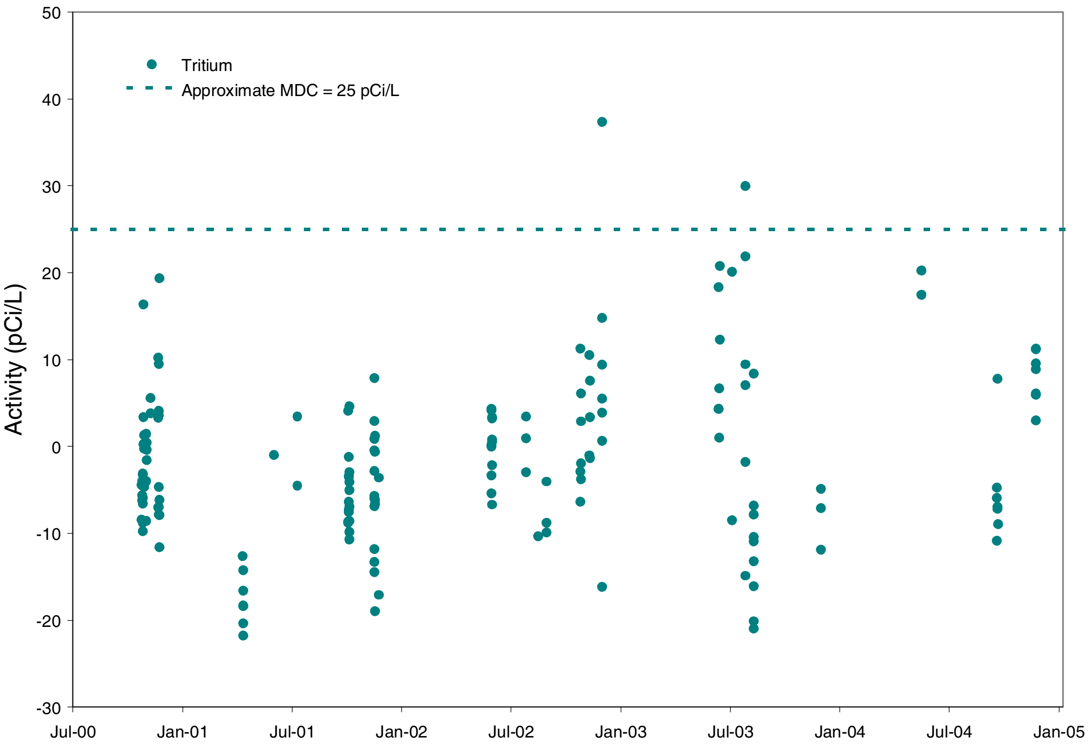

Figure 4-7. Tritium concentrations in offsite springs from 2000 to 2004

4.1.6 Results from NTS Potable Water Supply Wells

Results from the ten potable NTS water wells sampled in 2004 continue to indicate that subsurface nuclear testing has not impacted the NTS potable water supply network. The water samples from the supply wells had non-detectable concentrations of tritium except for one sample from UE-16D Water Well (WW), one sample from WW 5B, and one sample from WW 8 (Table 4-3). These three samples were only slightly above their sample-specific MDCs; and all other samples collected throughout the year from these wells had non-detectable concentrations of tritium.

There was a problem with the tritium analyses for all ten well samples collected in January 2004. Initially, all the January samples had tritium levels above their MDCs, but when the same samples were reanalyzed, eight of the ten samples were below their MDCs. The two samples that remained above their MDCs were for wells UE-16D WW and WW C-1. These results are inconsistent with all subsequent analyses performed in 2004 as well as the previous analyses performed over the past ten years for these two wells. Therefore, the January samples from these two wells were considered contaminated by an outside source and the results from these samples were rejected (Table 4-3).

Prior to 1994, WW C-1 (also known as Water Well C-1) had a history of validated tritium detections because this well was injected with approximately 0.1 to 0.2 curies of tritium in 1962 by a researcher conducting a tracer test (Lyles, 1990). Since 1995, tritium concentrations in WW C-1 have remained below their MDCs.

The radiological analytes that were principally detectable in 2004 in the potable water supply wells were gross alpha and gross beta radioactivity. This activity likely represents the presence of naturally occurring radionuclides, since there was a general lack of corresponding detectable man-made radionuclides in the samples. Very low, yet detectable, concentrations of naturally occurring ^{226}Ra and ^{228}Ra were also measured (Table 4-3). None of these detectable radiological analytes exceeded EPA established Levels of Concern or the established MCLs for drinking water (Table 4-3).

No man-made gamma-emitting radionuclides were detected in the potable water supply well samples.

These 10 NTS potable water supply wells have all been sampled routinely since 1999. No detectable trends in gross alpha or gross beta activity (Figure 4-8) or in tritium concentrations (Figure 4-9) have been found from 2000 to 2004.

The state of Nevada, Bureau of Health Protection Services independently sampled all of the NTS potable water supply wells at least once during 2004 at the same time as BN ETS personnel collected samples. The state of Nevada sample results also indicate that man-made radionuclides are at or below MDC and that naturally occurring radioactive materials, such as thorium and uranium decay chain radionuclikes, are within normal ranges (BHPS, 2005a; 2005b; 2005c; 2005d).

Table 4-3. Gross alpha, gross beta, tritium, and radium analysis results for NTS potable water supply wells

Monitoring Location and Date Sampled	Gross α ± Uncertainty (MDC)(a) (pCi/L)(b)	Gross β ± Uncertainty (MDC) (pCi/L)(c)	^{3}H ± Uncertainty (MDC) (pCi/L)(d)	^{226}Ra ± Uncertainty (MDC) (pCi/L)(e)	^{228}Ra ± Uncertainty (MDC) (pCi/L)(e)
Army #1 WW					
1/21/2004	3.8 ± 0.90 (0.80)	5.2 ± 1.2 (1.4)	-1.2 ± 13 (21)	0.20 ± 0.32 (0.53)	0.35 ± 0.36 (0.69)
4/21/2004	1.6 ± 1.20 (1.9)	-1.6 ± 1.5 (2.6)	-4.5 ± 14 (24)	0.56 ± 0.32 (0.39)	0.46 ± 0.63 (1.2)
4/21/2004 FD(f)	NA(g)	NA	0.60 ± 14 (24)	NA	NA
7/21/2004	2.6 ± 0.78 (0.88)	5.8 ± 1.4 (1.7)	8.3 ± 13 (21)	NA	NA
10/13/2004	3.2 ± 0.91 (0.93)	5.9 ± 1.4 (1.6)	5.9 ± 10 (17)	NA	NA
J-12 WW					
1/21/2004	0.71 ± 0.39 (0.56)	4.1 ± 0.96 (1.1)	1.5 ± 13 (22)	-0.15 ± 0.18 (0.40)	0.046 ± 0.33 (0.71)
4/21/2004	1.3 ± 0.62 (0.82)	2.7 ± 1.2 (2.0)	2.7 ± 14 (24)	0.27 ± 0.27 (0.43)	1.2 ± 0.57 (1.0)
7/21/2004	0.28 ± 0.53 (1.1)	4.5 ± 1.4 (2.1)	6.9 ± 13 (21)	NA	NA
10/13/2004	0.45 ± 0.49 (0.89)	3.8 ± 1.1 (1.5)	2.4 ± 10 (17)	NA	NA
J-13 WW					
10/13/2004	1.2 ± 0.55 (0.83)	3.0 ± 0.96 (1.5)	3.6 ± 10 (17)	NA	NA
UE-16D WW					
1/20/2004	5.6 ± 1.2 (0.83)	7.1 ± 1.4 (1.3)	R(h)	1.3 ± 0.53 (0.39)	0.26 ± 0.34 (0.68)
4/20/2004	5.7 ± 1.3 (1.1)	7.5 ± 1.8 (2.3)	-0.97 ± 14 (23)	2.1 ± 0.65 (0.61)	0.63 ± 0.37 (0.65)
7/20/2004	4.1 ± 0.94 (0.77)	6.5 ± 1.4 (1.3)	3.1 ± 12 (21)	NA	NA
10/12/2004	5.2 ± 1.3 (1.2)	7.8 ± 1.6 (1.5)	23 ± 11 (18)	NA	NA
10/12/2004 FD	NA	NA	28 ± 12 (18)	NA	NA
WW #4					
1/20/2004	4.6 ± 0.95 (0.61)	5.5 ± 1.2 (1.1)	18 ± 14 (23)	-0.11 ± 0.27 (0.54)	0.31 ± 0.34 (0.66)
4/20/2004	7.5 ± 2.0 (1.5)	4.4 ± 1.5 (2.3)	-3.3 ± 13 (23)	0.54 ± 0.33 (0.42)	0.56 ± 0.42 (0.76)
7/20/2004	4.8 ± 1.5 (1.6)	5.5 ± 1.6 (2.4)	9.2 ± 13 (21)	NA	NA
10/12/2004	4.0 ± 1.0 (0.88)	4.9 ± 1.2 (1.5)	9.9 ± 11 (18)	NA	NA
WW #4A					
1/20/2004	4.7 ± 1.0 (0.61)	5.2 ± 1.1 (1.1)	7.1 ± 13 (22)	0.25 ± 0.25 (0.36)	0.54 ± 0.38 (0.69)
4/20/2004	6.7 ± 1.3 (1.2)	6.3 ± 1.4 (2.1)	-3.3 ± 14 (24)	0.27 ± 0.32 (0.53)	0.90 ± 0.46 (0.81)
7/20/2004	5.1 ± 1.5 (1.5)	5.3 ± 1.7 (2.6)	9.0 ± 13 (21)	NA	NA
10/12/2004	5.7 ± 1.3 (0.82)	6.0 ± 1.3 (1.5)	9.4 ± 11 (18)	NA	NA
WW 5B					
2/2/2004	2.5 ± 0.73 (0.82)	9.2 ± 1.7 (1.1)	2.7 ± 13 (22)	0.042 ± 0.18 (0.34)	0.31 ± 0.34 (0.67)
7/20/2004	1.7 ± 0.71 (0.94)	11 ± 2.2 (1.7)	27 ± 13 (21)	NA	NA
10/12/2004	4.2 ± 1.0 (0.94)	11 ± 2.0 (1.2)	6.0 ± 10 (17)	NA	NA
WW 5C					
2/2/2004	4.3 ± 1.2 (1.3)	4.9 ± 1.3 (1.7)	-5.6 ± 13 (23)	0.19 ± 0.24 (0.37)	-0.054 ± 0.34 (0.72)
7/20/2004	4.4 ± 1.1 (0.89)	5.1 ± 1.4 (1.7)	19 ± 13 (21)	NA	NA
10/12/2004	6.5 ± 1.3 (0.91)	6.0 ± 1.3 (1.2)	6.7 ± 11 (18)	NA	NA
WW 8					
1/20/2004	0.14 ± 0.55 (1.2)	3.1 ± 1.2 (2.1)	15 ± 14 (23)	0.024 ± 0.16 (0.32)	0.20 ± 0.36 (0.74)
4/20/2004	0.13 ± 0.62 (1.1)	1.8 ± 1.3 (2.1)	2.1 ± 14 (23)	0.10 ± 0.22 (0.41)	1.4 ± 0.62 (1.1)
7/20/2004	0.44 ± 0.57 (1.1)	3.0 ± 1.2 (2.1)	-12 ± 12 (21)	NA	NA
7/20/2004 FD	NA	NA	-11 ± 12 (22)	NA	NA
10/12/2004	0.36 ± 0.44 (0.82)	2.5 ± 0.91 (1.4)	27 ± 12 (18)	NA	NA
WW C-1					
1/20/2004	11 ± 2.2 (1.5)	14 ± 2.8 (2.5)	R	0.66 ± 0.43 (0.60)	0.62 ± 0.38 (0.66)
4/20/2004	11 ± 3.5 (1.4)	16 ± 2.6 (2.6)	1.7 ± 14 (23)	1.61 ± 0.52 (0.50)	0.92 ± 0.41 (0.66)
7/20/2004	7.0 ± 1.8 (1.8)	13 ± 2.7 (2.8)	9.0 ± 13 (21)	NA	NA
10/12/2004	10 ± 2.0 (1.2)	15 ± 2.7 (2.1)	17 ± 11 (18)	NA	NA

Green shaded results are considered detected (result is greater than the sample specific MDC)
(a) ±2 standard deviations
(b) The EPA established MCL in drinking water for gross alpha (α) is 15 pCi/L
(c) The EPA "Level of Concern" in drinking water for gross beta (β) is 50 pCi/L
(d) The EPA established MCL in drinking water for tritium (^{3}H) is 20,000 pCi/L
(e) The EPA established MCL in drinking water for ^{226}Ra and ^{228}Ra combined is 5 pCi/L
(f) FD = field duplicate sample
(g) NA = specific analysis was not run on the sample
(h) R = analysis was rejected due to suspected contamination

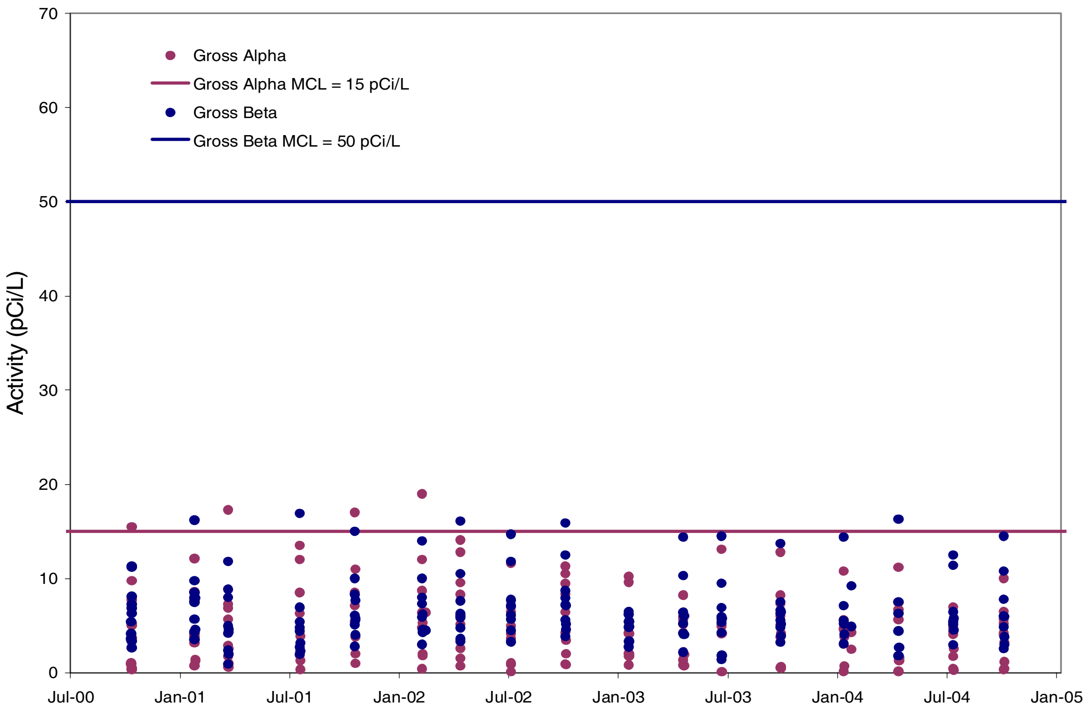

Figure 4-8. **Gross alpha and gross beta levels in NTS potable water supply wells from 2000 to 2004**

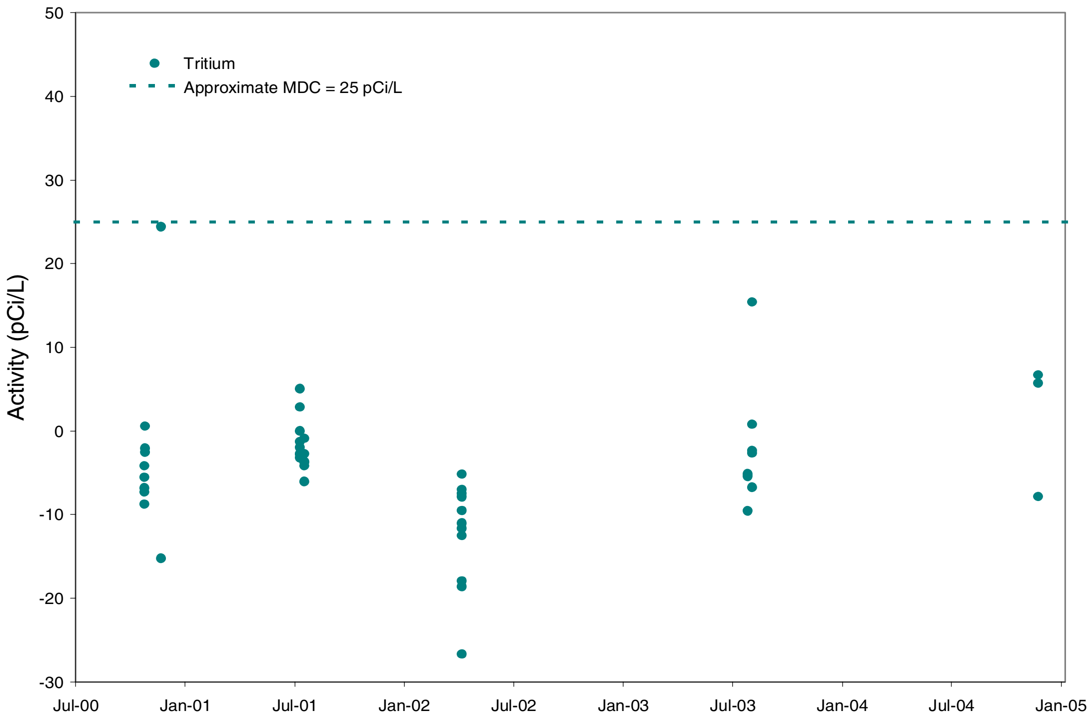

Figure 4-9. **Tritium concentrations in NTS potable water supply wells from 2000 to 2004**

4.1.7 Results from NTS Monitoring Wells

Analytical results from the network of onsite monitoring wells (see Figure 4-2) indicate that migration of radionuclides from the underground test areas is not significant. Four onsite monitoring wells (PM-1, U-19BH, UE-7NS, and WW A) have detectable concentrations of tritium, although they are all well below the federal MCL of 20,000 pCi/L (Table 4-4). Each of these four monitoring wells is located within 1 km (0.6 mi) of a historical underground nuclear test; all have consistently had detectable levels of tritium. These wells are discussed below, and their historic tritium concentrations are shown in Figure 4-10.

There were also measured tritium levels above the MDC from three wells sampled to validate performance of a waste pit at the Area 5 RWMS (UE5 PW-1, UE5 PW-2, and UE5 PW-3), but in all cases, a duplicate sample collected at the same time had measured tritium levels below the MDC.

Tritium was not detectable in other samples from onsite monitoring wells during 2004 (Table 4-4).

Well PM-1 – this well is located in the Central Pahute Mesa CAU. This well is constructed with unslotted casing from the surface to 2,300 m (7,546 ft) bgs and is an open hole from 2,300 to 2,356 m (7,546 to 7,730 ft) bgs. Results from depth profile sampling below the static water level in 2001 show a decreasing tritium concentration with depth, indicating that tritium is entering the borehole near the static water level at approximately 643 m (2,109 ft) bgs. Potential sources of the tritium include the underground nuclear tests Farm (U-20ab), Greeley (U-20g), and Kasseri (U-20z). The Farm test is closest to PM-1 but is believed to be downgradient from PM-1. The Greely test is 2,429 m (7,969 ft) upgradient from PM-1, and the Kasseri test is 1,196 m (3,924 ft) upgradient from PM-1.

Well U-19BH – this well is located in the Central Pahute Mesa CAU. It is an inventory emplacement borehole. There were several nuclear detonations conducted near U-19BH, but the source of the tritium in the borehole is unclear. Previous investigations suggest that the water in the well originates from a perched aquifer, but identifying the likely source of tritium is difficult due to a lack of data regarding the perched system (Brikowski et al., 1993). The results from a tracer test conducted in the well indicate that there is minimal flow across the borehole (Brikowski et al., 1993). The lack of measurable flow in the well suggests that the chemistry of the water sampled from the borehole may not be representative of the aquifer. The data are provided as a point of interest due to the detection of tritium.

Well UE-7NS – this well is located in the Yucca Flat CAU and was drilled 137 m (449 ft) from the Bourbon underground nuclear test (U-7n) which was conducted in 1967. This well was routinely sampled between 1978 and 1987, with the resumption of sampling in 1991. Tritium levels in this well have been decreasing in recent years (Figure 4-10). Well UE-7NS is the second known location on the NTS where the regionally important lower carbonate aquifer (LCA) has been impacted by radionuclides from nuclear testing (Smith et al., 1999). The first location where the LCA has been impacted by radionuclides from nuclear testing is Well UE-2CE. Well UE-2CE is located less the 200 m (656 ft) from the NASH test, which was conducted in Yucca Flat in 1967. Well UE-2CE is not currently configured for routine sampling.

Well WW-A (also known as USGS Water Well A) – this well is completed in alluvium in the Yucca Flat CAU (see Figure 4-2). It is located within 1 km (0.6 mi) of 14 underground nuclear tests in Yucca Flat, most of which appear to be upgradient of the well. The well has had measurable tritium since the late 1980s. The marked increase between 1985 and 1999 suggests inflow of tritium to this well from the HAYMAKER underground nuclear test (U-3aus) conducted in 1962 524 m (1,720 ft) north of Well WW-A. This well, which supplied non-potable water for construction, was shut down in the early 1990s. The concentrations measured in 2004 at WW-A indicate a slight downward trend since 1999 (Figure 4-4).

Detectable concentrations of gross alpha and gross beta were present in water collected from NTS onsite monitoring wells. The low measurable gross alpha and gross beta radioactivity in these wells is likely from natural sources. The high levels of gross alpha and gross beta activity in U-19BH are likely related to contamination.

No radionuclides were detected by gamma spectroscopy analyses at concentrations above their respective MDCs in any of the NTS monitoring wells in 2004.

Table 4-4. Gross alpha, gross beta, and tritium analysis results for NTS monitoring wells in 2004

Monitoring Location	Date Sampled	Gross α ± Uncertainty (MDC)(a) (pCi/L)(b)	Gross β ± Uncertainty (MDC) (pCi/L)(c)	^{3}H ± Uncertainty (MDC) (pCi/L)(d)
HTH #1 (1935 ft bgs)	3/24/2004	NA(e)	NA	-2.4 ± 13 (23)
HTH #1 (1935 ft bgs) FD(f)	3/24/2004	NA	NA	-8.2 ± 13 (22)
HTH #1 (2040 ft bgs)	3/24/2004	NA	NA	8.6 ± 14 (23)
HTH #1 (2130 ft bgs)	3/24/2004	NA	NA	-6.0 ± 13 (23)
HTH #1 (2300 ft bgs)	3/24/2004	NA	NA	0.54 ± 13 (22)
J-11 WW	7/13/2004	4.0 ± 1.9 (2.9)	21 ± 2.2 (2.6)	-14 ± 11 (20)
PM-1	6/30/2004	-0.17 ± 1.1 (1.9)	6.0 ± 2.4 (3.6)	149 ± 18 (20)
PM-1 FD	6/30/2004	NA	NA	137 ± 18 (20)
SM-23-1(g)	2/18/2004	3.5 ± 1.2 (1.5)	5.0 ± 1.0 (1.3)	-13 ± 12 (22)
U-19BH	3/23/2004	66 ± 11 (1.3)	99 ± 16 (2.6)	32 ± 15 (23)
U-19BH FD	3/23/2004	65 ± 11 (1.3)	93 ± 15 (2.7)	23 ± 14 (22)
UE-18R (1700 ft bgs)	3/23/2004	5.7 ± 1.1 (0.55)	2.1 ± 0.76 (1.1)	-4.8 ± 13 (22)
UE-18R (1700 ft bgs) FD	3/23/2004	NA(f)	NA	-15 ± 12 (22)
UE-18R (2130 ft bgs)	3/23/2004	12 ± 2.1 (0.68)	3.0 ± 0.86 (1.1)	2.4 ± 13 (21)
UE5 PW-1(h)	5/4/2004	NA	NA	34 ± 13 (20)
UE5 PW-1 FD	5/4/2004	NA	NA	2.7 ± 11 (19)
UE5 PW-1	10/19/2004	NA	NA	0.18 ± 13 (22)
UE5 PW-1 FD	10/19/2004	NA	NA	-3.2 ± 12 (21)
UE5 PW-2(h)	5/4/2004	NA	NA	11 ± 12 (20)
UE5 PW-2 FD	5/4/2004	NA	NA	30 ± 12 (20)
UE5 PW-2	10/19/2004	NA	NA	-7.1 ± 12 (21)
UE5 PW-2 FD	10/19/2004	NA	NA	-13 ± 12 (21)
UE5 PW-3(h)	5/4/2004	NA	NA	-3.0 ± 10 (17)
UE5 PW-3 FD	5/4/2004	NA	NA	37 ± 13 (20)
UE5 PW-3	10/20/2004	NA	NA	-4.5 ± 12 (21)
UE5 PW-3 FD	10/20/2004	NA	NA	-8.2 ± 12 (22)
UE-7NS	4/7/2004	-0.21 ± 0.74 (1.8)	3.1 ± 1.3 (2.2)	144 ± 19 (22)
UE-7NS FD	4/7/2004	NA	NA	123 ± 18 (23)
WW A	2/3/2004	0.93 ± 0.7 (1.2)	7.0 ± 1.6 (1.7)	471 ± 26 (20)
WW A FD	2/3/2004	NA	NA	475 ± 27 (20)
WW 2	2/11/2004	6.3 ± 1.6 (1.1)	6.6 ± 1.9 (2.8)	-2.4 ± 13 (22)
WW 2 FD	2/11/2004	4.2 ± 1.4 (1.5)	6.8 ± 2.0 (3.0)	NA

Green shaded results are considered detected (result is greater than the sample specific MDC)

Yellow shaded results are equal to or greater than the EPA-designated drinking water limits for each analyte

(a) ±2 standard deviations

(b) The EPA established MCL in drinking water for gross alpha (α) is 15 pCi/L

(c) The EPA Level of Concern in drinking water for gross beta (β) is 50 pCi/L

(d) The EPA established MCL in drinking water for tritium (^{3}H) is 20,000 pCi/L

(e) NA = Specific analysis was not run on the sample

(f) FD = field duplicate sample

(g) Compliance well for Area 23 sewage lagoon

(h) Compliance well for validation of waste pit P03U a Area 5 RWMS (see Section 9.1.6)

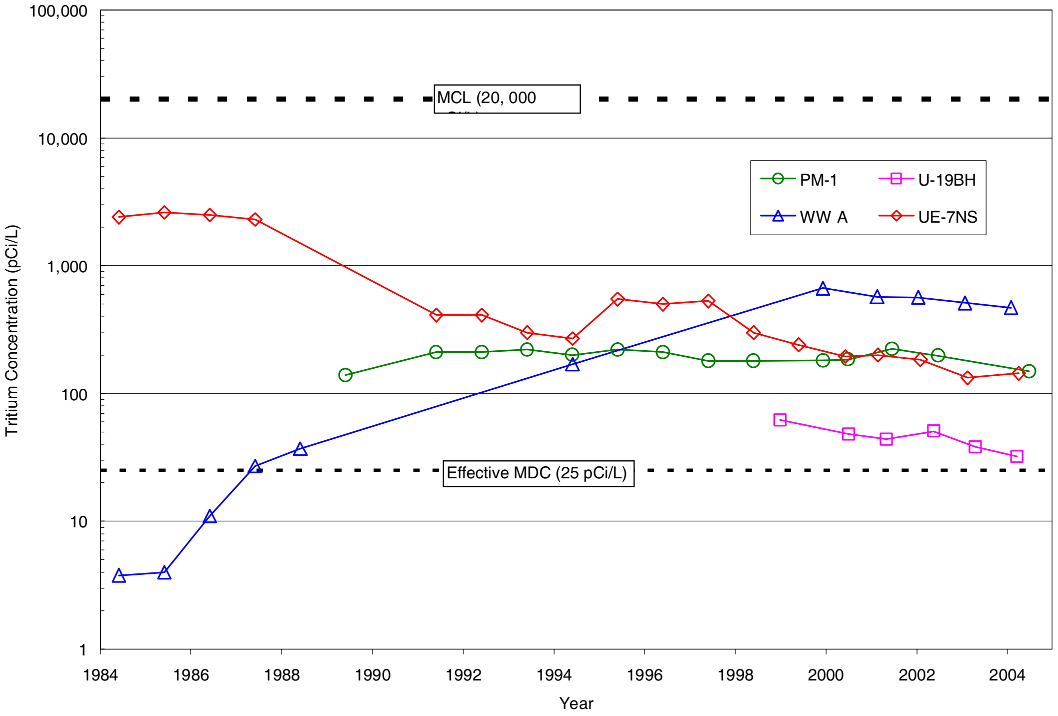

Figure 4-10. Concentrations of tritium in wells with a history of detectable levels

4.1.8 Results from NTS E Tunnel Ponds

Five primary basins were constructed to collect and hold water discharged from the E Tunnels in Area 12 where nuclear testing was conducted in the past (see Figure 4-3 and Figure 7-2). The water is perched groundwater that has percolated through fractures in the tunnel system. The Defense Threat Reduction Agency (DTRA) conducts monitoring of effluent waters from E Tunnel to determine if radionuclides and non-radiological contaminants exceed the allowable contaminant levels regulated under a state water pollution control permit (NEV 96021), which is issued to DTRA. During October, 2004, a DTRA contract company sampled the tunnel effluent near where water is discharged. During September, 2004, BN personnel sampled water from the pond influent (which at the time was flowing into Pond 5), and from Pond 5 itself. Sediment was also sampled from the basin of Pond 5. Effluent water was analyzed by DTRA for tritium, gross alpha, and gross beta (Table 4-5) and for 16 non-radiological contaminants and water quality parameters (DTRA, 2004). All other samples were analyzed by BN for tritium (water samples only), gamma-emitting radionuclides, uranium, plutonium, ^{90}Sr, and ^{241}Am (Table 4-6).

Table 4-5. Radiological results for E Tunnel Pond effluent pertaining to Water Pollution Control Permit NEV 96021

Parameter	Permissible Limit (pCi/L)	Average Measured Value (pCi/L)
Tritium	1,000,000	710,000
Gross Alpha	35.1	13.4
Gross Beta	101	72

Source: Water Pollution Control Permit NEV 96021 Quarterly Monitoring Report and Annual Summary Report for E Tunnel Waste Water Disposal System (DTRA, 2004)

Table 4-6. Routine radiological water monitoring results for E-Tunnel Ponds in 2004

Sample	^{3}H ± Uncertainty[(a)] (MDC)	^{90}Sr ± Uncertainty (MDC)	^{137}Cs ± Uncertainty (MDC)	^{238}Pu ± Uncertainty (MDC)	$^{239+240}$Pu ± Uncertainty (MDC)	^{241}Am ± Uncertainty (MDC)
Water - Concentration units are pCi/L						
Influent to Pond 5	738,000 ± 74,300 (1,620)	0.51 ± 0.39 (0.63)	62.70 ± 6.38 (2.84)	0.36 ± 0.09 (0.04)	3.10 ± 0.39 (0.05)	0.26 ± 0.08 (0.06)
Pond 5 Water	721,000 ± 72,600 (1,610)	0.29 ± 0.26 (0.47)	55.30 ± 4.38 (2.95)	0.40 ± 0.09 (0.03)	3.25 ± 0.41 (0.04)	0.18 ± 0.07 (0.06)
Pond 5 Water FD[(b)]	730,000 ± 73,500 (1,620)	0.59 ± 0.36 (0.58)	49.00 ± 5.75 (3.17)	0.40 ± 0.09 (0.03)	3.60 ± 0.44 (0.01)	0.25 ± 0.07 (0.04)
Sediment - Concentration units are pCi/gram						
Pond 5 Sediment	NA[(c)]	-0.02 ± 0.21 (0.49)	17.00 ± 0.25 (0.06)	0.05 ± 0.02 (0.02)	0.34 ± 0.08 (0.01)	0.01 ± 0.02 (0.01)
Pond 5 Sediment FD	NA	0.30 ± 0.31 (0.61)	19.70 ± 1.38 (0.06)	0.02 ± 0.02 (0.01)	0.36 ± 0.08 (0.01)	0.01 ± 0.02 (0.02)

Green shaded results are considered detected (results greater than the sample-specific MDC)

(a) ± 2 standard deviations

(b) FD = Field duplicate

(c) Not applicable: tritium is not measured in samples which do not contain water

The majority of samples had radionuclide concentrations above their MDC (Table 4-6). While tritium concentrations in tunnel effluent were elevated, they were about 29 percent lower than the limit allowed under permit NEV 96021 for that discharge system (Table 4-5). Tritium was found in all pond inlet and pond water samples at concentrations slightly lower than the previous two years' samples (Figure 4-11). Most pond water samples had tritium concentrations very close to those in tunnel effluent, but there have been measurements of tritium in pond water much lower than the tunnel effluents (Figure 4-11). This is likely due to precipitation events that dilute the original tritium concentrations. Concentrations of ^{90}Sr, ^{137}Cs, plutonium, and ^{241}Am were at levels comparable with the past two years. Uranium was not detected in samples collected during 2004.

Due to the elevated concentrations of radionuclides in the E Tunnel containment ponds, the ponds are fenced and posted with radiological warning signs. Given that the ponds are available to wildlife, animals are also sampled under RREMP monitoring to assess potential radiological doses to wildlife and to humans consuming game animals (see Section 7.0 and Section 8.0).

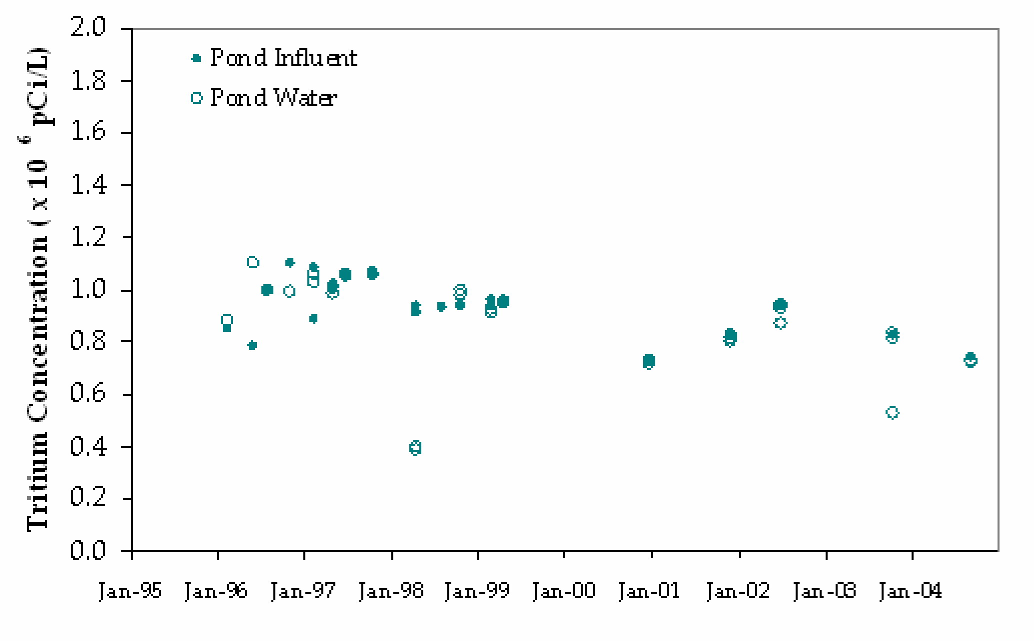

Figure 4-11. Tritium concentration in E Tunnel Ponds from 1995 – 2004

4.1.9 Results from NTS Sewage Lagoons

Each sewage lagoon at the NTS is part of a closed system used for the evaporative treatment of sanitary sewage. Sewage storage and treatment at the NTS has transitioned from lagoons to septic systems at several locations in recent years. Two permitted sewage lagoons remain: Area 6 Yucca and Area 23 Mercury (A23) (see Figure 4-3). The permits for these lagoons do not require that the water or sediments be monitored for radioactivity (see Section 4.2.4). However, to more completely demonstrate the proper management of effluents on the NTS, limited radiological analyses are conducted for these lagoons under the RREMP (DOE, 2003b).

The lagoon water samples were analyzed for tritium using standard (un-enriched) analyses and by gamma spectroscopy for other radionuclides. No tritium was detected at concentrations above MDCs in the lagoon water samples (Table 4-7) and no man-made gamma-emitting radionuclides were detected.

Table 4-7. Tritium water monitoring results for NTS sewage lagoons in 2004

Monitoring Location	Date Sampled	^{3}H ± Uncertainty[(a)] (MDC) (pCi/L)			
Area 23 Mercury	1/13/2004	-115	±	172	(290)
	4/6/2004	134	±	166	(278)
	7/7/2004	-27	±	197	(358)
	10/26/2004	-29	±	121	(210)
Area 6 Yucca	1/13/2004	-98.1	±	172	(290)
	4/6/2004	42.1	±	165	(292)
	7/7/2004	-124	±	185	(352)
	10/26/2004	-119	±	118	(214)

(a) ± 2 standard deviations

4.1.10 UGTA Wells

The UGTA Project took custody of one new well drilled in 2004, U-19ad PS#1A. Groundwater from eight UGTA Project wells was sampled and analyzed in 2004 (Figure 4-12). A multi-agency team consisting of personnel from Stoller-Navarro Joint Venture (SNJV), Los Alamos National Laboratory (LANL), and LLNL collected samples at these wells using downhole sampling pumps. During sample collection, the field parameters temperature, pH, and conductivity were measured. Samples were then analyzed for selected radionuclides as well as gross alpha and gross beta. Well water data are maintained in the UGTA Project geochemical database by SNJV, Las Vegas, NV.

A tracer test for well ER-6-1 was conducted, and samples were obtained and analyzed from ER-6-1 and ER-6-1 #2 during the test. Well ER-6-2 was developed, tested, and sampled in 2004. Water samples from all of these UGTA wells contained no detectible tritium or man-made radionuclides.

Well RNM #1 was pumped and sampled in 2004. Analysis results are pending.

The UGTA Project sampled four post-shot/cavity wells (“Hot Wells”) in 2004: U-3cn PS#2A; U-19ad PS#1A; ER-20-5 #1; and ER-20-5 #3 (Figure 4-12). The first two wells access test cavities from underground nuclear tests BILBY and CHANCELLOR, respectively. The two ER-20-5 wells were drilled near the TYBO test. Preliminary results show expected levels of radionuclides for post-shot wells. Sample tritium concentrations ranged from 113,000 pCi/L to 38,000,000 pCi/L (Table 4-8). Final laboratory analytical results for these wells are pending.

The results of well sampling will support the NNSA’s continuing efforts to create a long-term monitoring program for wells in or near underground nuclear test cavities. The program objectives are to characterize the hydrologic source term and to evaluate the decay and potential migration of radionuclides through monitoring at or near the source.

Table 4-8. Tritium concentrations in UGTA hot wells sampled in 2004

Sump Water Source	^{3}H (pCi/L)
ER-20-5 #1	38,000,000
ER-20-5 #3	113,000
U-3cn PS #2A	7,900,000
U-19ad PS #1A	22,000,000

Source: Eaton, 2005 (personal communication)

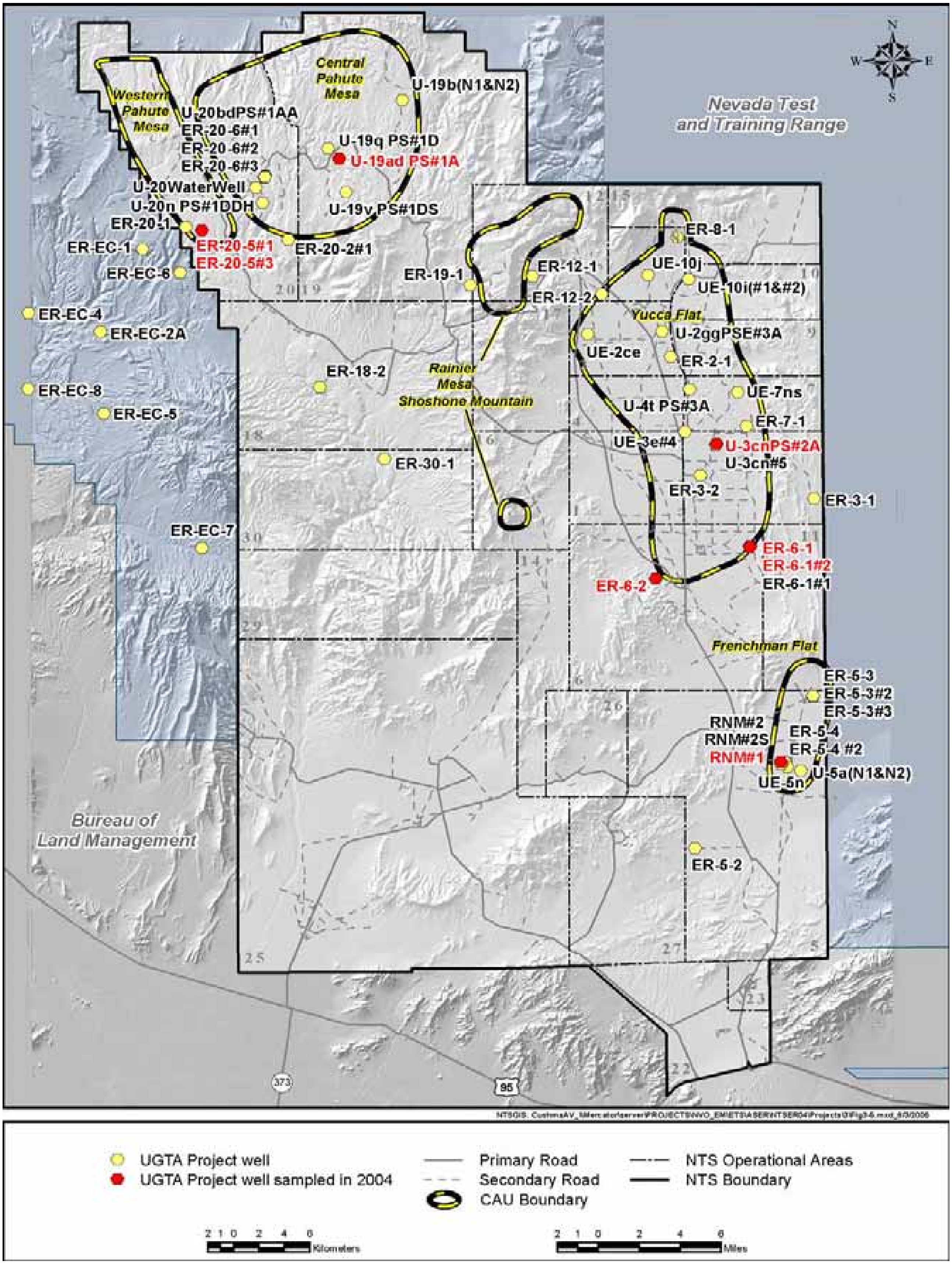

Figure 4-12. UGTA Project wells on and off the NTS

4.1.11 Environmental Impact

The tritium data provide no evidence that radionuclides have traveled significant distances from underground testing areas, much less to offsite water supply wells. Where detectable tritium was found in a well sample, it was often at concentrations very near its MDC and at levels not consistently detectable in samples taken from the same well at the same time or later in the year. All but one sample from offsite wells and springs had tritium levels below detectable levels. The one exception came from monitoring well PM-3, for which a duplicate sample taken at the same time in the same sample run had a tritium concentration below detectable levels.

Four samples from NTS potable supply wells had tritium levels above their MDCs, but subsequent quarterly samples from the same wells were below their MDCs.

The onsite monitoring wells UE5 PW-1, UE5 PW-2, and UE5 PW-3 had tritium levels above their MDC in single samples, but duplicate samples taken at the same time had tritium levels below their MDCs.

Groundwater from NTS monitoring wells PM-1, U-19BH, UE-7NS, and WW A also had detectable levels of tritium in 2004. These wells, however, have histories of consistently detectable tritium levels and are in close proximity to underground tests.

No man-made radionuclides were detected in any wells, whether or not detectable tritium was measured. Most groundwater samples had gross alpha and beta levels above detection limits, but below the EPA limits for drinking water. The samples from the offsite monitoring well ER-OV-02 exceeded the gross alpha drinking water standard; this is attributed to the decay of naturally occurring radioactive elements particularly in volcanic host rock. The samples from U-19BH exceeded the gross alpha and gross beta drinking water limits, and this well is in close proximity to underground tests. Neither of these two monitoring wells supply drinking water.

4.2 Non-Radiological Drinking Water and Wastewater Monitoring

The quality of drinking water and wastewater on the NTS 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. BN is tasked with ensuring that such systems meet the applicable water quality standards and permit requirements (see Section 2.2). The NTS non-radiological water monitoring goals are shown below. BN ES personnel meet these goals by conducting field water sampling and analyses, performing assessments, and maintaining documentation. The major compliance measures/actions that BN ES personnel monitor/perform on the NTS are also shown below. This section describes the results of 2004 monitoring. Radiological monitoring of drinking water on and off the NTS was presented in the preceding Sections 4.1.4 and 4.1.6.

Non-Radiological Water Monitoring Goals	*Compliance Measures/Actions*
Ensure that the operation of NTS public water systems (PWS) and private water systems provide high quality drinking water to workers and visitors of the NTS	Number of PWS samples containing coliform bacteria
Determine if NTS PWS are operated in accordance with the requirements in Nevada Administrative Code (NAC) 445A under permits issued by the state	Concentration of nitrates, organic contaminants, Phase V inorganic contaminants, secondary standards, and disinfection byproducts in PWS samples
Determine if the operation of commercial septic systems to process domestic wastewater on the NTS meets operational standards in accordance with the requirements NAC 445A under permits issued by the state	Measurements of 5-day Biological Oxygen Demand (BOD), total suspended solids (TSS), and pH in sewage lagoon water
	Inspection of sewage lagoon systems
Determine if the operation of industrial wastewater systems on the NTS meets operational standards of federal and state regulations as prescribed under the GNEV93001 state permit	pH and concentration of 18 contaminants in water from groundwater monitoring well SM-23-1
	Concentrations of 16 contaminants/water quality parameters in E Tunnel effluent water

4.2.1 Drinking Water Monitoring

Nine permitted wells supply the potable water needs of NTS operations (Figure 4-13); these are grouped into three PWSs (Figure 4-13) that are operated by BN for NNSA/NSO. The PWSs are operated in accordance with the requirements in NAC 445A under permits issued by the Nevada State Health Division, Bureau of Health Protection Services (BHPS), which are renewed annually. There are also four private water systems which are not subject to NAC 445A.

4.2.1.1 Water Quality of PWS and Permitted Water Hauling Trucks

The three PWS must meet water quality standards for National Primary and Secondary Drinking Water Standards. The PWS must also meet other standards and conditions listed in the regulations relating to design, operation, and maintenance. For work locations at the NTS that are not part of a public water system, NNSA/NSO hauls potable water for use in decontamination and sanitation. The NTS uses two water tanker trucks, which are permitted by the BHPS to haul water to a public water system. Normal use of these trucks involves hauling to private water systems and to hand-washing stations at construction sites, activities which are not subject to permitting. NNSA/NSO,

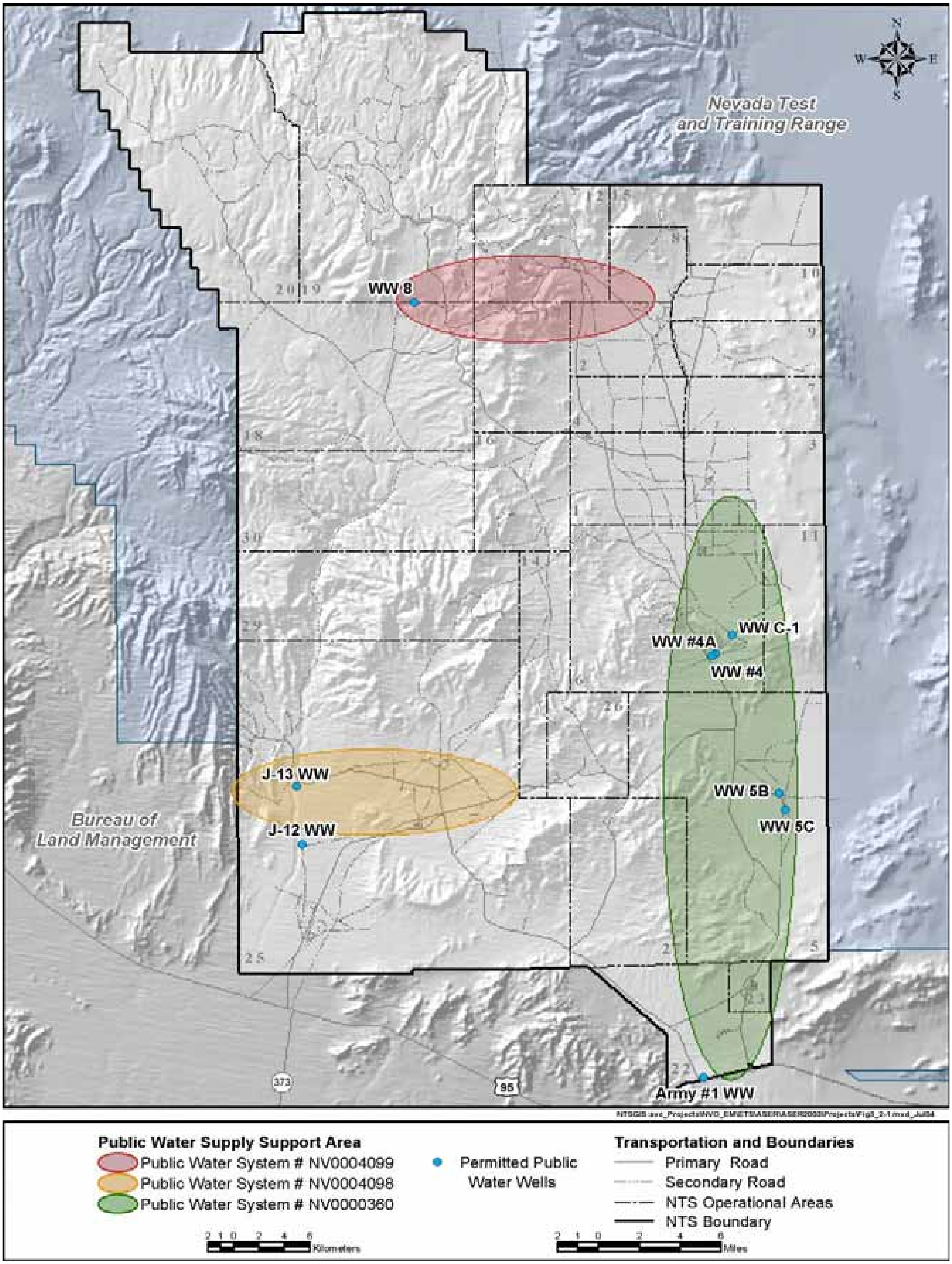

Figure 4-13. Drinking water systems on the NTS

however, retains the permits in case of emergency. These permits are also renewed annually. The two permitted potable water hauling trucks are subject to water quality standards for coliform bacteria. Table 4-9 lists the water quality parameters monitored in 2004, sample frequencies, and sample locations. The largest PWS (Area 23 and 6) serves the main work areas of the NTS. It was monitored monthly for coliform bacteria at seven locations approved by the BHPS within the distribution systems. The two smaller systems (Area 12 and Area 25) were monitored quarterly for coliform bacteria. At all building locations, the sampling point for coliform bacteria is one of the sinks within one of the building's bathrooms. Monitoring for other contaminants took place at the six points of entry to the PWSs. Although not required by regulation or permit, the private water systems were monitored quarterly for coliform bacteria to ensure safe drinking water. All potable water hauling trucks were monitored monthly for coliform bacteria.

All water samples were collected in accordance with accepted practices and the analyses were performed by state-approved laboratories. Approved analytical methods listed in NAC 445A and Title 40 Code of Federal Regulations (CFR) 141 were used by the laboratories.

Table 4-9 Water quality monitoring parameters and sampling design for NTS public drinking water systems

PWS	Contaminant	2004 Monitoring Requirement	Monitoring Locations
Area 23 and 6	Coliform Bacteria	36 samples (3/month)	Buildings 5-7, 6-624, 6-900, 22-1, 23-710, 23-777, 23-1103
	Nitrates	4 samples (1/entry point)	Entry points (Army Well Tank, Mercury Tank, 4/4a Tank, C-1 Wellhead)
	Organic Contaminants	4 samples (1/entry point)	Entry points (Army Well Tank, Mercury Tank, 4/4a Tank, C-1 Wellhead)
	Phase V Inorganic Contaminants	4 samples (1/entry point)	Entry points (Army Well Tank, Mercury Tank, 4/4a Tank, C-1 Wellhead)
	Disinfection By-Products	3 samples	Buildings 6-900, 22-1, and 180
	Secondary Standards	4 samples (1/entry point)	Entry points (Army Well Tank, Mercury Tank, 4/4a Tank, C-1 Wellhead)
Area 12	Coliform Bacteria	4 samples (1/quarter)	Building 12-45
	Nitrates	1 sample	Entry point (Area 12 Tank)
	Organic Contaminants	1 sample	Entry point (Area 12 Tank)
	Disinfection By-Products	1 sample	Building 12-30
	Secondary Standards	1 sample	Entry point (Area 12 Tank)
	Lead and Copper	5 samples	Buildings 12-23, 12-31, 12-35, 12-30, 12-928
Area 25	Coliform Bacteria	4 samples (1/quarter)	Building 25-4320
	Nitrates	1 sample	Entry point (J-11 Tank)
	Organic Contaminants	1 sample	Entry Point (J-11 Tank)
	Phase V Inorganic Contaminants	1 sample	Entry Point (J-11 Tank)
	Disinfection By-Products	1 sample	Building 4320
	Secondary Standards	1 sample	Entry Point (J-11 Tank)
	Fluoride	2 samples (1/well)	Well J-12, Well J-13
Water Hauling Truck 84846	Coliform Bacteria	12 samples (1/month)	From water tank on truck after filling at Area 6 potable water fill stand
Water Hauling Truck 84847	Coliform Bacteria	12 samples (1/month)	From water tank on truck after filling at Area 6 potable water fill stand

In 2004, monitoring results indicated that the PWS and the permitted water hauling trucks complied with National Primary Drinking Water Quality Standards (Table 4-10). Two of the water systems slightly exceeded a Secondary Standard for pH. State of Nevada regulations do not include notification requirements for exceeding the pH standard.

Table 4-10. Water quality analysis results for NTS public drinking water systems in 2004

Contaminant	Maximum Contaminant Level (mg/L)	Results (mg/L) Area 23 and 6 PWS [(a)]	Area 12 PWS	Area 25 PWS
Coliform Bacteria [(b)]	Coliforms present in 1 sample/month	Absent in all samples	Absent in all samples	Absent in all samples
Nitrates	10	BDL[(c)] - 4.3	1.4	2
Organic Contaminants				
Vinyl chloride	0.0002	BDL	BDL	BDL
Benzene	0.005	BDL	BDL	BDL
Carbon tetrachloride	0.005	BDL	BDL	BDL
1,2-Dichloroethane	0.005	BDL	BDL	BDL
Trichloroethylene	0.005	BDL	BDL	BDL
para-Dichlorobenzene	0.075	BDL	BDL	BDL
1,1-Dichloroethylene	0.007	BDL	BDL	BDL
1,1,1-Trichloroethane	0.2	BDL	BDL	BDL
cis-1,2-Dichloroethylene	0.07	BDL	BDL	BDL
1,2-Dichloropropane	0.005	BDL	BDL	BDL
Ethylbenzene	0.7	BDL	BDL	BDL
Monochlorobenzene	0.1	BDL	BDL	BDL
o-Dichlorobenzene	0.6	BDL	BDL	BDL
Styrene	0.1	BDL	BDL	BDL
Tetrachloroethylene	0.005	BDL	BDL	BDL
Toluene	1	BDL	BDL	BDL
trans-1,2-Dichloroethylene	0.1	BDL	BDL	BDL
Xylenes (total)	10	BDL	BDL	BDL
Dichloromethane	0.005	BDL	BDL	BDL
1,2,4-Trichloro-benzene	0.07	BDL	BDL	BDL
1,1,2-Trichloro-ethane	0.005	BDL	BDL	BDL
Disinfection Byproducts				
Total Trihalomethanes: (bromodichloromethane, chloroform, dibromochloromethane, trichlorofluoromethane)	0.08	0.0066	BDL	BDL
Haloacetic Acids (HAA5): (monochloroacetic acid, dichloroacetic acid, trichloroacetic acid, mono-bromoacetic acid, dibromoacetic acid)	0.06	0.0011	BDL	BDL

Table 4-10. (continued)

Contaminant	Maximum Contaminant Level (mg/L)	Results (mg/L) Area 23 and 6 PWS (a)	Results (mg/L) Area 12 PWS	Results (mg/L) Area 25 PWS
Phase V Inorganic Contaminants				
Antimony	0.006	BDL	BDL	BDL
Beryllium	0.004	BDL	0.00029	BDL
Nickel	None	1.5 - 7.0(b)	BDL	2.4
Thallium	0.002	BDL	BDL	BDL
Cyanide	0.2	BDL	BDL	BDL
Secondary Standards				
Copper	1.0	<0.001 - 0.022	0.002	<1.0
Iron	0.3	<0.02 - 0.25	0.167	0.16
Magnesium	125.5	8.0 - 24.0	1.04	1.2
Manganese	0.05	<0.00002 - 0.0036	0.00008	0.0043
Zinc	5.0	<0.00005 - 0.0062	0.00001	<0.005
Fluoride	2.0	0.9 - 1.0	0.89	1.9
Chloride	250.0	11.0 - 23.0	9.4	6.8
Sulfate	250.0	24.0 - 40.0	15.3	21
pH	6.5 - 8.5	7.68 - 8.73	7.84	8.52
Color	15.0 color units	< 5.0 color units	3 color units	<5.0
Odor	3.0 threshold odor number	< 1.0 odor number	ND	<1.0
TDS	500	300 - 380	150	230
Foaming Agents	0.05	ND	ND	ND
Lead (Area 12 PWS only)	0.015	NA(d)	0.0085	NA
Copper (Area 12 PWS only)	1.3	NA	0.062	NA
Fluoride (Area 25 PWS only)	4.0	NA	NA	1.8 - 2.4

Highlighted cells indicate those water quality results which exceeded maximum contaminant levels

(a) Coliform bacteria were not present in any samples collected from Water Hauling Trucks 84846 and 84847 nor from the following private water systems: JASPER Compound, U3ah/at Complex, Area 6 Weather Station, and G Tunnel Office

(b) Multiple samples analyzed at Area 23 and 6 PWS throughout year. Results show lowest and highest concentration of contaminant among samples analyzed.

(c) BDL = below detection limits

(d) NA = Not applicable

4.2.1.2 *Sanitary Survey of PWS and Inspection of Permitted Water Hauling Trucks*

The BHPS conducts a periodic sanitary survey of the permitted PWS. A sanitary survey consists of an inspection of the wells, tanks, and other visible portions of the PWS to ensure that they are maintained in a sanitary configuration. As non-community water systems, the minimum survey frequency for a sanitary survey is five years. The BHPS has been performing the survey more frequently, however. The BHPS inspects the two water hauling trucks annually at the time of permit renewal to make sure they still meet the requirements of NAC 445A.

The BHPS did not conduct a sanitary survey of the PWS in 2004. Their last sanitary survey took place in 2002. BHPS conducted an annual inspection of the permitted water hauling trucks at the time of permit renewal; no findings were noted.

4.2.2 Domestic Wastewater Monitoring

To obtain a permit for a proposed new NTS septic system, an assessment is conducted to ensure that the sources producing discharges are domestic in nature. BN and the Nevada State Health Division conduct this assessment. After the design of a new system is completed, a permit package is submitted through NNSA/NSO to the BHPS. Subsequent to state approval, a "permit to construct" is issued. At the completion of construction, the state conducts a final inspection. Upon approval, the state issues a "permit to operate."

Existing septic systems that are not permitted may be permitted by submitting a narrative describing facility operations, flow test results, tank and leach field sizing, engineering drawings, personnel numbers, existing flow (volume) information, and a fixture count. The application is reviewed by the state and an onsite inspection is conducted by BHPS. Approval results in the issuance of a "permit to operate."

There are seven active septic systems being used in place of inactive lagoons on the NTS (Figure 4-14). These are inspected periodically by BN for sediment loading and are pumped as required. A state permitted septic pumping contractor is used. The state conducts onsite inspections of pumper trucks and pumping contractor operations.

BN personnel perform management assessments of permitted facilities and services to determine and document adherence to permit conditions. The assessments are performed according to existing directives and procedures.

In 2004, the following compliance actions relating to domestic wastewater on the NTS occurred:

- Three new septic systems were permitted at the NTS. These include one for Area 12 Building 910 (Permit NY-1110-HAA-A), one for the U1a Complex (Permit NY-1112), and one for Area 1 Building 121 (Permit NY-1113).
- Septic System design was initiated for Area 1 Phoenix Complex. This new design will utilize an aerobic treatment process and disposal through an underground drip system. The final permit package submittal will be completed in 2005.
- A septic tank pumping contractor permit (NY-17-03318), 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 December 2004.

4.2.3 Industrial Wastewater Monitoring

Industrial discharges on the NTS were limited to two operating sewage lagoon systems in 2004: Area 6 Yucca Lake and Area 23 Mercury (these lagoon systems also receive domestic wastewater) (Figure 4-14). The Area 6 Yucca Lake system consists of two primary lagoons and two secondary lagoons. All lagoons in this system are lined using compacted native soils that meet the state requirements for transmissivity (10^{-7}cm/sec). This system is monitored quarterly for influent quality and annually for influent toxicity.

The Area 23 Mercury system consists of one primary lagoon and three infiltration basins. All lagoons in this system are unlined, and groundwater well SM-23-1 is monitored for this system. Monitoring is conducted quarterly for influent quality and annually for influent toxicity and groundwater contamination.

The locations where water samples were collected for analysis within each sewage system include:

- Each influent headwork for systems where there is direct access to influent flows
- Each pond near the lagoon's inlet for systems where there is no direct access to influent flows
- Each infiltration basin at a place where a sample most closely representing the infiltrating waste water can be collected
- Each groundwater monitoring well or alternative monitoring device

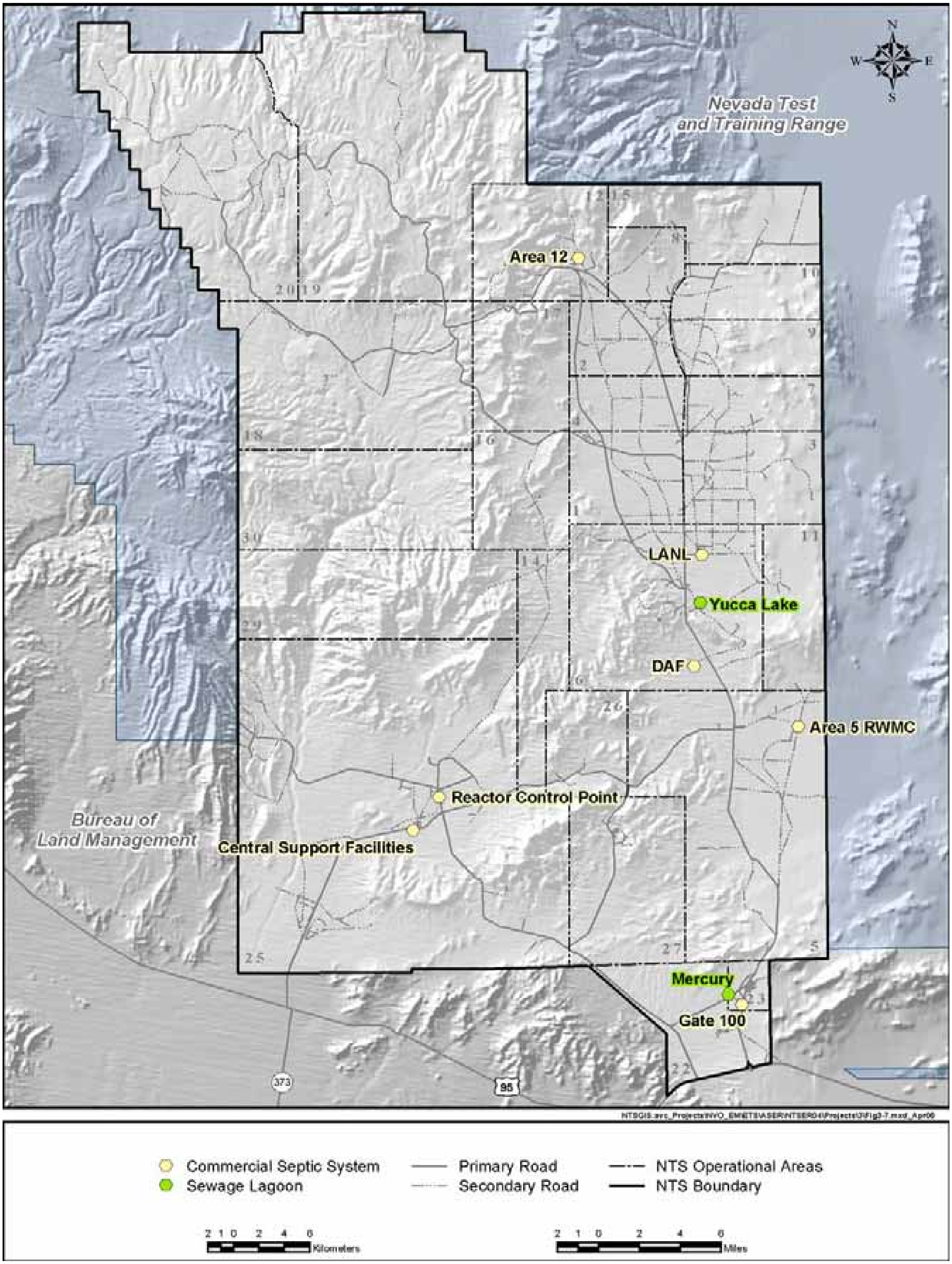

Figure 4-14. Active permitted sewage disposal systems on the NTS

Composite samples are flow-weighted (10 hours) at the Area 6 Yucca Lake and Area 23 Mercury systems; these systems are equipped with an ultrasonic flow meter for this purpose.

All water samples were collected in accordance with accepted practices, and the analyses were performed by state-approved laboratories. Approved analytical methods listed in NAC 445A and Title 40 CFR 141 were used by the laboratories.

In 2004, the Water Pollution Control General Permit GNEV93001 expiration date was extended from December 7, 2004 to May 7, 2005. This extension was granted to allow completion of a project at the Area 23 Mercury sewage lagoons. That project, which began in 2004 and will be completed in 2005, was to combine the primary lagoon and the first installation basin. This project will also install a geosynthetic clay liner and high-density polyethylene liner to convert the primary lagoon to total containment. Once this project is complete, a new permit will be issued that will have reduced monitoring requirements and no longer require the sampling of well SM-23-1.

4.2.3.1 *Quarterly Analysis of Influent Water Quality*

A composite sample from each influent headwork was collected quarterly. The composite sample was analyzed for three parameters: 5-day biological oxygen demand (BOD_5), total suspended solids (TSS), and pH (Table 4-11). The compliance limits for these parameters, established under Water Pollution Control General Permit GNEV93001, are shown in Table 4-11. All quarterly monitoring results for BOD_5, TSS, and pH for sewage system influent waters were within permit limits in 2004.

Table 4-11. Water quality analysis results for NTS sewage lagoon influent waters in 2004

		Minimum and Maximum Values from Quarterly Samples	
Parameter	**Units**	**Area 6 Yucca**	**Area 23 Mercury**
BOD_5	mg/L	45.3 - 190	42.5 - 86
BOD_5 Permit Limit		No Limit	No Limit
BOD_5 Mean Daily Load [(a)]	kg/d	1.50 – 7.16	9.32 – 16.32
BOD_5 Mean Daily Load Limit		8.66	172
TSS	mg/L	99.5 - 320	57.9 - 161
TSS Permit Limit		No Limit	No Limit
pH	S.U.	7.93 – 8.61	7.20 – 8.12
pH Permit Limit		6.0 – 9.0	6.0 – 9.0

(a) BOD 5 Mean Daily Load in kg/d = (mg/L BOD x L/d Average Flow x 3.785)/10^6.

4.2.3.2 *Annual Analysis of Toxicity of Sewage Lagoon Pond Waters*

A grab sample from the Area 23 Mercury primary lagoon and an equal-volume composite sample from the two Area 6 Yucca Lake primary lagoons were collected in April.

Each grab and composite sample was filtered, the solids discarded, and the filtrate analyzed directly, using methods of analysis cited in EPA Publication SW-846. Each sample was analyzed for those contaminants listed in Table 4-12. The limits for these contaminants are also specified under state permit; they are the same limits specified in 40 CFR 261.24, Table 1, Maximum Concentration of Contaminants for the Toxicity Characteristic. Annual monitoring of Area 6 Yucca Lake and Area 23 Mercury sewage lagoon waters adjacent to lagoon inlets showed that no contaminants exceeded permit limits (Table 4-12).

Table 4-12. Water toxicity analysis results for NTS sewage lagoon pond water in 2004

Contaminant	Limit[a] (mg/L)	Area 6 Yucca (mg/L)	Area 23 Mercury (mg/L)
Benzene	0.5	< 0.005	< 0.005
Carbon Tetrachloride	0.5	< 0.005	< 0.005
Chlordane	0.03	< 0.0001	< 0.0001
Chlorobenzene	100	< 0.005	< 0.005
Chloroform	6.0	< 0.005	< 0.005
Cresol (Total)	200	0.15	< 0.050
2,4-D	10	0.0016	0.0014
1,4-Dichlorobenzene	7.5	0.005	< 0.050
1,2-Dichloroethane	0.5	< 0.005	< 0.005
1,1-Dichlorethylene	0.7	< 0.005	< 0.005
2,4-Dinitrotoluene	0.13	< 0.050	< 0.050
Endrin	0.02	< 0.0001	< 0.0001
Heptachlor	0.008	< 0.0001	< 0.0001
Hexachlorobenzene	0.13	< 0.050	< 0.050
Hexachlorobutadiene	0.5	< 0.050	< 0.050
Hexachloroethane	3.0	< 0.050	< 0.050
Lindane	0.4	< 0.0001	< 0.0001
Methoxychlor	10	< 0.0005	< 0.0005
Methylethyl Ketone	200	< 0.010	< 0.010
Nitrobenzene	2.0	0.012	< 0.050
Pentachlorophenol	100	< 0.250	< 0.012
Pyridine	5.0	< 0.100	< 0.050
Tetrachloroethylene	0.7	< 0.005	< 0.005
Toxaphene	0.5	< 0.005	< 0.005
Trichloroethylene	0.5	< 0.005	< 0.005
2,4,5-Trichlorophenol	400	< 0.250	< 0.120
2,4,6-Trichlorophenol	2.0	0.005	< 0.050
2,4,5-TP (Silvex)	1.0	0.00057	0.0008
Vinyl Chloride	0.2	< 0.010	< 0.010
Arsenic	5.0	0.0052	0.0175
Barium	100	0.0223	0.0568
Cadmium	1.0	< 0.0004	< 0.0004
Chromium	5.0	0.0017	0.0085
Lead	5.0	< 0.002	< 0.002
Mercury	0.2	< 0.0001	< 0.0001
Selenium	1.0	< 0.0034	< 0.0034
Silver	5.0	< 0.0006	< 0.0006

(a) Source: 40 CFR 261.24, Table 1

4.2.3.3 *Annual Analysis of Groundwater Monitoring Wells Associated With Sewage Lagoons*

The Area 23 Mercury lagoons are the only lagoons required to have groundwater monitoring, because the lagoons and infiltration basins there are unlined. Since they are unlined, the mode of disposal is evaporation/infiltration. The monitoring well (SM-23-1) is sampled annually; the sample is analyzed for those contaminants/parameters listed in Table 4-13. The compliance limits are those prescribed under the Nevada Drinking Water Standards (NDWS). In 2004, samples were collected in the second quarter; no concentration limits were exceeded (Table 4-13).

Table 4-13. Groundwater analysis results for NTS groundwater monitoring well SM-23-1 in 2004

Contaminant/Parameter	NDWS Limit [(a)]	Results
	pCi/L ± Uncertainty[(b)]	
Adjusted Gross Alpha	15	5.2 ± 1.33
Gross Beta/photon emitter	50	5.8 ± 1.07
Tritium	20,000	764 ± 267[(c)]
	mg/L	
Arsenic	0.05	0.0137
Cadmium	0.005	< 0.0004
Chloride	400	103
Chromium	0.1	0.0035
Copper	1.3	< 0.0012
Fluoride	4	1.1
Iron	0.6	0.0195
Lead	0.015	< 0.0020
Magnesium	150	26.5
Manganese	0.1	0.0007
Mercury	0.002	< 0.0001
Nitrate (Nitrogen)	10	5.8
pH (Hydrogen Ion Activity)	6.5 – 8.5 SU	7.44
Selenium	0.05	0.0036
Sulfate	500	103
Zinc	5	< 0.0004

(a) Source: NDWS (NAC 445A.144)
(b) ± 2 standard deviations
(c) Results of un-enriched tritium analyses from General Engineering Laboratories. This value differs from the enriched tritium analysis result of -13 ± 12 pCi/L (see Table 4-4) from Sanford, Cohen, and Associates Laboratory.

4.2.3.4 *Sewage System Inspections*

The sewage system operators inspect active systems weekly and inactive lagoon systems quarterly. State inspections of active and inactive lagoon systems are conducted annually. Operators 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.

In 2004, there was one notable inspection finding at each active lagoon. Each lagoon had problems related to the flow meters located at the influent headworks. The problems were investigated and determined to be caused by several electrical storms that caused power outages at the NTS during the month of September.

NDEP conducted an annual inspection of active and inactive sewage lagoon systems on April 27 and 28, 2004. The inspection found no problems with the field maintenance program in keeping the lagoons, sites, and access roads functional.

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5.0 Direct Radiation Monitoring

U.S. Department of Energy (DOE) Order 5400.5 *Radiation Protection of the Public and the Environment* and DOE Order 435.1 *Radioactive Waste Management* have requirements to protect the public and environment from exposure to radiation (see Section 2.3). Energy from radionuclides present in the Nevada Test Site (NTS) environment could potentially be deposited inside humans and animals through inhalation and ingestion. Section 3.1 and Section 4.1 present the results of monitoring radionuclides in air and water on the NTS. Monitoring results are used to estimate internal radiation dose to the public via inhalation and ingestion. Energy absorbed from radioactive materials residing outside the body results in an external dose. External dose is measured under the Direct Radiation Monitoring Program of Bechtel Nevada (BN) Environmental Technical Services (ETS). This section presents the results of monitoring direct ionizing radiation on the NTS from all sources, including natural radioactivity from cosmic or terrestrial sources and from man-made radioactive sources. These data are then used to document and trend gamma radiation exposure rates on the NTS.

Direct radiation monitoring is conducted to assess the state of the external radiation environment, detect changes in that environment, and measure gamma radiation levels near potential exposure sites. DOE Order 450.1 *Environmental Protection Program* states that environmental monitoring should be conducted to detect, characterize, and respond to releases from DOE activities, assess impacts, and estimate dispersal patterns in the environment. In addition, DOE Order 5400.5 states that "it is also an objective that potential exposures to members of the public be as low as is reasonably achievable (ALARA)". The specific goals for the direct radiation monitoring program are shown below.

Direct Radiation Monitoring Program Goals
Assess the proportion of dose to the public which comes from background radiation versus NTS operations
Measure the potential external dose to a member of the public in order to determine if the total dose (internal and external) exceeds 100 millirem per year (mrem/yr) (1 millisievert [mSv]/yr), the dose limit of DOE Order 5400.5
Determine if radiation levels from the Radioactive Waste Management Complex (RWMC) are likely to result in a dose exceeding the 25 mrem/yr (0.25 mSv/yr) dose limit to members of the public as specified in DOE M 435.1-1
Monitor operational activities involving radioactive material, radiation-generating devices, or accidental releases of radioactive material to ensure exposure to members of the public are kept ALARA as stated in DOE Order 5400.5
Determine if the absorbed radiation dose from external radiation exposure to NTS terrestrial plants and aquatic animals is less than 1 rad/day (0.01 Gy/day), and if the absorbed radiation dose to NTS terrestrial animals is less than 0.1 rad/day (1mGy/day) (limits prescribed by DOE Order 5400.5 and DOE Standard DOE-STD-1153-2002)
Determine the exposure rates through time at various soil contamination areas to fulfill the requirements of DOE Order 450.1 to characterize releases in the environment

An oversight monitoring program has been established by the NNSA/NSO to independently monitor direct radiation within communities adjacent to the NTS. This independent oversight is provided through the Community Environmental Monitoring Program (CEMP) and managed by the Desert Research Institute (DRI). DRI's 2004 direct radiation monitoring results are presented in Sections 6.1.2 and 6.1.3.

5.1 Measurement of Direct Radiation

The measure of direct radiation is exposure to electromagnetic (i.e., gamma and X-ray) radiation. Electromagnetic radiation is able to travel long distances through air and to penetrate living tissue causing ionizations within the tissues of the body. In contrast, alpha and weak beta particles do not travel far in air (a few centimeters for alpha and about 10 m (32.8 ft) for beta particles). Alpha particles only deposit negligible energy externally; they rarely penetrate the outer dead layer of skin. Beta particles are generally absorbed in the immediate layers of skin below the outer layer.

Direct radiation exposure is usually measured in the unit milliroentgen (mR), which is a measure of *exposure* in terms of a specified number of ionizations in air. Generally, the *dose* resulting from an exposure from the most common external radionuclides can be approximated by equating a 1 mR exposure with a 1 mrem (0.01 mSv) dose.

5.2 TLD Surveillance Network Design

Monitoring occurs at certain NTS areas which have elevated radiation levels as a result of one or more of the following: (1) historical weapons testing, (2) current and past radioactive waste management activities, and (3) current operational activities that involve radioactive material or radiation-generating devices. A surveillance network of thermoluminescent dosimeter (TLD) sampling locations has been established on the NTS. The objectives and design of the network are described in detail in the *Routine Radiological Environmental Monitoring Plan* (RREMP) (DOE, 2003b). For more details on sampling and analysis methods, the reader is encouraged to refer to the RREMP.

TLDs are used to measure ionizing radiation exposure from all sources, including natural and man-made radioactivity. The TLD used is the Panasonic UD-814AS, consisting of four elements housed in an air-tight, water-tight, ultraviolet-light-protected case. A slightly shielded lithium borate element is used to check low-energy radiation levels. The average of three calcium sulfate elements is used to measure penetrating gamma radiation.

A pair of TLDs is placed at 1 ± 0.3 m (28 to 51 in) above the ground surface at each monitoring location and is exchanged for analysis quarterly. The quarterly analysis of TLDs is performed using automated TLD readers that are calibrated and maintained by the BN Radiological Control Department (RCD). Reference TLDs are exposed to 100 mR from a ^{137}Cs radiation source under very controlled conditions and are read with TLDs collected from the environment to scale their response.

In 2004 there were a total of 107 active environmental TLD locations on the NTS (Figure 5-1). They include the following numbers and types of locations:

- Background (B) – 8 locations where radiation effects from NTS operations are negligible.
- Environmental 1 (E1) – 42 locations where there is no measurable added radioactivity from past operations but where the locations are of interest due to either (1) the presence of personnel or the public in the area or (2) the potential for receiving radiation exposure from a current operation.
- Environmental 2 (E2) – 35 locations where there is measurable added radioactivity from past operations and the locations are of interest due to (1) the potential for personnel to be in the area and (2) the need to monitor trends in exposure rates in the area, excluding locations in the WO category below.
- Waste Operations (WO) – 16 locations in and around the RWMSs in Areas 3 and 5.
- Control (C) – 6 locations in two buildings in Mercury. Control TLDs are kept in a stable environment and are used as a quality check of TLDs and the analysis process.

5.2.1 Data Quality

Quality Assurance and Quality Control (QA/QC) protocols, including Data Quality Objectives, have been developed and are maintained as essential elements of direct radiation monitoring as directed by the RREMP. 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. Agreement between the results provided by the paired TLDs at each location was very good, with an average relative percent difference between measurements of 3.0 percent for 2004. Quarterly results from Control TLDs were not significantly different from those of previous years and exhibited a coefficient of variation between quarters ranging from 1 to 7 percent. This is a measure of the inherent variation associated with the TLD sampling process. The RCD maintains certification through the U.S. Department of Energy Laboratory Accreditation Program for dosimetry.

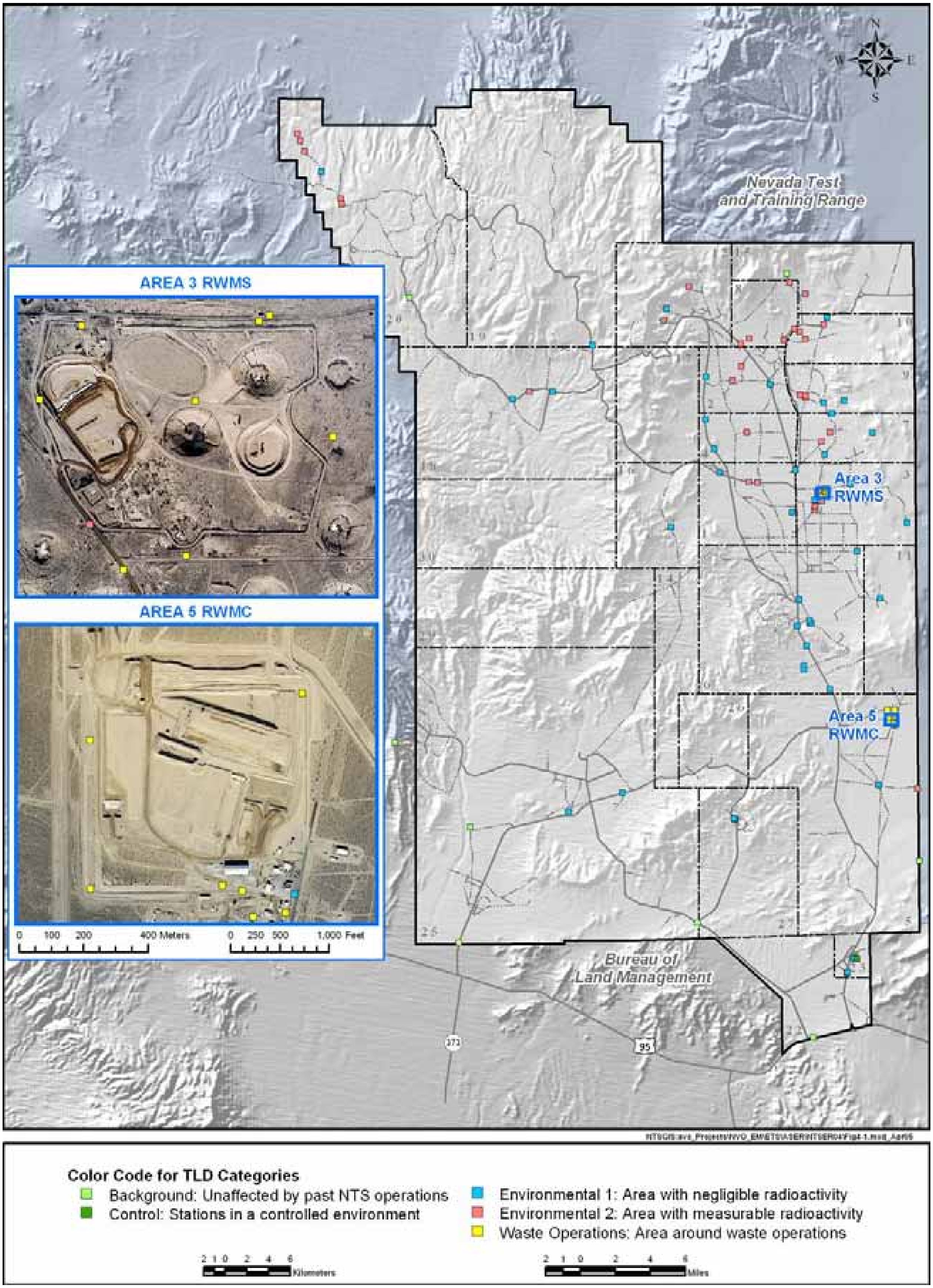

Figure 5-1. Location of TLDs on the NTS

5.2.2 Data Reporting

Direct radiation is reported as exposure per unit of time. TLD analysis results are maintained in a database as mR per day (mR/d), calculated by dividing the average mR exposure per quarter for each paired TLD by the number of days in the quarter. Annual exposures are also reported to determine compliance with the federal annual direct radiation exposure limits. Mean annual exposure (mR/yr) at each location is estimated by averaging the four quarterly estimates. An estimate of average daily exposures can be calculated by dividing the results reported in Table 5-1 and Table 5-2 by 366.

5.3 Results

Annual exposures for all TLD locations are summarized in Table 5-1 and Table 5-2. There were eight background TLD locations on the NTS. During 2004, the estimated average annual exposure at the background locations was 110 mR/yr and ranged from 60 to 156 mR/yr (0.16 to0.43 mR/d) (Table 5-2). For comparison, the CEMP measured the average annual exposure in Las Vegas, Nevada as 100 mR/yr during 2004 (see Table 6-3). All values reported in the following sections include the contribution from background. Dose limits prescribed by DOE orders only apply to exposures above background levels.

Table 5-1. Annual direct radiation exposure rates measured at TLD locations on the NTS in 2003

				Estimated Annual Exposure (mR/yr)				
NTS Area	Location	Location Type[(a)]	Number of Quarterly Samples	Mean[(b)]	Median	SD[(c)]	Min[(d)]	Max[(e)]
5	3.3 Mi SE of Aggregate Pit	B	4	62	62	1	60	63
15	U-15e Substation	B	4	113	113	1	112	115
20	Stake A-118	B	4	154	154	2	152	156
22	Army #1 Water Well	B	4	84	84	1	82	85
25	Gate 25-4-P	B	4	129	129	2	127	131
25	Guard Station 510	B	3	126	126	2	124	129
25	Jackass Flats & A-27 Roads	B	4	80	80	3	76	82
25	Yucca Mountain	B	4	141	140	4	137	146
23	Bldg 652, Rm 11, Pig,	C	4	26	26	2	24	29
23	Bldg 652, Rm 11, Pig, NE	C	4	25	26	0	25	26
23	Bldg 652, Rm 11, Pig, NW	C	4	25	25	1	24	27
23	Bldg 652, Rm 11, Pig, SE	C	4	25	25	1	25	27
23	Bldg 652, Rm 11, Pig, SW	C	4	26	26	1	25	26
23	Building 650 Dosimetry	C	4	60	61	2	58	62
1	BJY	E1	4	117	118	4	112	120
1	Sandbag Storage Hut	E1	4	112	112	4	107	117
1	Stake C-2	E1	4	117	116	5	112	123
2	Stake M-140	E1	4	134	134	2	132	135
2	Stake TH-58	E1	4	93	93	3	91	97
3	LANL Trailers	E1	4	120	120	3	117	123
3	Stake OB-20	E1	4	88	87	2	85	91
3	Well ER 3-1	E1	4	124	125	4	119	127
4	Stake TH-41	E1	4	111	110	3	108	116
4	Stake TH-48	E1	4	118	118	4	114	122
5	Building 5-31	E1	4	114	114	9	105	124
5	Water Well 5B	E1	4	112	112	1	110	113

Table 5-1. (continued)

				Estimated Annual Exposure (mR/yr)				
NTS Area	Location	Location Type[(a)]	Number of Quarterly Samples	Mean[(b)]	Median	SD[(b)]	Min[(c)]	Max[(d)]
6	CP-6	E1	4	70	71	2	68	72
6	DAF East	E1	4	91	91	2	88	94
6	DAF North	E1	4	101	102	3	97	104
6	DAF South	E1	4	135	134	2	132	137
6	DAF West	E1	4	83	83	2	81	85
6	Decon Facility NW	E1	4	124	124	2	122	128
6	Decon Facility SE	E1	4	133	133	2	131	134
6	Stake OB-11.5	E1	4	130	130	3	126	133
6	Yucca Compliance	E1	4	93	94	3	89	96
6	Yucca Oil Storage	E1	4	98	98	2	96	101
7	Reitmann Seep	E1	4	125	126	4	119	128
7	Stake H-8	E1	4	128	128	4	124	132
9	Papoose Lake Road	E1	4	88	88	1	86	88
9	U-9cw South	E1	4	102	103	2	98	104
9	V & G Road Junction	E1	4	112	111	3	109	116
10	Gate 700 South	E1	4	134	134	3	131	136
11	Stake A-21	E1	4	130	131	4	124	135
12	Upper N Pond	E1	4	130	130	2	127	132
16	3545 Substation	E1	4	137	136	6	132	144
18	Stake A-83	E1	4	144	144	4	140	149
18	Stake F-11	E1	4	147	148	4	142	151
19	Stake P-41	E1	4	158	159	8	148	167
20	Stake J-41	E1	4	139	138	4	134	144
23	Gate 100 Truck Parking 1	E1	4	155	95	136	73	358
23	Gate 100 Truck Parking 2	E1	4	66	65	3	64	70
23	Mercury Fitness Track	E1	4	59	60	2	57	61
25	HENRE	E1	4	123	122	4	120	129
25	NRDS Warehouse	E1	4	123	123	3	119	126
27	Cafeteria	E1	4	110	109	3	108	114
27	JASPER-1	E1	4	113	113	2	110	116
1	Bunker 1-300	E2	4	119	121	5	111	123
1	T1	E2	4	343	336	75	266	433
2	Stake L-9	E2	4	176	176	5	170	181
2	Stake N-8	E2	4	600	601	14	582	615
3	Stake A-6.5	E2	4	140	140	3	137	143
3	T3	E2	4	403	405	12	390	414
3	T3 West	E2	4	394	396	16	374	412
3	T3A	E2	4	524	508	64	470	612
3	T3B	E2	4	500	502	9	489	507
3	U-3co North	E2	4	209	208	5	203	216
3	U-3co South	E2	3	147	148	2	144	149
4	Stake A-9	E2	4	739	739	39	704	776
5	Frenchman Lake	E2	4	411	416	19	387	427
7	Bunker 7-300	E2	4	257	255	9	248	269
7	T7	E2	4	118	118	2	117	121
8	Baneberry 1	E2	4	419	426	18	394	432
8	Road 8-02	E2	4	126	126	3	122	130
8	Stake K-25	E2	4	106	106	3	102	109

Table 5-1. (continued)

NTS Area	Location	Location Type(a)	Number of Quarterly Samples	Estimated Annual Exposure (mR/yr) Mean(b)	Median	SD(c)	Min(d)	Max(e)
8	Stake M-152	E2	4	165	166	5	159	171
9	B9A	E2	4	132	133	4	127	136
9	Bunker 9-300	E2	4	124	123	4	120	130
9	T9B	E2	4	582	586	16	558	595
10	Circle & L Roads	E2	4	122	123	5	115	126
10	SEDAN East Visitor Box	E2	4	133	132	3	130	137
10	SEDAN West	E2	4	257	257	4	252	262
10	T10	E2	4	281	281	6	275	287
12	T-Tunnel #2 Pond	E2	4	259	262	10	245	267
12	Upper Haines Lake	E2	4	108	108	2	104	110
15	EPA Farm	E2	4	111	111	3	107	113
18	JOHNNIE BOY North	E2	4	144	144	7	135	152
20	PALANQUIN	E2	4	246	248	8	235	253
20	SCHOONER-1	E2	4	863	868	25	830	888
20	SCHOONER-2	E2	4	294	294	7	284	301
20	SCHOONER-3	E2	4	139	140	5	132	144
20	Stake J-31	E2	4	174	171	6	170	183
3	A3 RWMS Center	WO	4	141	140	3	139	145
3	A3 RWMS East	WO	4	145	145	2	144	148
3	A3 RWMS North	WO	4	121	121	4	117	125
3	A3 RWMS South	WO	4	393	393	7	385	401
3	A3 RWMS West	WO	4	129	124	11	122	145
5	A5 RWMS East Gate	WO	4	135	135	9	126	143
5	A5 RWMS Expansion NE	WO	4	135	134	3	132	139
5	A5 RWMS Expansion NW	WO	4	141	141	3	137	144
5	A5 RWMS NE Corner	WO	4	122	122	4	117	126
5	A5 RWMS NW Corner	WO	4	149	124	53	120	228
5	A5 RWMS South Gate	WO	4	108	108	3	106	112
5	A5 RWMS SW Corner	WO	4	124	124	3	121	127
5	WEF East	WO	4	125	125	1	124	125
5	WEF North	WO	4	127	127	8	119	134
5	WEF South	WO	4	138	139	10	125	149
5	WEF West	WO	4	128	128	4	125	133

(a) Location types:

B = Background locations

C = Control locations

E1 = Environmental locations with exposure rates near background but monitored for potential for increased exposure rates due to NTS operations

E2 = Environmental locations with measurable radioactivity from past operations, excluding those designated "WO"

WO = Locations in or near waste operations

(b) Time weighted average

(c) Standard deviation

(d) Minimum value

(e) Maximum value

Table 5-2. Summary statistics for annual direct radiation exposure by TLD location type

Location Type	Number of Quarterly Samples	Estimated Average Annual Exposure (mR/yr) Mean	Median	SD[(a)]	Min[(b)]	Max[(c)]
Background (B)	31	110	115	31	60	156
Control (C)	24	31	26	13	24	62
Environmental 1 (E1)	168	115	117	29	57	358
Environmental 2 (E2)	139	283	210	194	102	888
Waste Operations (WO)	64	148	128	66	106	401
All Locations	**426**	**170**	**126**	**142**	**24**	**888**

(a) Standard deviation
(b) Minimum value
(c) Maximum value

5.3.1 *Potential Exposure to the Public along the NTS Boundary*

Most of the NTS is not accessible to the public; only the southern portion of the NTS boundary borders public land. Therefore, the only place the public has potential for exposure to direct radiation from the NTS is along the southern boundary.

Gate 100 is the primary entrance point to the NTS. The outer parking areas are accessible to the public. Trucks hauling radioactive materials, primarily low-level radioactive waste being shipped for disposal in the RWMC, often park outside Gate 100 while waiting for entry to the NTS. Two TLD locations were established in October 2003 to monitor this truck parking area. The TLD on the north end of the parking area (Gate 100 Truck Parking 2) had an estimated average annual exposure of 66 mR/yr and ranged from 64 mR/yr in the third quarter to 70 mR/yr during the fourth quarter. These estimated annual exposures fall within those measured at NTS background locations. The TLD location on the west side of the parking area (Gate 100 Truck Parking 1) showed increased average exposures of 113 mR/yr in the third quarter and 358 mR/yr during the fourth quarter, up from 73 and 77 mR/yr during the first and second quarters, respectively. It is likely that waste shipments entering the NTS are responsible for this increase. NTS background exposure rates ranged from 60 to 156 mR/yr during 2004, therefore only the fourth quarter measurement was above the range of background levels. Nobody resides full-time in the truck parking area. If an individual did reside there 24 hours a day for the fourth quarter, they may have received an external dose of about 54 to 80 mrem (fourth quarter exposure rate minus background multiplied by the length of the fourth quarter [98 days]). Given this extremely conservative scenario, the dose would still be below the 100 mrem/yr limit.

While the public has access only to the southern portions of the NTS borders, other people may have access to other boundaries of the NTS. The great majority of the NTS is bounded by the NTTR. Military or other personnel on the NTTR who are not classified as radiation workers would also be subject to the 100 mrem/yr dose limit for members of the public. The only place a soil contamination area crosses a boundary with NTTR is in the Frenchman Lake region of Area 5 along the southeast boundary of the NTS. A TLD location was established in July 2003 near the NTS boundary in the Frenchman Lake playa. The mean estimated annual exposure measured at Frenchman Lake during 2004 was 411 mR. This exposure rate would exceed the 100 mrem/yr dose limit to a hypothetical person residing year-round at this location. However, there are no living quarters or full-time workers at this location.

5.3.2 *Exposure Rates at Radioactive Waste Management Sites (RWMSs)*

The Radioactive Waste Management Manual, DOE M 435.1-1 (DOE, 2001a), states that low-level waste disposal facilities shall be operated, maintained, and closed so that a reasonable expectation exists that dose to members of the public shall not exceed 25 mrem/yr. Given that the RWMSs are located well within the NTS boundaries, there are no members of the public which could access these areas for significant periods of time. However, exposure rates are measured by TLDs located at the RWMSs to show the potential dose to a hypothetical person residing year-round at each RWMS.

5.3.2.1 *Area 3 RWMS*

The Area 3 RWMS is located in Yucca Flat. Between 1952 and 1972, 60 nuclear weapons tests were conducted within 400 meters of the Area 3 RWMS boundary. Fourteen of these tests were atmospheric tests which left radionuclide contaminated surface soil and, therefore, elevated radiation exposure rates across the area. Waste pits in the Area 3 RWMS are subsidence craters from seven subsurface tests that are being filled with low-level radioactive waste. These are then covered with clean soil; the result of this is a lower exposure rate inside the Area 3 RWMS compared with the average exposure rate at the fence line or in Area 3 outside the fence line.

Annual exposure rates during 2004 in and around the Area 3 RWMS are shown in Figure 5-2. The exposure rates measured inside Area 3 RWMS and three of four measurements at the boundary were within the range of background exposure rates. All exposure rates above the range of NTS background levels were associated with historic above-ground nuclear weapon test locations. Given this, current Area 3 RWMS operations would have contributed negligible external exposure to a hypothetical person residing at the Area 3 RWMS boundary during 2004.

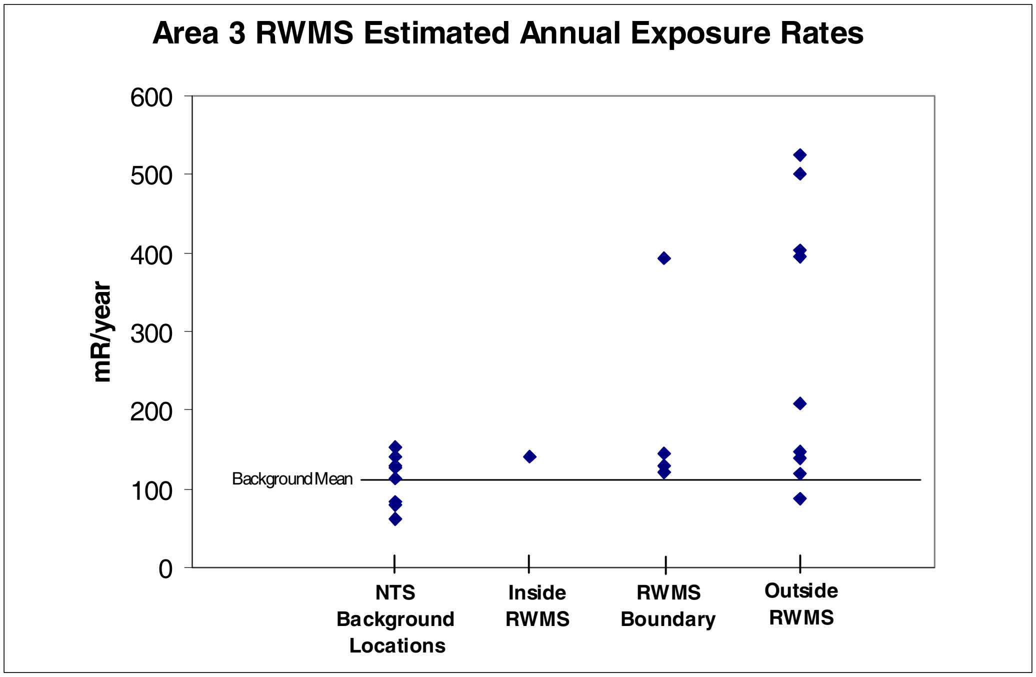

Figure 5-2. Annual exposure rates at the Area 3 RWMS during 2004

5.3.2.2 *Area 5 RWMS*

The Area 5 RWMS is located on the northern portion of Frenchman Flat. Ten underground nuclear weapons tests were conducted within 3 km (1.9 mi) of the Area 5 RWMS between 1965 and 1971. Nine of these released radioactivity to the surface which contributed to the exposure rates in the area. No nuclear weapons testing occurred within the boundaries of the Area 5 RWMS. During 2004, the annual exposure rates at Area 5 RWMS TLD locations were within the range of exposure rates measured at NTS background locations (Figure 5-3). However, significant variation was recorded in the first quarter at one location along the western boundary of the Area 5 RWMS. At this location the average exposure rate was 227 mR/yr during the first quarter, up from 124, 121, and 121 mR/yr measured in the second, third, and fourth quarters, respectively. This variation is thought to be associated with waste operations. Waste shipments being placed into Pit 11, adjacent to this TLD location were likely the cause of the elevated exposure. A hypothetical person residing full-time at this TLD location during the first quarter may have received a net external dose of about 70 to 218 mrem (227 mrem minus background [60 to 156 mrem/yr], multiplied by the length of the first quarter [77 days]).

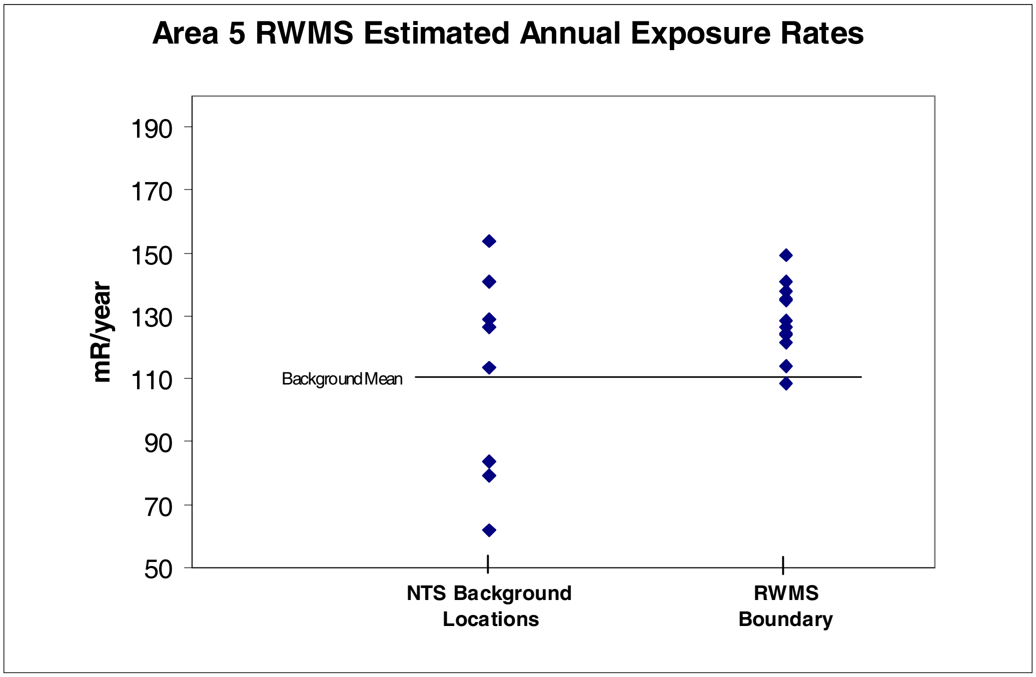

Figure 5-3. Annual exposure rates at the Area 5 RWMS during 2004

5.3.3 Exposure Rates from NTS Operational Activities

During 2004 there were 42 TLDs located where current NTS operations had the potential to produce elevated radiation exposure rates (E1 locations). The estimated mean annual exposure rate at these locations was 115 mR/yr, within 5 percent of the estimated mean annual exposure rate at background locations (110 mR/yr) (see Table 4-2). Overall, annual exposure rates were not different between B (background) and E1 locations (Figure 5-4). In Figure 5-4, the box includes the middle 50 percent of values; the middle line is the median; the "+" is the mean; and the whiskers extend to the lowest and highest values.

One E1 location had elevated daily exposure rates exceeding background rates during the third and fourth quarters. This was at the Gate 100 Truck Parking 1 TLD location (see Section 5.2.1). At all other E1 locations, NTS operations produced radiation exposures comparable to those at background locations.

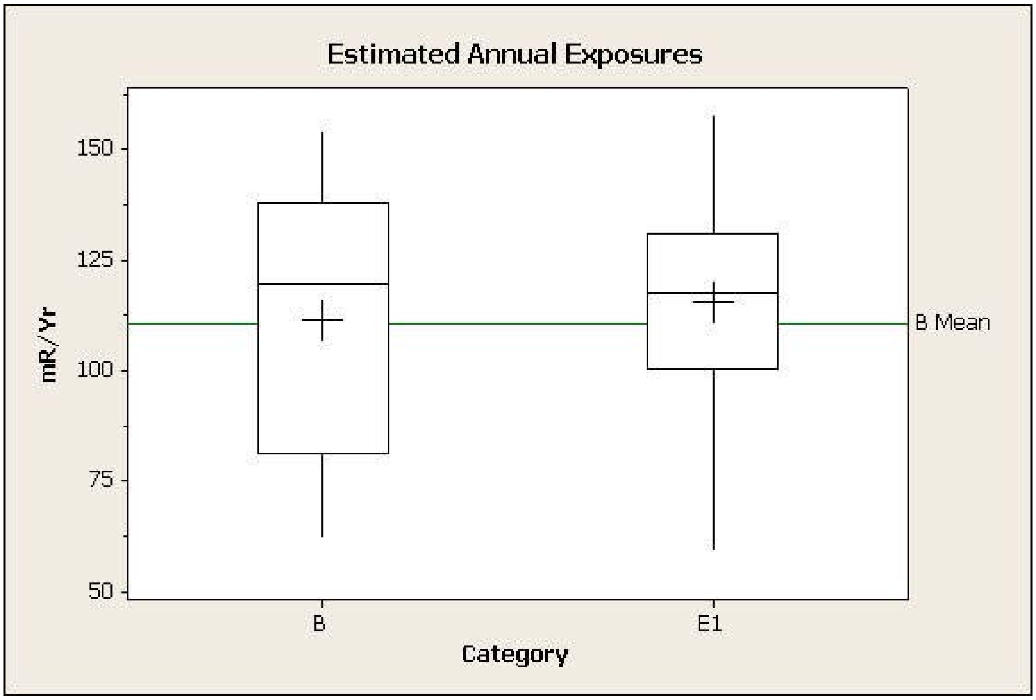

Figure 5-4. Annual exposure rates at B and E1 locations on the NTS in 2004

5.3.4 *Exposure to NTS Plants and Animals*

The TLD location with the highest annual exposure (Schooner 1) had a maximum measurement of 2.43 mR/d during the fourth quarter of 2004. At an elevation near the ground (e.g., 3 cm [1.2 in]), the exposure would be about four times higher than at 1 m (3.3 ft) where TLDs are placed. Therefore, daily exposure rates near the ground surface at the Schooner 1 TLD location would be about 10 mR/d. This would result in an external dose that is approximately 10 percent of the most limiting total dose rate to biota (0.1 rad/day limit to terrestrial animals). Based on this, dose to plants and animals from external radiation exposure at NTS monitoring locations is low compared with dose limits.

5.3.5 *Exposure Rate Patterns in the Environment over Time*

DOE Order 450.1 states that environmental monitoring should be conducted to characterize releases from DOE activities. Monitoring the exposure rates at locations of past releases on the NTS over time helps to do this. Small quarter-to-quarter changes are normally seen in exposure rates from all locations. In 2004, the first quarter was slightly higher and the third quarter slightly lower; the difference was statistically significant (p=0.013) but quite minor (4.0 percent difference between quarter 1 and quarter 3). Overall there was a slight decrease of about 1 percent in exposure rates in 2004 compared with 2003.

Changes through time are displayed in Figure 5-5 for annual TLD measurements by location type for those locations which have been monitored for at least eleven years. The Schooner TLD locations, which have the highest exposure rates of any current TLD locations on the NTS, are not included in this figure because they were established in 2003. The two highest exposure rates shown in Figure 5-5, Stake A-9 and Stake N-8, continue to decrease with a half-life of about 15 and 12 years, respectively. The next three highest exposure rates are from the Sedan West, T-Tunnel #2 Pond, and Bunker 7-300 locations, where exposure rates have decreased by an average of 4.6, 4.7, and 3.0 percent since 1989, respectively. All five of these locations are in the E2 category at known contaminated sites with the predominant photon-emitting radionuclides being ^{137}Cs, ^{60}Co, ^{152}Eu, and ^{241}Am. The observed decreases in exposure rates are due to the natural decay of radionuclides and to the dispersal of radionuclides in the environment. Exposure rates at all other locations have been relatively stable over time indicating little added radioactivity at those locations.

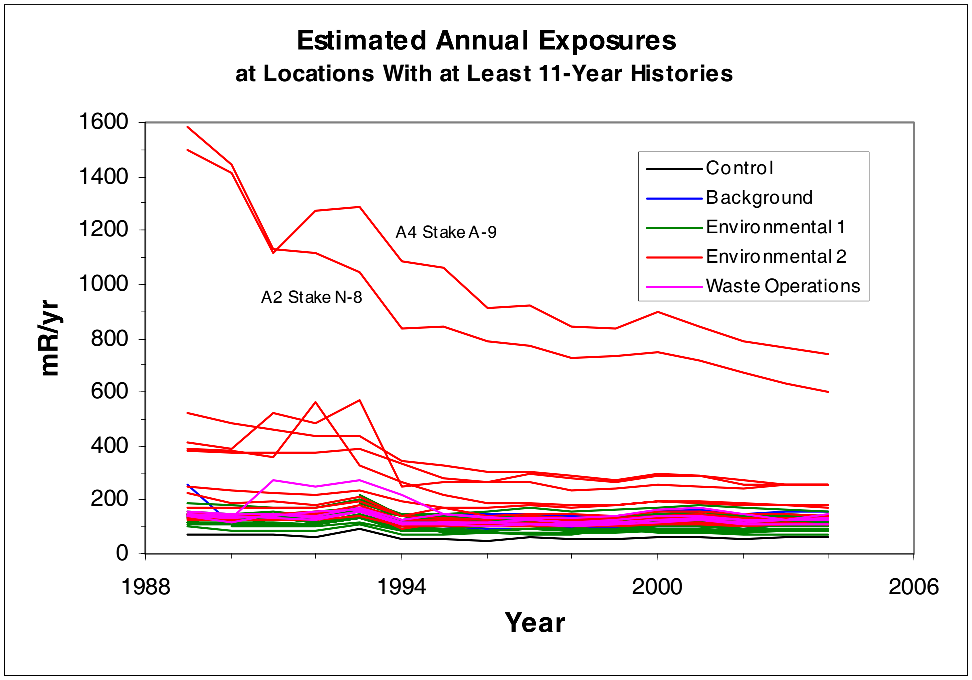

Figure 5-5. Trend in direct radiation exposure measured at TLD locations with at least eleven-year data histories

5.4 Environmental Impact

Direct radiation exposure to the public from NTS operations in 2004 was negligible. Radionuclides historically released to the environment on the NTS have resulted in localized elevated exposure rates. These areas of elevated exposure rates are not open to the public nor are there personnel working in these areas. Overall exposure rates at the RWMSs appear to be lower inside or at the boundary compared with those outside the RWMSs. This is likely due to the presence of radionuclides released from historical testing distributed throughout the area around the RWMSs and the clean soil used inside the RWMSs to cap waste pits. External dose to plants and animals at the location with the highest measured exposure rates was a small fraction of the dose limit to biota. There should be no detrimental effects to biota from external radiation exposure at these sites.

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6.0 Oversight Radiological Monitoring of Air and Water

Community oversight for the NTS is provided through the Community Environmental Monitoring Program (CEMP) whose mission is to monitor and communicate environmental data that are relevant to the safety and well-being of participating communities and their surrounding areas. Previously, the CEMP network functioned as a first line of offsite detection of potential radiation releases from underground nuclear tests at the Nevada Test Site (NTS), and it can be outfitted to fulfill this role again should underground testing resume. It currently exists as a non-regulatory public informational and outreach program, although quarterly reporting of monitoring data is furnished to the U. S. Environmental Protection Agency (EPA) Region IX as a supplemental requirement to NTS onsite monitoring. The CEMP is sponsored by the U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office (NNSA/NSO), and is administered and operated by the Desert Research Institute (DRI) of the University and Community College System of Nevada.

Monitored and collected data include, but are not necessarily limited to, background and airborne radiation data, meteorological data, and tritium concentrations in community and ranch drinking water wells. Network stations, located in Nevada and Utah, are managed by local citizens, many of them high school science teachers, whose routine tasks are to maintain the equipment, 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 web site at <http://www.cemp.dri.edu/>. A detailed historical background of the CEMP can be found at <http://www.cemp.dri.edu/CEMPhist.html> along with more detailed descriptions of the various types of sensors found at the stations and on outreach activities conducted by the CEMP.

6.1 Offsite Air Monitoring

During CY 2004, 26 CEMP stations managed by DRI comprised the Air Surveillance Network (ASN) (Figure 6-1). Two newer stations installed at Ely and Warm Springs Summit in the summer and fall of 2003 respectively have now been on line their first full calendar year. The ASN stations include various equipment, as described below. The Beatty, Nevada CEMP station is shown in Figure 6-2.

CEMP Low Volume Air Sampling Network - During CY 2004, the CEMP ASN included continuously operating low-volume particulate air-samplers located at 24 of the 26 CEMP station locations. No low-volume air samplers are located at Medlins Ranch or Warm Springs Summit, but an air sampler system was re-established at Sarcobatus Flats. Duplicate air samples were collected from up to three ASN stations each week. The duplicate samplers are operated at randomly selected stations for three months (one calendar quarter) before being moved to a new location. The new air sampler added to Sarcobatus Flats, Nevada in August of 2004 re-established an important air data collection capability that was removed prior to DRI acquiring administration of the program.

Glass-fiber filters from the low-volume particulate samplers are collected by the CEMs, mailed to DRI, then prepared and forwarded to an independent laboratory to be analyzed for gross alpha and gross beta activity. Samples are held for a minimum of seven 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.

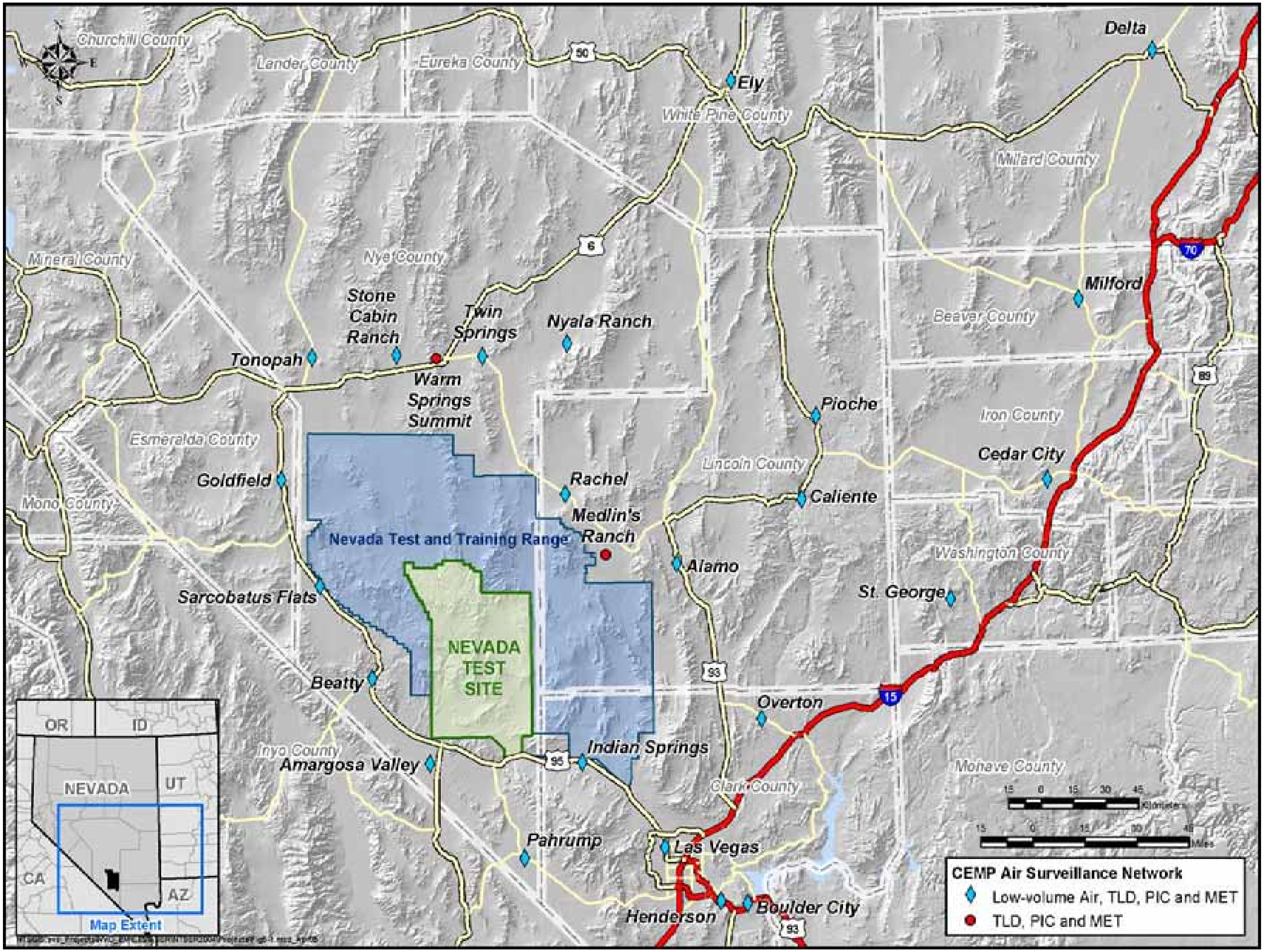

Figure 6-1. 2004 CEMP Air Surveillance Network

Figure 6-2. CEMP station at Beatty, Nevada

CEMP TLD Network – Thermoluminescent dosimetry (TLD) is another of the essential components of environmental radiological assessments. This is used to determine both individual and population external exposure to ambient radiation from natural and artificial sources. In CY2004, the TLD network consisted of fixed environmental TLDs at 25 of the 26 CEMP stations (see Figure 6-1). A TLD is not currently deployed at Warm Springs Summit due to limited access during the winter months. The TLD used was a Panasonic UD-814AS. Within the TLD, a slightly shielded lithium borate element is used to check low-energy radiation levels while three calcium sulfate elements are used to measure penetrating gamma radiation. For quality assurance purposes, duplicate TLDs are deployed at three randomly-selected environmental 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 PIC Network – The pressurized ion chamber (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 26 stations in the CEMP network (see Figure 6-1). 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. Since the addition of a full suite of meteorological instrumentation at the CEMP stations, variations in PIC readings caused by weather events such as precipitation or changes in barometric pressure are more readily identified. These variations can be easily viewed by selecting the Time Series Graph link from the CEMP home page, < http://www.cemp.dri.edu/>, after selecting a desired station and then selecting the desired variables.

CEMP Meteorological (MET) Network – Because changing weather conditions can have a significant effect on measurable levels of background radiation, meteorological instrumentation is in place at each of the 26 CEMP stations. 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 accessible by accessing the CEMP home page at <http://www.cemp.dri.edu/>.

6.1.1 Air Particulate Sampling Results

A sample of airborne particulates from a CEMP ASN station is collected by drawing air through a 2 in (5 cm) diameter glass-fiber filter at a constant flow rate of 2 cubic feet per minute (cfm) (86.6 liters (L)/min) at standard temperature and pressure. The actual flow rate and volume is measured and recorded with an in-line air-flow calibrator. The particulate filter is mounted in a filter holder that faces downward at a height of 5 ft (1.5 m) above the ground. The total actual volume collected ranges from approximately 19,000 to 28,000 cubic feet (ft^3) (538 to 793 m^3) depending on the elevation of the station and changes in air temperature and/or pressure.

6.1.1.1 Gross Alpha and Gross Beta

Gross alpha and beta analysis 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 $1.73 \pm 0.46 \times 10^{-15}$ μCi/mL ($6.40 \pm 1.70 \times 10^{-5}$ Bq/m^3) (Table 6-1). Most of the results for CY 2004 exceeded the analytical minimum detectable concentration (MDC) (see Glossary, Appendix D) and, overall, are similar to results from previous years. Figure 6-3 shows the long-term maximum, mean, and minimum alpha trend for the CEMP stations as a whole.

Table 6-1. Gross alpha results for the CEMP offsite Air Surveillance Network in 2004

Sampling Location	Number of Samples	Concentration (x 10^{-15} μCi/mL [3.7 x 10^{-5} Bq/m^3])			
		Mean	Standard Deviation	Minimum	Maximum
Alamo	52	2.18	1.03	0.56	5.49
Amargosa Valley	52	2.29	1.26	0.56	6.63
Beatty	52	1.82	1.08	0.19	4.50
Boulder City	52	2.96	1.15	0.49	6.81
Caliente	52	2.17	1.22	0.38	7.02
Cedar City	52	2.46	1.10	0.79	5.95
Delta	52	1.46	0.61	0.48	2.90
Ely	52	1.20	0.51	0.29	2.46
Garden Valley	52	1.32	0.53	0.36	2.60
Goldfield	51	1.41	0.66	0.36	3.81
Henderson	50	1.60	0.58	0.79	3.26
Indian Springs	48	1.36	0.50	0.40	3.00
Las Vegas	52	2.19	1.14	0.56	5.60
Milford	51	1.68	0.79	0.55	3.75
Nyala Ranch	52	1.11	0.43	0.46	2.51
Overton	51	1.90	0.91	0.37	5.11
Pahrump	52	1.66	0.62	0.29	3.20
Pioche	52	1.29	0.43	0.50	2.27
Rachel	49	1.67	0.79	0.24	3.58
Sarcobatus Flats	14	2.15	1.21	0.70	4.95
Stone Cabin Ranch	52	1.40	0.49	0.48	2.64
St. George	50	1.50	0.59	0.61	2.92
Tonopah	50	1.45	0.47	0.36	2.64
Twin Springs	52	1.37	0.52	0.47	2.56
Network Mean = 1.73 ± 0.46 x 10^{-15} μCi/ml					
Mean MDC = 0.59 x 10^{-15} μCi/mL		**Standard Error of Mean MDC = 0.08 x 10^{-15} μCi/mL**			

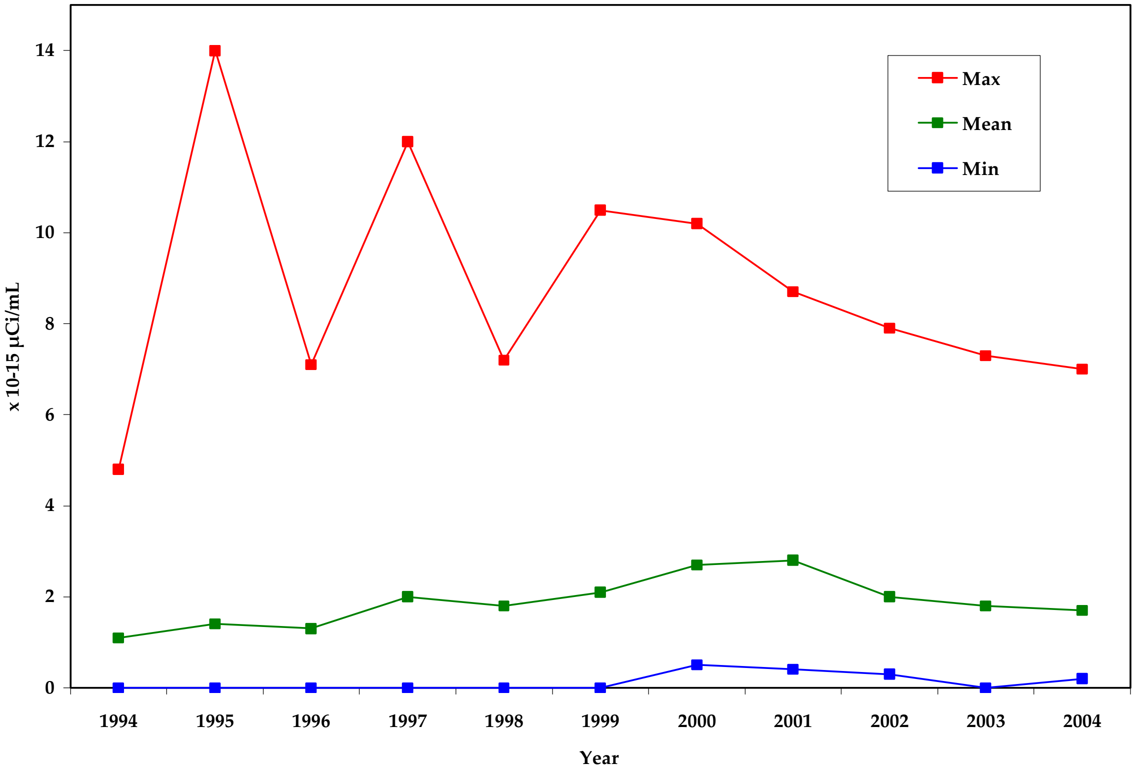

Figure 6-3. Historical trend for gross alpha analysis for all CEMP stations

The mean annual gross beta activity across all sample locations was 2.18 ± 0.18 x 10^{-14} µCi/mL (8.07 ± 0.67 x 10^{-4} Bq/m^3) (Table 6-2). Most of these results also exceeded the MDC, and are similar to previous years' data. Figure 6-4 shows the long-term maximum, mean, and minimum beta trend for the CEMP stations as a whole.

Table 6-2. Gross beta results for the CEMP offsite Air Surveillance Network in 2004

Sampling Location	Number of Samples	Concentration (x 10^{-14} µCi/mL [3.7 x 10^{-4} Bq/m^3])			
		Mean	Standard Deviation	Minimum	Maximum
Alamo	52	2.11	0.57	0.86	3.90
Amargosa Valley	52	2.37	0.63	1.09	4.83
Beatty	52	2.17	0.64	0.28	4.38
Boulder City	52	2.46	0.92	1.14	7.43
Caliente	52	2.16	0.75	0.96	5.62
Cedar City	52	2.23	0.66	1.06	4.68
Delta	52	2.30	1.08	1.34	6.04
Ely	52	1.85	0.44	0.97	3.20
Garden Valley	52	1.97	0.50	1.04	3.44
Goldfield	51	2.10	0.68	0.74	4.98
Henderson	50	2.31	0.71	1.00	5.46
Indian Springs	48	2.13	0.59	0.98	4.76
Las Vegas	52	2.24	0.64	0.86	4.86
Milford	51	2.31	0.88	0.94	5.56

Table 6-2. (continued)

Sampling Location	Number of Samples	Concentration (x 10^{-14} μCi/mL [37 μBq/m^3]) Mean	Standard Deviation	Minimum	Maximum
Nyala	52	1.86	0.72	0.82	4.92
Overton	51	2.42	0.79	0.89	6.07
Pahrump	52	2.24	0.58	1.06	4.74
Pioche	52	1.90	0.52	0.84	3.84
Rachel	49	2.19	0.65	0.76	4.89
Sarcobatus Flats	14	2.46	0.59	1.34	3.73
Stone Cabin	52	1.98	0.43	0.98	3.00
St. George	50	2.40	1.00	1.18	7.05
Tonopah	50	1.99	0.46	0.98	3.13
Twin Springs	52	2.17	1.03	0.89	6.8
Network Mean = 2.18 ± 0.18 x 10^{-14} μCi/mL					
Mean MDC = 0.11 x 10^{-14} μCi/mL		**Standard Error of Mean MDC = 0.01 x 10^{-14} μCi/mL**			

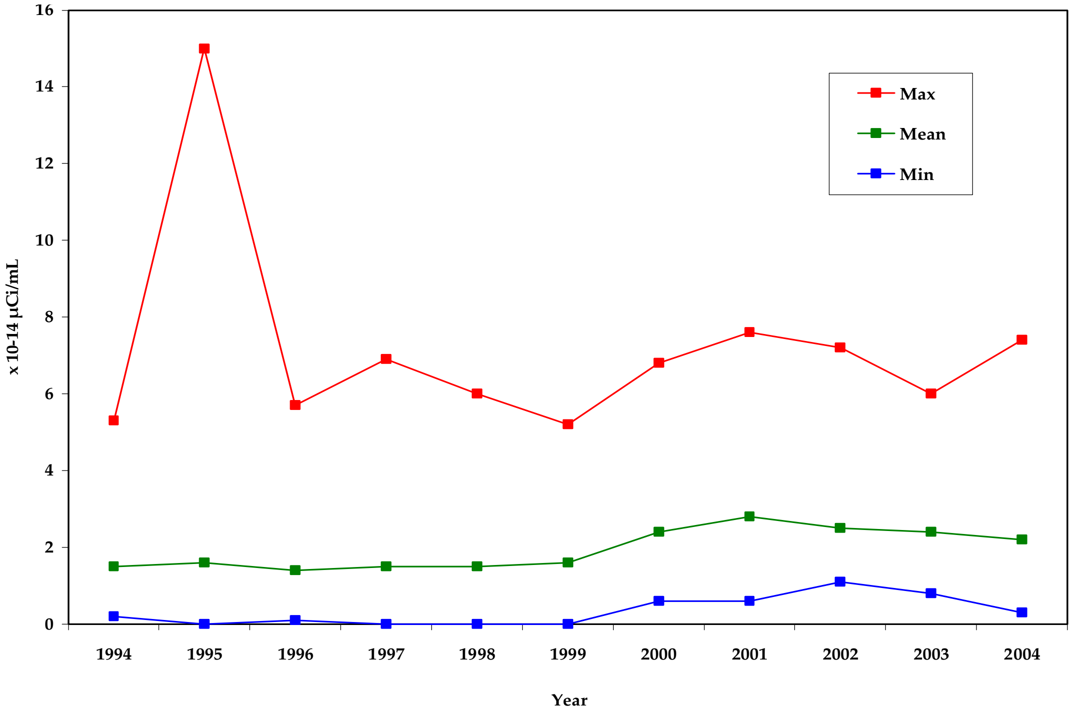

Figure 6-4. Historical trend for gross beta analysis for all CEMP stations

The overall gross alpha results show a generally increasing trend from 1994 to 2001 before trending downward the last three years. Likewise, the gross beta results show a similar trend beginning in 1998. These trends are also reflected by most of the stations on an individual basis. Although this trend merits further evaluation, it may likely be explained as being a result of persistent drought conditions throughout the southwest and Great Basin states. Drought in these regions has existed to varying degrees since 1996. These dry conditions could be directly responsible for an increase in suspended air particles collected by the air-sampling network. The apparent spikes in the maximum trend lines for gross alpha and beta are the result of a single analysis for that year. These analyses occurred prior to the CEMP being directed by DRI, so specific information is not available.

6.1.1.2 *Gamma Spectroscopy*

Gamma spectroscopy analysis was performed on all samples from the low-volume air-sampling network. The filters were composited by station on a quarterly basis after gross alpha/beta analysis. As in previous years, all samples were gamma spectrum negligible with respect to man-made radionuclides (i.e. gamma-emitting radionuclides were not detected). In most of the samples, naturally occurring ^{7}Be was detected above the analytical MDC. 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 76.4 ± 24.7 x 10^{-15} μCi/mL.

6.1.2 *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 plexiglass holder approximately one meter above the ground, and are exchanged quarterly. TLD results are not presented for Warm Springs Summit at this time since 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 2004 ranged from 81 milliroentgens (mR) (0.81 millisieverts [Sv]) at Pahrump, Nevada, to 157 mR (1.57 mSv) at Twin Springs, Nevada, with a mean annual exposure of 119 mR (1.19 mSv) for all operating locations. Results are summarized in Table 6-3 and are consistent with previous years' data. Figure 6-5 shows the long-term trend for the CEMP stations as a whole.

Table 6-3. TLD monitoring results for the CEMP offsite Air Surveillance Network in 2004

Sampling Location	Number of Days	Daily Exposure (mR)			Total Annual Exposure (mR)
		Mean	Minimum	Maximum	
Alamo	364	0.32	0.29	0.34	115
Amargosa Valley	367	0.29	0.27	0.31	107
Beatty	364	0.40	0.35	0.43	145
Boulder City	368	0.29	0.27	0.31	106
Caliente	371	0.34	0.31	0.37	125
Cedar City	371	0.25	0.23	0.29	93
Delta	371	0.27	0.24	0.31	100
Ely	365	0.29	0.28	0.31	106
Garden Valley	372	0.37	0.34	0.38	135
Goldfield	364	0.37	0.35	0.38	135
Henderson	368	0.31	0.28	0.33	113
Indian Springs	367	0.27	0.25	0.29	98
Las Vegas	364	0.27	0.26	0.29	100
Medlin's Ranch	364	0.39	0.36	0.41	141
Milford	371	0.39	0.35	0.41	141
Nyala Ranch	364	0.31	0.30	0.32	114
Overton	369	0.26	0.23	0.29	93
Pahrump	367	0.22	0.20	0.25	81
Pioche	371	0.31	0.30	0.33	114
Rachel	364	0.38	0.36	0.40	140
Sarcobatus Flats	364	0.42	0.37	0.46	155
Stone Cabin Ranch	365	0.39	0.38	0.40	142
St. George	371	0.24	0.20	0.29	88
Tonopah	364	0.37	0.33	0.40	136
Twin Springs	365	0.43	0.41	0.47	157
Overall Annual Mean = 119 mR					

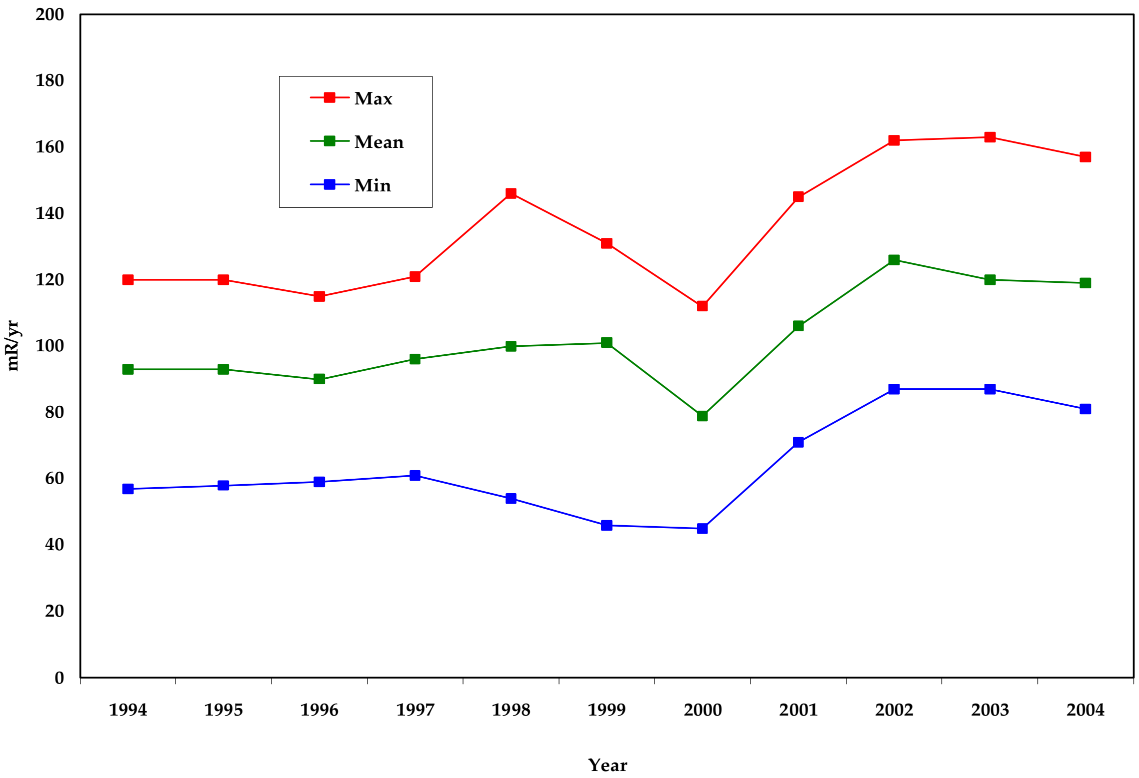

Figure 6-5. Historical trend for TLD analysis for all CEMP stations

As with the gross alpha and beta results, the TLD data also shows a generally increasing trend from 1996 to 2002 before showing a slight decrease the last two years. This again may be consistent with drought conditions observed in the regions around the monitoring network. As the soil becomes drier due to lack of precipitation, the naturally occurring radionuclides may more easily escape into the atmosphere as part of the increased suspended particle load. This could result in an increase in natural radioactivity detected by the TLD. As with the gross alpha and beta results further evaluation is needed.

6.1.3 PIC Results

The PIC data presented in this section are based on daily averages of gamma exposure rates from each station. Table 6-4 contains the maximum, minimum, and standard deviation of daily averages (in microroentgens per hour [μR/hr]) for the periods during 2004 when telemetry 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 mR/yr). The exposure rate ranged from 67.10 mR/yr (0.67 mSv) in Pahrump to 178.35 mR/yr (1.80 mSv) in 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 EPA and are shown in Table 6-5. The annual exposure levels observed at the CEMP stations in 2004 are well within these United States background levels.

Table 6-4. PIC monitoring results for the CEMP offsite Air Surveillance Network in 2004

	Daily Average Gamma Exposure Rate (µR/hr)				Annual Exposure (mR/yr)
Sampling Location	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	
Alamo	13.10	0.42	12.00	14.19	114.71
Amargosa Valley	12.57	0.16	11.98	13.16	110.11
Beatty	16.93	0.45	15.80	18.06	148.31
Boulder City	16.07	0.23	14.28	17.86	140.77
Caliente	15.31	0.24	14.45	16.16	134.07
Cedar City	10.87	0.27	9.85	11.88	95.18
Delta	10.86	0.35	9.88	11.83	95.09
Ely	11.63	0.35	10.32	12.94	101.88
Garden Valley	15.94	0.30	14.84	17.03	139.59
Goldfield	14.82	0.35	13.76	15.88	129.82
Henderson	15.91	0.31	14.69	17.13	139.37
Indian Springs	11.39	0.18	10.83	11.94	99.73
Las Vegas	10.85	0.73	8.83	12.86	95.00
Medlin's Ranch	16.68	0.25	15.80	17.56	146.12
Milford	20.36	0.43	19.02	21.70	178.35
Nyala Ranch	12.87	0.41	11.86	13.88	112.74
Overton	9.98	0.21	9.21	10.74	87.38
Pahrump	7.66	0.15	7.21	8.11	67.10
Pioche	15.13	0.30	14.07	16.19	132.54
Rachel	14.84	0.30	13.95	15.72	129.95
Sarcobatus Flats	17.20	0.28	16.36	18.03	150.63
Stone Cabin Ranch	16.69	0.66	14.92	18.45	146.16
St. George	9.49	0.53	8.30	10.68	83.13
Tonopah	15.70	0.33	14.60	16.79	137.49
Twin Springs	19.17	0.46	17.81	20.53	167.93
Warm Springs Summit	19.08	0.48	17.65	20.50	167.10

Table 6-5. Average natural background radiation for selected U.S. cities (excluding radon)

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

Source: <http://www.wrcc.dri.edu/cemp/Radiation.html.> "Radiation in Perspective," August 1990 (Access Date: 3/22/2005)

6.1.4 *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 impact from radionuclides originating on the NTS. Activity observed in gross alpha and beta analyses of low-volume air sampler filters was consistent with previous years' results and are within the range of activity found in other communities of the United States which are not adjacent to man-made radiation sources. Also, no man-made gamma-emitting radionuclides were detected. Likewise, 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 6-5).

Occasional elevated gamma readings (10–50 percent above normal average background) 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 6-6, generated from the CEMP web site, illustrates an example of this phenomenon.

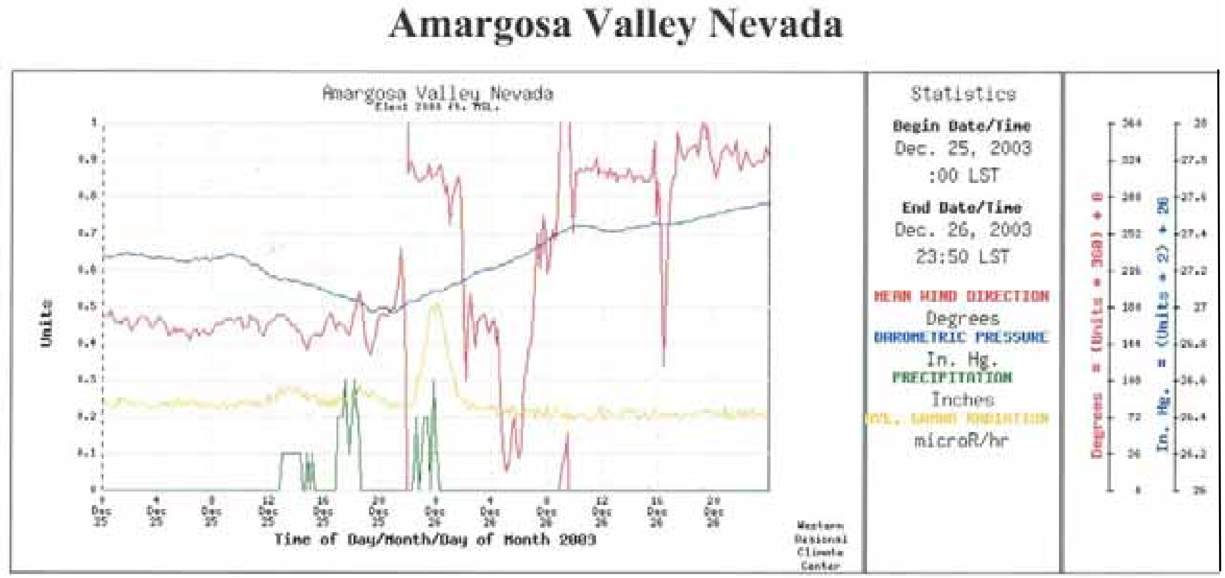

Figure 6-6. The effect of meteorological phenomena on background gamma readings

6.2 Offsite Surface and Groundwater Monitoring

Dring fiscal year 2004, the DRI was tasked by NNSA to provide independent verification of the tritium activity within some of the offsite groundwater wells, municipal water supply systems, and springs used for water supplies in areas surrounding the NTS. Samples collected by DRI personnel provide a direct comparison to the results obtained by the RREMP (Section 4.1) in some cases.

The sole analyte for this project was tritium. Tritium is one of the most abundant radionuclides generated by an underground nuclear test, and since it is a constituent of the water molecule itself, it is also one of the most mobile radionuclides.

6.2.1 Sample Locations and Methods

During the period of June 1 to June 25, 2004, 4 springs, 17 wells, and 3 water supply systems were sampled. Sample locations were selected based upon input from the CEMs and local ranch owners participating in the CEMP project. All wells were sampled utilizing downhole submersible pumps. Samples from water supply systems were collected via discharge from a faucet connected to that system. Springs were sampled by hand at the orifice, along surface drainage, or from the water supply system connected to the spring discharge. Each well was pumped a minimum of 5 to 15 minutes prior to sampling to purge water from the pump tubing and well annulus. This process ensured that the resultant sample was representative of local groundwater. Table 6-6 lists all of the sample points, their locations, the date they were sampled, and the sampling method. The locations of the sample points are shown in Figure 6-7.

6.2.2 Procedures and Quality Assurance

DRI utilized several methods to ensure that radiological results reported herein conform to current quality assurance protocols (see Section 19.0 for a detailed description of the CEMP quality assurance program). This was achieved through the use of Standard Operating Procedures (SOPs), field quality assurance samples, and laboratory quality assurance procedures. DRI's SOPs are detailed instructions that describe the method and materials, using step-by-step instructions, which are required to collect field water quality samples and protect the samples from tampering and environmental conditions that may alter their chemistry.

The second tier of quality assurance utilized on this project consisted of field quality assurance samples. The intent of these samples and procedures was to provide direct measures of the contribution of radioactive material that was derived from the bottles, sampling equipment, and the environment to the activity of tritium measured within the samples. Duplicate samples were collected to establish a measure of the repeatability of the analysis. Matrix spike duplicates were also collected to ensure no other parameters in the sample water were present that could cause erroneously high or low tritium values. Twelve samples (33 percent of the sample load) were collected for the purposes of meeting field quality assurance requirements. Laboratory quality assurance controls consisted of the utilization of published laboratory techniques for the analysis of enriched tritium, method blanks, laboratory control samples, and laboratory duplicates. The laboratory quality assurance samples provide a measure of the accuracy and the confidence of the reported results.

Enriched tritium analyses were run on all water samples. The decision level (Lc) (see Glossary, Appendix D) of tritium ranged from 10.5 to 16 pCi/L. The Lc is the result that must be exceeded before there is a 95 percent confidence that the sample contains radioactive material above background. The MDC (see Glossary, Appendix D) for tritium was approximately 26 pCi/L. BN reports that the MDC for enriched tritium analyses for the RREMP water samples is approximately 25 pCi/L (see Section 4.1.2).

Table 6-6. CEMP water monitoring locations sampled in 2004

Monitoring Location Description	Latitude	Longitude	Date Sampled	Sample Collection Method
Adaven Springs	38 08.25	115 36.20	6/15/2004	By hand from stream discharging from spring orifice
Alamo city water supply system - source of water is municipal well field	37 21.74	115 10.14	6/1/2004	By hand from municiple water well
Amargosa Valley school well	36 34.16	116 27.66	6/22/2004	By hand at well head
Beatty Water and Sewer - municipal well	36 54.94	116 45.65	6/2/2004	By hand at well head at utility headquarters
Boulder City – at Hemingway Park from municipal water distribution system	35 59.74	114 49.90	6/25/2004	By hand from a drinking fountain inside Hemingway Park
Caliente municipal water supply well	37 36.95	114 30.83	6/8/2004	By hand at well head
Cedar City municipal water supply well #7 10 mi west of town	37 39.39	113 13.14	6/10/2004	By hand at well head
Delta municipal well	39 21.59	112 34.65	6/9/2004	By hand at well head
Goldfield Municipal Water Supply well about 12 mi north of town	37 52.40	117 14.96	6/2/2004	By hand at well head
Henderson CCSN - source of water is municipal water system originating at Lake Mead	36 00.43	114 57.95	6/25/2004	By hand from faucet inside college building
Indian Springs municipal well	36 34.41	115 40.10	6/22/2004	By hand at well head
Las Vegas Valley Water District #103	36 13.94	115 15.13	6/25/2004	By hand at well head
Medlin’s Ranch - spring 11 mi west of ranch house	37 24.10	115 32.25	6/16/2004	By hand at kitchen faucet
Milford municipal well	38 22.96	113 01.19	6/9/2004	By hand at well head
Nyala Ranch water well	38 14.93	115 43.72	6/15/2004	By hand from front yard hose faucet at house
Overton water well located at Arrow Canyon about 10 mi west of town	36 44.06	114 44.87	6/24/2004	By hand at well head
Pahrump municipal well	36 12.38	115 59.11	6/22/2004	By hand at well head located near old Calvada Headquarters
Pioche municipal well located 1 mile east of town	37 56.98	114 25.78	6/8/2004	By hand at well head
Rachel - Little Ale Inn well	37 38.79	115 44.75	6/1/2004	By hand from bar faucet inside Lil Ale Inn Restaurant
Sarcobatus Flats well	37 16.78	117 01.92	6/2/2004	By hand at well head
St. George Dameron Valley well 16 mi north of St George	37 11.60	113 38.77	6/10/2004	By hand at well head
Stone Cabin Ranch Spring	38 12.44	116 37.91	6/15/2004	By hand from kitchen faucet at ranch house
Tonopah public utilities well field located 10 mi from town	38 11.68	117 04.70	6/16/2004	By hand at well head
Twin Springs Ranch Spring	38 12.21	116 10.55	6/15/2004	By hand from front yard hose faucet at house

Note: Sample locations were resurveyed in 2004 using global positioning satellite data and location latitudes and longitudes were updated with the new coordinate data. The following sample locations were moved in 2004: St. George was moved approximately 17 km based on request by the CEM, Caliente was moved approximately 370 m due to mechanical problems in the well sampled previously, Goldfield was moved approximately 500 m based on request by the CEM, and Pahrump was moved approximately 1,970 m based on request by the CEM. All updated sample locations are shown in Figure 6-7.

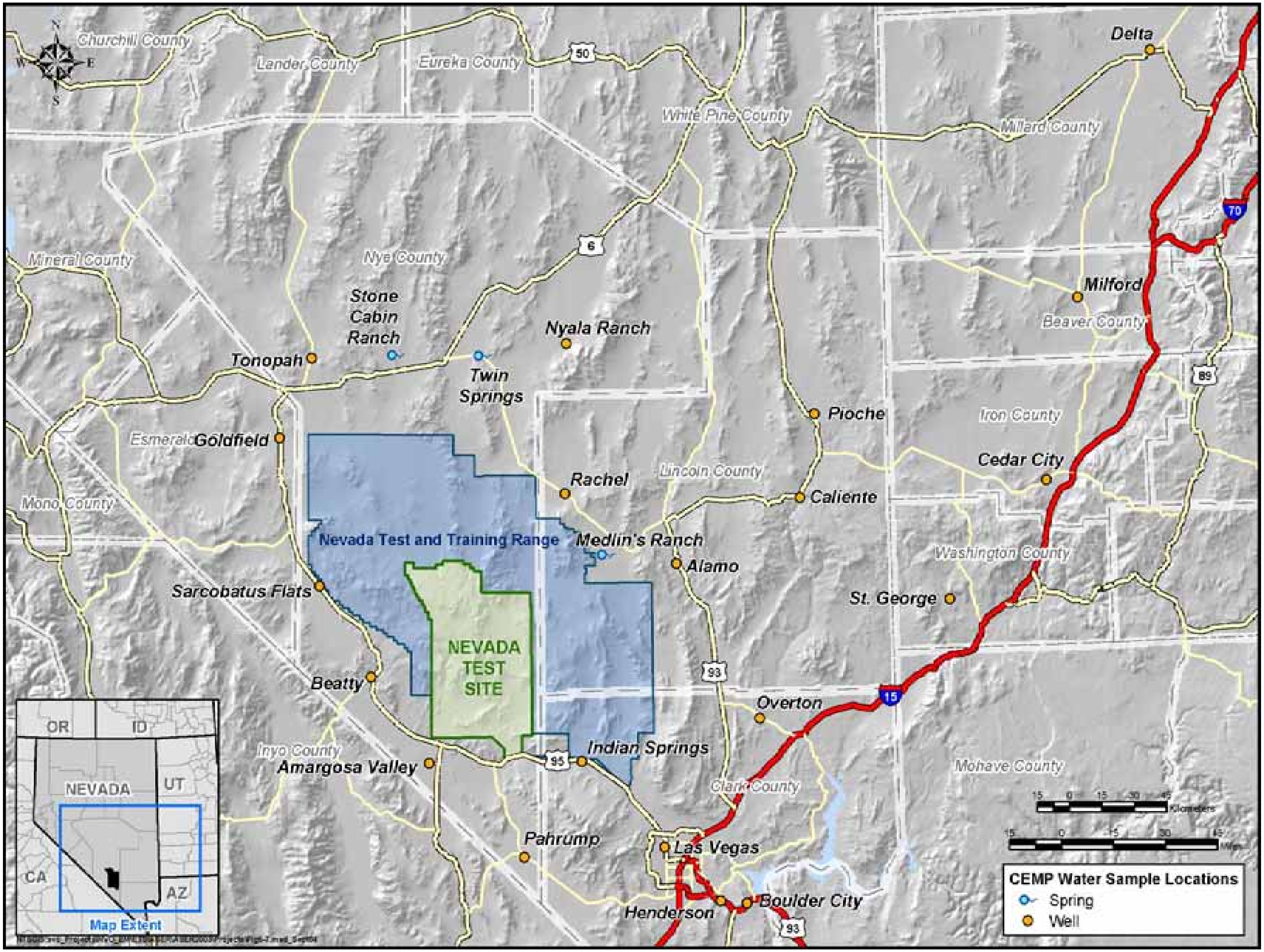

Figure 6-7. 2004 CEMP water monitoring locations

6.2.3 Results of Surface Water Monitoring from Springs

Measured tritium (^3H) concentrations from the springs ranged from -3 to 12 pCi/L (Table 6-7). Three of the samples, Medlin's Ranch, Stone Cabin Ranch, and Twin Springs Ranch, yielded results that were indistinguishable from background (i.e., ≤ Lc). The Adaven Springs sample result, at 12 ± 22 pCi/L, was statistically at Lc. All sample analyses were well below the safe drinking water limit of 20,000 pCi/L. Sample results for Adaven Springs, Medlin's Ranch, Stone Cabin Ranch, and Twin Springs Ranch were similar to results reported by DRI in the Nevada Test Site Environmental Report 2003 (DOE, 2004d).

Table 6-7. Tritium results for CEMP offsite springs and spring discharges in 2004

Monitoring Location	**^3H ± Uncertainty[(a)] (pCi/L)**	**Lc**
Adaven Springs	12 ± 22	12
Medlin's Ranch - spring located 11 miles west of ranch house	9 ± 18	14
Stone Cabin Ranch	-2 ± 16	12
Twin Springs Ranch	-3 ± 16	12

(a) ± 2 standard deviations

6.2.4 Results of Groundwater Monitoring

The results for the 20 groundwater tritium analyses from the DRI Tritium Laboratory are presented in Table 6-8. The measured activities ranged from -5 to 29 pCi/L. All of the samples, with the exception of Henderson and Boulder City, yielded results that were statistically indistinguishable from background (≤ Lc). Results from Henderson and Boulder City were statistically greater than background. The water in these samples originated from Lake Mead. Slightly elevated tritium activities in Lake Mead are well documented by previous investigations (DOE, 2002d; DOE, 2003c; DOE, 2004) and are due to residual tritium persisting in the environment that originated from global atmospheric nuclear testing. All sample analyses were well below the safe drinking water limit of 20,000 pCi/L. Trending of the data was not conducted due to the limited number of previously collected samples (three previous sets have been collected by DRI thus far). The only notable changes were at the Boulder City water treatment plant (from 27 ± 16 pCi/L in 2002 to 35 ± 28 pCi/L in 2003 and back to 29 ± 17 in 2004). The change in measured tritium activity at Boulder City is well within the range of uncertainty associated with the 2002, 2003, and 2004 analyses.

6.2.5 Environmental Impact

Results of the CEMP tritium analyses conducted on selected offsite groundwater wells and water supply systems surrounding the NTS showed no evidence of tritium migration offsite via groundwater. Most of the samples analyzed were below the decision level for tritium (see Tables 6-7 and 6-8). The greatest observed activities, (27 pCi/L and 29 pCi/L from Henderson and Boulder City, respectively) were well below the safe drinking water standard of 20,000 pCi/L.

Table 6-8. Tritium results for CEMP offsite wells in 2004

Monitoring Location	^3H ± Uncertainty[(a)] (pCi/L)	Lc (pCi/L)
Alamo City	-3 ± 23	13
Amargosa Valley	-2 ± 24	14
Beatty	-2 ± 23	16
Boulder City	29 ± 17	10
Caliente	7 ± 23	12
Cedar City	-4 ± 21	16
Delta	2 ± 20	16
Goldfield	-4 ± 23	13
Henderson	27 ± 16	11
Indian Springs	-1 ± 25	14
Las Vegas	3 ± 18	14
Milford	-5 ± 20	16
Nyala Ranch	-1 ± 19	12
Overton	3 ± 22	14
Pahrump	-1 ± 23	14
Pioche	2 ± 22	16
Rachel	-1 ± 20	13
Sarcobatus Flats	3 ± 25	13
St. George	-3 ± 21	16
Tonopah	-2 ± 19	13

Green shaded results are considered detected (result greater than the MDC of 26 pCi/L)

(a) ± 2 standard deviations

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7.0 Radiological Biota Monitoring

Historical atmospheric nuclear weapons testing and outfalls from underground nuclear tests provide a source of radiation contamination and exposure to Nevada Test Site (NTS) plants and animals (biota). U.S. Department of Energy (DOE) Order 5400.5 *Radiation Protection of the Public and the Environment* requires that all DOE sites monitor radioactivity in the environment to ensure that the public does not receive a radiological dose greater than 100 mrem/yr from all pathways of exposure, including the ingestion of contaminated plants and animals.

Current NTS land use precludes the harvest of plants or plant parts (e.g., pine nuts and wolf berries) for direct consumption by humans. Therefore, the ingestion of game animals is the primary potential biotic pathway for radionuclide contamination from the NTS to the public. Game birds and game mammals that occur on the NTS may travel off the site and become available, through hunting, for consumption by the public. Game animals are therefore monitored by Bechtel Nevada (BN) Environmental Technical Services (ETS) under the *Routine Radiological Environmental Monitoring Plan* (RREMP) (DOE, 2003b).

Game animals and plants are sampled annually from known contaminated sites on the NTS to estimate hypothetical doses to hunters (i.e., the public), measure the potential for radionuclide transfer through the food chain, and determine if NTS plants and animals themselves are exposed to radiation levels harmful to their populations. This section describes the biota monitoring program designed to meet public and environmental radiation protection regulations (see Section 2.3) and presents the results of field sampling and analyses in 2004. The reader is directed to the RREMP (DOE, 2003b) for a more detailed description of monitoring design and methods. The estimated radiological dose, both to humans consuming game animals from the NTS and to biota found in contaminated areas of the NTS, that was calculated based on 2004 monitoring data is presented in Section 8.0.

Radiological Biota Monitoring Goals	*Analytes Measured in Plant and Animal Tissues*
Determine if the potential dose to humans consuming game animals from the NTS is less than 100 millirems per year (mrem/yr), the limit set by DOE Order 5400.5	Americium-241 (^{241}Am)
	Cesium-137 (^{137}Cs)
	Tritium (^{3}H)
Determine if the absorbed radiation dose to NTS biota is less than the following limits set by DOE Order 5400.5 and DOE Standard DOE-STD-1153-2002: < 1 rad/day for terrestrial plants and aquatic animals < 0.1 rad/day for terrestrial animals	Plutonium- 239+240 ($^{239+240}$Pu)
	Strontium-90 (^{90}Sr)
	Uranium isotopes

7.1 Species Selection

The goal for vegetation monitoring is to sample the most contaminated plants within the NTS environment. Contaminated plants are generally found inside demarcated radiological areas near the "ground zero" locations of historical above-ground nuclear tests. The plant species selected for sampling represent the most dominant plant life forms (e.g., trees, shrubs, herbs, or grasses) at these sites. Woody vegetation (i.e., shrubs versus forbs or grasses) is primarily selected for sampling because such vegetation is reported to have deeper penetrating roots and higher concentrations of tritium (Hunter and Kinnison, 1998). Additionally, this vegetation serves as a major source of browse for game animals that might eat such vegetation and potentially migrate offsite. Grasses and forbs are also sampled when present, however, because they are also a source of food for wildlife. Plant parts collected for analysis represent new growth over the past year.

Three criteria were used to determine which animal species to monitor for assessing potential dose to the public: 1) the species should have a relatively high probability of entering the human food chain; 2) the species should have a home range which 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) the species should be sufficiently abundant at a site to acquire an adequate tissue sample for laboratory analysis. These criteria limited the candidate game animals on the NTS to those listed below.

Candidate NTS Game Animals Monitored

Birds	*Small Mammals*	*Large Mammals*
Mourning dove (*Zenaida macroura*)	Cottontail rabbit (*Sylvilagus audubonii*)	Mule deer (*Odocoileus hemionus*)
Chukar (*Alectoris chukar*)	Jackrabbit (*Lepus californicus*)	Pronghorn antelope (*Antilocapra americana*)
Gambel's quail (*Callipepla gambelii*)		

No native fish or amphibians are found in surface waters of the NTS. There is no potential radiological dose pathway directly from NTS aquatic animals to humans. No aquatic invertebrates or non-native fish or amphibians are sampled for radionuclide tissue analyses.

7.2 Site Selection

The monitoring design focuses on sampling those sites having the highest known concentrations of radionuclides in other media (e.g., soil and surface water) and sites that have relatively high densities of candidate game animals. Currently, five sites are selected for monitoring; each site is sampled at least once every five years. These sites are E Tunnel Ponds, Palanquin, Sedan, T2, and Plutonium Valley (Figure 7-1). The control site selected for each contaminated site has similar biological and physical features. Control sites are sampled to document radionuclide levels representative of background. Below is a brief description of the two sites monitored during 2004.

Plutonium Valley – Plutonium Valley is located in Area 11 on the eastern edge of the NTS at an elevation of 1,250 m (4,100 ft). Four safety experiments were conducted in Plutonium Valley from November 1, 1955 through January 18, 1956 in which conventional explosives were used on nuclear weapons. In one of these tests there was a slight yield that resulted in the production of fission products (e.g., ^{137}Cs and ^{90}Sr), but the primary contaminant produced and dispersed in the area was plutonium. A control area for Plutonium Valley is located about 24 km (14.9 mi) southwest of the sample site near a spring in Area 27. Any of the candidate game species is likely to be present in Plutonium Valley or at the control site.

E Tunnel Ponds – The E Tunnel Ponds are located just southeast of Rainier Mesa in Area 12 in the northern part of the NTS at an elevation of 1,828 m (6,000 ft). Radionuclide-contaminated water and soils occur at this site. The E Tunnel Ponds were constructed to collect and hold contaminated water (mainly from tritium) which drains out of E Tunnel where nuclear testing was conducted. The water is perched groundwater that has percolated through fractures in the tunnel system. A special sampling effort, focusing on bats, took place at E Tunnel Pond 5 during 2004. The E Tunnel Ponds are the only perennial source of radiologically contaminated water on the NTS. There was interest, from a biota dose perspective, to determine radiolonuclide concentrations in bats and their food source. Camp 17 pond is the normal control site for E Tunnel Ponds, but because bats can have large home ranges that can encompass both Camp 17 pond and the E Tunnel Ponds, the Well J-11 pond in Area 25 was used as a control site. No known radiologically-contaminated waters used by bats occur in the region of Well J-11 pond.

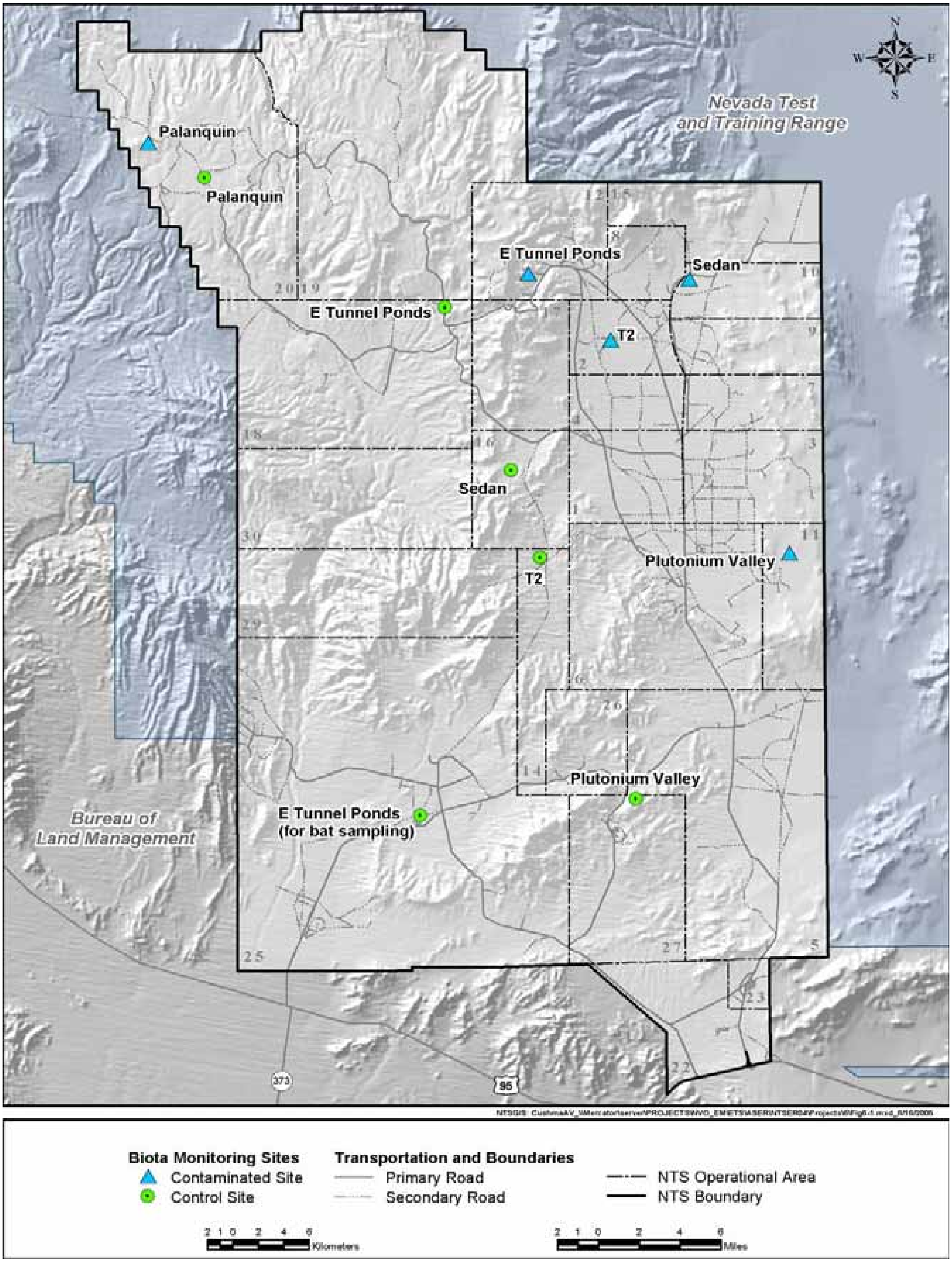

Figure 7-1. Radiological biota monitoring sites on the NTS

7.3 Sampling Methods

During CY 2004, biota samples were successfully collected at Plutonium Valley, the Plutonium Valley control site, E Tunnel Pond 5, and the E Tunnel control site. Sample methods and the numbers and types of samples collected in 2004 are described below.

7.3.1 Plants

Plant sampling occurred on July 1, 2004. At each site, two samples of each plant species shown in Table 7-1 were collected. These species represent the dominant shrubs, forbs, and grasses present at each site. Each sample consisted of about 300 to 500 grams (g) (10.6 to 17.6 ounces [oz]) of fresh-weight plant material and consisted of a composite of material from many plants of the same species in the sample area. Only current year's growth was collected from each plant and consisted of new green leaves and stems. Green leaves and stems from shrubs and forbs were hand-plucked and stored in air-tight plastic bags. Rubber gloves were used by samplers and changed between each composite sample collected. Samples were labeled and stored in an ice chest. Within four hours of collection, the samples were delivered to the laboratory. Water was separated from plant samples by distillation. Water and dried plant tissues were submitted to a commercial laboratory for analysis of radionuclides. Water from plants was analyzed for tritium and dried plant tissue was analyzed for gamma-emitting radionuclides, ^{90}Sr, uranium, plutonium, and ^{241}Am.

Table 7-1. Plant species sampled at Plutonium (Pu) Valley and Pu Valley Control Site in 2004

Plant Common Name	Name Abbreviation[(a)]	Plant Scientific Name	Pu Valley	Pu Valley Control Site
Bashful four o'clock	BFOC	*Mirabilis pudica*	X	
Basin wildrye	BWR	*Leymus cinereus*		X
Four-wing saltbush	FWSB	*Atriplex canescens*	X	X
Goodding's willow	GW	*Salix gooddingii*		X
Green rabbitbrush	GRB	*Chrysothamnus viscidiflorus*	X	X
Nevada jointfir	NJF	*Ephedra nevadensis*	X	X
Panamint prince's plume	PPP	*Stanleya elata*	X	
Prince's plume	PP	*Stanleya pinnata*		X
Russian thistle	RT	*Salsola paulsenii*	X	

(a) plant name abbreviation used in the sample results table (Table 7-3).

7.3.2 Animals

State and federal permits were secured to trap and analyze rabbits, Gambel's quail, chukar, mourning doves, and bats during 2004 as well as to sample road-killed, large game animals. Animal trapping took place at the Plutonium Valley and Plutonium Valley control sites June through July. Live-traps for both game birds and rabbits were run at these sites for 173 and 84 trap-nights, respectively. Three jackrabbits and two mourning doves were trapped at Plutonium Valley, and three cottontail rabbits, two Gambel's quail and one mourning dove were trapped at the Plutonium Valley Control site.

Bat sampling at the E Tunnel Ponds (Figure 7-2) and J-11 pond took place during September. Mist nets were used to capture bats at the E Tunnel Ponds on three nights for an average of 3.0 hours each night and at the J-11 pond on two nights for an average of 2.25 hours each night. On three nights, a light trap was used to capture flying insects around the E Tunnel ponds. A total of 29 bats representing seven species were sampled from E Tunnel Pond 5. A total of 10.3 g (0.36 oz) (wet weight) of flying insects representing seven Orders (Odonata, Lepidoptera, Neuroptera, Diptera, Hymenoptera, Coleoptera, and Hemiptera) were also captured approximately 10 m (33 ft) from the E Tunnel

Figure 7-2. E Tunnel Ponds biota sampling site

Ponds. Eight bats, all of the same species, were captured from the Well J-11 pond. Samples were composited to obtain adequate sample size in all cases except for the one big brown bat (*Eptesicus fuscus*) which was large enough to be an individual sample. The individuals and species in each analyzed sample are listed in Table 7-2.

Opportunistic sampling of one pronghorn antelope road-kill occurred in October on the Mercury Highway on Frenchman Flat.

In the laboratory, each animal specimen was separated into two samples: a muscle tissue sample and a sample representing the whole body minus the portion of muscle (body fraction). All samples were individually homogenized as much as possible using an industrial meat grinder and food processor. Water was distilled from the samples and submitted to a laboratory for tritium analysis. The dried tissue samples were also submitted to a laboratory for analysis of gamma-emitting radionuclides, ^{90}Sr, uranium, plutonium, and ^{241}Am.

To document the general abundance of the candidate game species present during the collection period, three permanent 1-km (0.62-mi) transects were established in the vicinity of the Plutonium Valley fenced radioactive material area to count jackrabbits, cottontail rabbits, mourning doves, chukar and Gambel's quail. The transects were walked once each on June 17, 2004, June 28, 2004 and July 27, 2004, for a total of nine transects walked. Few target wildlife species were observed. A total of seven doves were recorded and these all occurred on transects walked June 17, 2004. No cottontails were observed on transects but one jackrabbit was observed on a transect walked June 28, 2004. This result was supported by trapping results as jackrabbits and no cottontail rabbits were captured in Plutonium Valley. The number of target species recorded during 2004 was too low to calculate species density.

Table 7-2. Bats and invertebrates sampled at E Tunnel Ponds and E Tunnel Ponds Control Site in 2004

Location	Sample Designation	Sample Composition
E Tunnel Ponds	Bats 1	1 big brown bat (*Eptesicus fuscus)*
	Bats 2	3 fringed myotis (*Myotis thysanodes)* and 2 long-eared myotis *(Myotis evotis)*
	Bats 3	5 long-legged myotis (*Myotis volans)*
	Bats 4	5 small-footed myotis (*Myotis ciliolabrum)* and 1 California myotis (*Myotis californicus)*
	Bats 5	5 small-footed myotis (*Myotis ciliolabrum)*
	Bats 6	7 western pipistrelle *(Pipistrellus hesperus)*
	Inverts	10.3 g(a) invertebrates (from the Orders: Odonata, Lepidoptera, Neuroptera, Diptera, Hymenoptera, Coleoptera, Hemiptera)
Well J-11 Pond (E Tunnel Ponds Control)	Control Bats	8 western pipistrelle *(Pipistrellus hesperus)*

(a) grams wet weight

7.4 Results

7.4.1 Plants

Concentrations of man-made radionuclides detected in 2004 NTS plant samples are shown in Table 7-3. The only man-made radionuclides detected in plant samples were ^{90}Sr, $^{239+240}$Pu, and ^{241}Am. As expected, most of the plant samples collected from the area in Plutonium Valley had detectable levels of radionuclides (primarily $^{239+240}$Pu) and those detectable concentrations were higher than those in plants taken from the control site 24 km (14.9 mi) away.

Table 7-3. Radionuclide concentrations in plants from Pu Valley and Control Site in 2004

	Radioncuclide Concentratons ± Uncertainty(a) (pCi/g)(b)		
Sample	**^{90}Sr**	**$^{239+240}$Pu**	**^{241}Am**
Plutonium Valley			
BFOC #1	0.015 ± 0.022	0.007 ± 0.008	-0.002 ± 0.002
BFOC #2	0.029 ± 0.034	0.010 ± 0.010	0.009 ± 0.013
FWSB #1	0.021 ± 0.042	0.023 ± 0.012	0.011 ± 0.008
FWSB #2	0.072 ± 0.041	0.014 ± 0.010	0.001 ± 0.004
GRB #1	0.026 ± 0.026	0.053 ± 0.017	0.105 ± 0.028
GRB #2	0.027 ± 0.030	0.047 ± 0.017	0.003 ± 0.005
NJF #1	0.015 ± 0.023	0.087 ± 0.019	0.573 ± 0.089
NJF #2	0.029 ± 0.024	0.077 ± 0.023	0.011 ± 0.008
PPP #1	0.047 ± 0.031	0.015 ± 0.009	0.258 ± 0.061
PPP #2	0.028 ± 0.028	0.012 ± 0.008	0.006 ± 0.008
RT #1	0.034 ± 0.024	0.004 ± 0.005	0.001 ± 0.004
RT #2	0.065 ± 0.043	0.008 ± 0.006	0.009 ± 0.009
Percent of Samples Above MDC:	**25%**	**83%**	**42%**
Plutonium Valley - Control			
BWR #1	0.042 ± 0.055	0.001 ± 0.004	0.002 ± 0.004
BWR #2	0.037 ± 0.039	0.003 ± 0.005	0.002 ± 0.005
FWSB #1	0.054 ± 0.048	-0.002 ± 0.003	0.001 ± 0.004
FWSB #2	0.037 ± 0.052	-0.002 ± 0.002	0.001 ± 0.003
GRB #1	0.024 ± 0.048	0.000 ± 0.002	0.001 ± 0.003
GRB #2	0.088 ± 0.068	0.000 ± 0.002	0.005 ± 0.005
GW #1	0.032 ± 0.033	0.007 ± 0.006	0.001 ± 0.004
GW #2	0.023 ± 0.029	-0.002 ± 0.002	0.003 ± 0.005
NJF #1	-0.003 ± 0.050	0.000 ± 0.002	0.007 ± 0.006
NJF #2	-0.014 ± 0.036	0.001 ± 0.003	0.009 ± 0.008
PP #1	0.000 ± 0.028	0.003 ± 0.005	0.001 ± 0.004
PP #2	0.043 ± 0.030	0.002 ± 0.005	-0.001 ± 0.001
Percent of Samples Above MDC:	**0%**	**8%**	**17%**
Average MDC:	**0.062**	**0.009**	**0.011**

Green shaded results are considered detected (result greater than the sample specific MDC

(a) ± 2 standard deviations

(b) picocuries per gram dry weight of sample

7.4.2 *Animals*

No man-made radionuclides were detected in the muscle tissue from the pronghorn antelope killed by a vehicle in Area 5, south Frenchman Flat.

All animals sampled from Plutonium Valley had detectable concentrations of $^{239+240}$Pu and ^{241}Am (Table 7-4). Of these, $^{239+240}$Pu was the only man-made radionuclide detected in muscle tissue (of one mourning dove). It is expected that most plutonium should be detected in the body fraction as plutonium tends to concentrate in bone tissue or be bound with soil in the gut. The other detected man-made radionuclide, ^{238}Pu, was detected only in the body fraction of two jackrabbits and one dove. Barely detectable concentrations of $^{239+240}$Pu were found in two cottontail rabbits and the two quail sampled from the control site (Table 7-4).

Table 7-4. Radionuclide concentrations in animals from Pu Valley and Control Site in 2004

	Radioncuclide Concentrations ± Uncertainty(a) (pCi/g)(b)		
Sample	**^{238}Pu**	**$^{239/240}$Pu**	**^{241}Am**
Plutonium Valley			
Dove #1 (muscle)	0 ± 0.003	0.003 ± 0.004	0.005 ± 0.008
Dove #1 (body fraction)	0.001 ± 0.004	0.15 ± 0.024	0.039 ± 0.018
Dove #2 (muscle)	0.003 ± 0.005	0.012 ± 0.007	0.011 ± 0.01
Dove #2 (body fraction)	0.038 ± 0.014	2.13 ± 0.168	0.294 ± 0.054
Jackrabbit #1 (muscle)	0.002 ± 0.005	0.002 ± 0.006	0.005 ± 0.007
Jackrabbit #1 (body fraction)	0.012 ± 0.009	0.26 ± 0.042	0.059 ± 0.019
Jackrabbit #2 (muscle)	-0.003 ± 0.004	0.005 ± 0.006	0.004 ± 0.006
Jackrabbit #2 (body fraction)	0.008 ± 0.007	0.471 ± 0.066	0.105 ± 0.026
Jackrabbit #3 (muscle)	-0.001 ± 0.003	0.005 ± 0.005	-0.001 ± 0.006
Jackrabbit #3 (body fraction)	0.017 ± 0.011	1.06 ± 0.129	0.201 ± 0.043
Number of Samples above MDC:	**30%**	**60%**	**50%**
Plutonium Valley - Control			
Desert Cottontail #1 (muscle)	0.003 ± 0.006	-0.001 ± 0.004	0.001 ± 0.006
Desert Cottontail #1 (body fraction)	0.002 ± 0.005	0.006 ± 0.006	0.006 ± 0.006
Desert Cottontail #2 (muscle)	0.001 ± 0.006	0.003 ± 0.003	0.004 ± 0.006
Desert Cottontail #2 (body fraction)	-0.002 ± 0.004	0.004 ± 0.005	0.007 ± 0.01
Desert Cottontail #3 (muscle)	0 ± 0.004	0.004 ± 0.003	0.004 ± 0.006
Desert Cottontail #3 (body fraction)	0.01 ± 0.008	0.012 ± 0.008	0.002 ± 0.007
Dove #1 (muscle)	-0.002 ± 0.005	0.005 ± 0.006	0.001 ± 0.006
Dove #1 (body fraction)	0 ± 0.002	0.01 ± 0.008	0.001 ± 0.007
Quail #1 (muscle)	0.001 ± 0.005	0.01 ± 0.008	0.004 ± 0.007
Quail #1 (body fraction)	-0.001 ± 0.004	0.025 ± 0.011	0.003 ± 0.008
Quail #2 (muscle)	-0.002 ± 0.003	-0.001 ± 0.003	-0.001 ± 0.006
Quail #2 (body fraction)	0.001 ± 0.005	0.014 ± 0.008	0.009 ± 0.011
Number of Samples above MDC:	**0%**	**42%**	**0%**
Pronghorn (muscle)	0.003 ± 0.004	-0.003 ± 0.004	0.005 ± 0.006
Number of Samples above MDC:	**0%**	**0%**	**0%**
Average MDC:	**0.01**	**0.009**	**0.015**

Green shaded results are considered detected (result greater than the sample specific MDC

(a) ± 2 standard deviations (b) picocuries per gram dry weight of sample

All biota samples collected from E Tunnel Pond 5 had detectable concentrations of tritium (Table 7-5). Observed tritium concentrations were consistent with levels measured in birds sampled at the E Tunnel ponds in recent years (DOE, 2001b; DOE, 2002d; DOE, 2003c; DOE, 2004d). The composite insect sample also had detectable concentrations of ^{137}Cs and ^{241}Am. Of the composite bat samples, one had detectable concentrations of ^{137}Cs and ^{241}Am and another had a barely detectable concentration of $^{239+240}$Pu. Again, concentrations of these radionuclides observed in the 2004 bat samples were consistent with concentrations observed in birds sampled at E Tunnel Ponds in recent years. There were no man-made radionuclides detected in the composite bat sample collected at the E Tunnel Ponds control site (Table 7-5).

Table 7-5. Radionuclide concentrations in animals from E Tunnel Pond 5 and E Tunnel Control Site

Sample	**Radioncuclide Concentrations ± Uncertainty[(a)]** ^{3}**H (pCi/L)[(b)]**	^{137}**Cs (pCi/g)[(c)]**	$^{239/240}$**Pu (pCi/g)**	^{241}**Am (pCi/g)**
E Tunnel				
Bats 1	66471 ± 1857	0.103 ± 0.107	0.004 ± 0.003	0 ± 0.001
Bats 2	60312 ± 2002	0.206 ± 0.195	0 ± 0.016	0.003 ± 0.004
Bats 3	50631 ± 1609	0.638 ± 0.164	0.007 ± 0.016	0.008 ± 0.006
Bats 4	19110 ± 1328	0.081 ± 0.09	-0.01 ± 0.015	0.001 ± 0.004
Bats 5	15081 ± 1194	0.088 ± 0.094	0.013 ± 0.018	0.002 ± 0.003
Bats 6	43111 ± 1956	0.016 ± 0.324	-0.01 ± 0.021	0.004 ± 0.005
Percent of Samples Above MDC:	**100%**	**17%**	**17%**	**17%**
Inverts	42014 ± 2030	0.31 ± 0.236	0 ± 0.003	0.008 ± 0.006
Percent of Samples Above MDC:	**100%**	**100%**	**0%**	**100%**
E Tunnel - Control				
Control bats	62 ± 897	0.03 ± 0.056	0.002 ± 0.003	0 ± 0.001
Percent of Samples Above MDC:	**0%**	**0%**	**0%**	**0%**
Average MDC:	**1189**	**0.139**	**0.027**	**0.007**

Green shaded results are considered detected (result greater than the sample specific MDC)

(a) ± 2 standard deviations

(b) picocuries per liter of water distilled from the sample

(c) picocuries per gram dry weight of sample

7.5 *Environmental Impact*

As expected, radionuclides were detected in biota sampled in Plutonium Valley and near the E Tunnel Ponds. These were locations associated with historic testing of nuclear weapons. While these radionuclides were detected, they pose negligible risk to humans. The potential dose to a person hunting and consuming these animals is well below dose limits to members of the public (see Section 8.1.4). Also, radionuclide concentrations were below levels considered harmful to the health of the plants or animals as the dose resulting from observed concentrations were less than 1 percent of dose limits set to protect populations of plants and animals (see Section 8.2).

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8.0 Radiological Dose Assessment

U.S. Department of Energy (DOE) Order 450.1 *Environmental Protection Program* and DOE Order 5400.5 *Radiation Protection of the Public and the Environment* (see Section 2.3) require 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. This chapter uses data gathered in 2004 and radiation surveys in the past that inventoried the radionuclide content of NTS surface soils to estimate these radiological doses with the aid of mathematical models. The data used are presented in Sections 3.0 through 7.0 of this report and include the 2004 results for onsite compliance monitoring of air, water, and biota, and the offsite monitoring results of air and water conducted under the Community Environmental Monitoring Program (CEMP). Estimated doses calculated and presented in this chapter must fall below the limits established by DOE in order to demonstrate that the general public and the environment are not exposed to hazardous levels of radioactivity from the NTS. The specific goals for the dose assessment component of radiological monitoring are shown below along with the compliance measures which are calculated in order to accomplish these goals.

Radiological Dose Assessment Goals	***Compliance Measures***
Determine if the maximum radiation dose to a member of the general public from airborne radionuclide emissions at the NTS is less than the Clean Air Act, National Emission Standards for Hazardous Air Pollutants limit of 10 millirems per year (mrem/yr) (0.1 millisieverts [Sv]/yr)	Committed effective dose equivalent (CEDE) (see Glossary, Appendix D) for an offsite maximally exposed individual (MEI) from air emissions, in mrem/yr (or mSv/yr)
Determine if the total radiation dose to a member of the general public from all possible pathways (direct exposure, inhalation, ingestion of water and food) as a result of NTS operations is less than the limit of 100 mrem/yr established by DOE Order 5400.5	CEDE for an offsite MEI from all pathways, in mrem/yr (or mSv/yr)
Determine if the absorbed radiation dose to NTS biota is less than the following limits set by DOE Order 5400.5 and DOE Standard DOE-STD-1153-2002: < 1 rad/day for terrestrial plants and aquatic animals < 0.1 rad/day for terrestrial animals	Absorbed dose to onsite plants and animals, in rad/day

8.1 Radiological Dose to the Public

Several steps are taken to compute radiological dose to the public from all pathways. Many sources of information and mathematical models are used. This section briefly describes these steps, identifies how field monitoring data interface with other NTS data sources (e.g., radionuclide inventory data, climatological data) to provide input to the mathematical models, identifies the mathematical models, and presents the results of each step.

8.1.1 Determining Human Exposure Pathways

As prescribed in the *Routine Radiological Environmental Monitoring Plan* (RREMP) (DOE, 2003b), BN routinely samples air, groundwater, and biota 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.

The potential pathways by which a member of the general public can receive a radiation dose resulting from past or present NTS operations include:

- Exposure of the body to direct radiation in the environment resulting from radionuclides being transported off the NTS by winds and deposited on the ground offsite
- Inhalation of airborne radionuclide emissions transported offsite by wind
- Ingestion of meat from migratory wild game animals which drink from surface waters and eat vegetation containing NTS-related radioactivity
- Ingestion of water from underground aquifers containing radionuclides which have migrated from the sites of past underground nuclear tests

Since the migration of radioactivity in groundwater has not been detected in the past or in 2004 (see Section 4.1), exposure through ingestion of water was not considered in the 2004 calculated dose to public. Air and biota monitoring results indicated there was a potential for offsite residents to receive a radiation dose from past or current activities on the NTS from the first three pathways.

8.1.2 Identifying Onsite Sources and Radionuclide Air Emission Rates

An atmospheric diffusion model called Clean Air Package 1988, Version 2.0 (CAP88-PC) is used, according to 40 CFR, Part 61, Subpart H, for calculating the radiation CEDEs received by hypothetical offsite receptors from airborne emissions. To use this model, certain factors must be identified and quantified. Two of these factors include: (1) location of all potential sources of radioactive air emissions on the NTS, and (2) radionuclides released from these locations, in Ci/yr. These sources for calendar year (CY) 2004 were:

- Release of tritium during the calibration of equipment at Building 650, Area 23
- The re-suspension of surface soil contaminated by past nuclear testing at NTS
- The evaporation of tritiated water discharged from post-shot wells and E Tunnel
- The evaporation and transpiration of tritiated water from soil and vegetation, respectively, at sites of past nuclear tests and from the Area 3 and Area 5 RWMSs

Table 8-1 presents those locations which were potential sources of radioactive emissions in 2004. The radionuclide emission rates (in Ci/yr) at each site are also presented. Brief descriptions of the methods used for estimating these quantities are given in the table footnotes. More detailed descriptions of the methods and emission sources are reported in Grossman (2005). Note that in the last row of the table, the total amounts of ^{241}Am and $^{239+240}$Pu emissions from soil re-suspension are presented. They are the sum of emission rates computed (see footnote [d]) for each area of the NTS with surface contamination (Areas 1-11, 12, 13, 15, 16, 17, 18, 19, 20, and 30). Other radionuclides (^{60}Cs, ^{90}Sr, ^{137}Cs, ^{152}Eu, ^{154}Eu, ^{155}Eu, and ^{238}Pu), although found in surface soils by past radiation surveys, were not included because combined, they contributed only ten percent or less to the total dose of the MEI.

8.1.3 Calculating Dose to Humans from NTS Air Emissions

The radiation doses to offsite residents from airborne NTS emissions are estimated with the CAP88-PC software. The following variables are entered into the software for each point/grouped source:

- Distance and appropriate compass sector for each populated location within 80 km (50 mi) of each emission source
- The calculated annual radionuclide emission rates (Table 8-1)
- The estimated annual emission rates for each of the NTS areas with surface contamination (Areas 1-11, 12, 13, 15, 16, 17, 18, 19, 20, and 30) (shown summed for "Grouped NTS Areas" in Table 8-1)

- Wind data collected in 2004 from meteorological data acquisition stations (see Section 16.0) such as wind direction, frequency, and stability classification
- A rural food source scenario (versus an urban scenario), which conservatively assumes that all food at the populated areas around the NTS was either home-produced or obtained from within the 80-km radius assessment area. The CAP88-PC software applies factors to estimate the deposition of airborne radionuclides onto crops and soil, their uptake into crops, and their transfer to milk and meat.

Table 8-1. Radiological atmospheric releases from NTS for 2004 used in the CAP88-PC model

Source	Radionuclide	Quantity (Ci)
Area 23 Building 650	^{3}H	0.000042(a)
Area 12 E Tunnel Ponds	^{3}H	12(b)
Well U-3cn PS#2A	^{3}H	0.52(b)
Well U-19ad PS#1A	^{3}H	18(b)
Well ER-20-5 #1	^{3}H	4.5(b)
Well ER-20-5 #3	^{3}H	0.020(b)
Area 3 RWMS	^{3}H	83(c)
Area 5 RWMS	^{3}H	4.9(c)
Area 10 Sedan	^{3}H	200(c)
Area 20 Schooner	^{3}H	240(c)
All Sources Total	**^{3}H**	**560**
Grouped NTS Areas Total	**^{241}Am**	**0.047(d)**
Grouped NTS Areas Total	**$^{239+240}Pu$**	**0.29(d)**

(a) Quantity of tritium gas released during the calibration of laboratory equipment.

(b) Estimated from tritium concentration in water discharged into containment ponds or open tanks, assuming all water was completely evaporated during the year.

(c) Estimated from calculations with CAP88-PC software and annual mean concentration of tritium in air measured by air sampling at a location near the emission source.

(d) Calculated from inventory of radionuclides in surface soil determined by Radionuclide Inventory and Distribution Program (DOE, 1991), a re-suspension model (NRC, 1983), and equation parameters derived at the NTS (DOE, 1992).

The variables referenced above were entered into the CAP88-PC model, and the CEDEs for an individual living within each populated area was computed for each emission source location on the NTS. These calculated CEDEs were then summed to determine the annual total CEDEs at each offsite population area within 80 km of the emission sources.

Based on these calculations for CY 2004, the location of the MEI (the hypothetical individual receiving the highest offsite dose) was Cactus Springs, Nevada, where the CEDE was 0.12 mrem/yr (0.0012 mSv/yr) (Figure 8-1). This dose is well below (only 1.2 percent of) the National Emission Standards for Hazardous Air Pollutant (NESHAP) limit of 10 mrem/yr (0.1 mSv/yr) and is consistent with the estimates computed for past years (1996 to the present) (Figure 8-2).

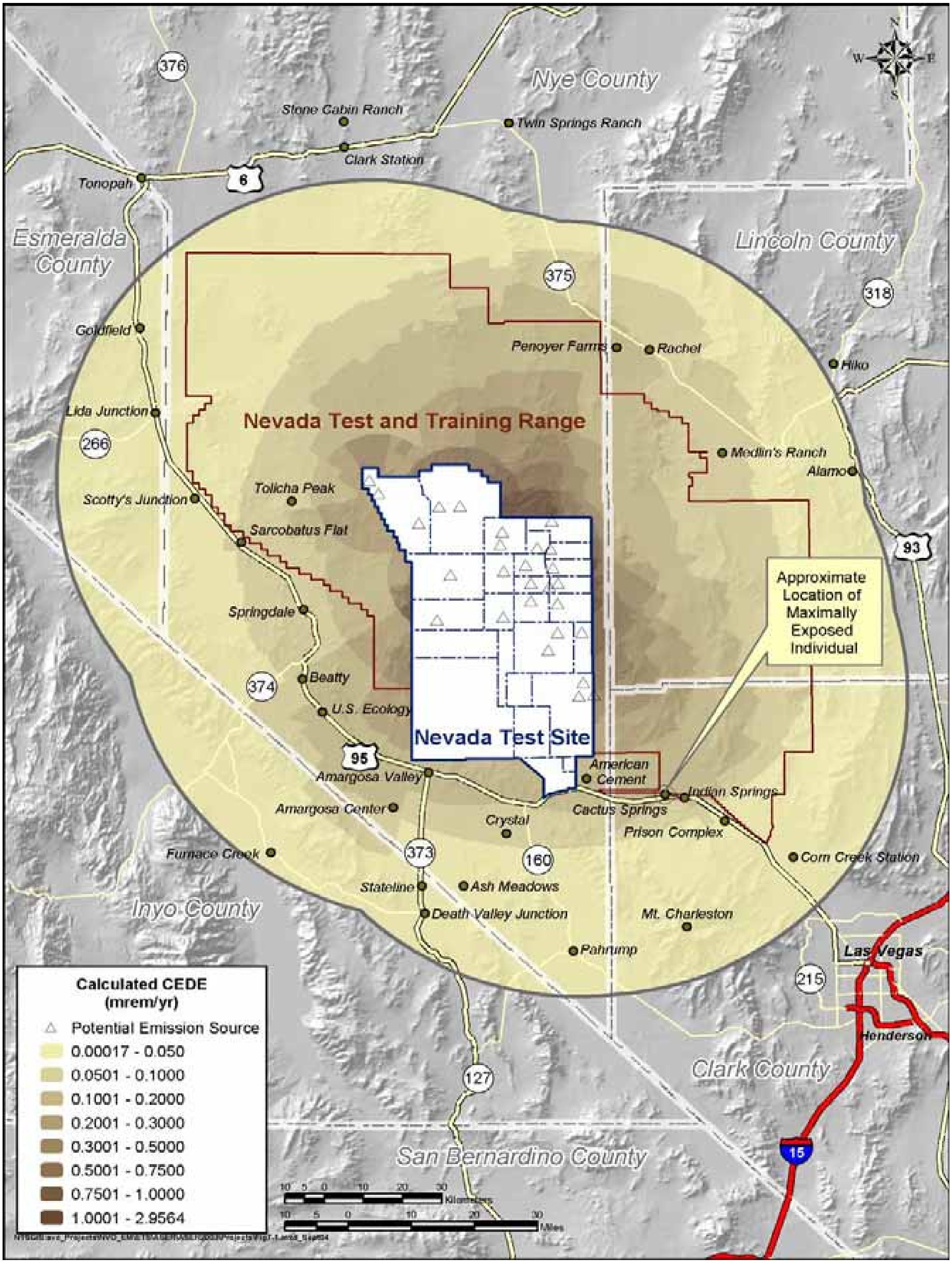

Figure 8-1. Map of the NTS showing CY 2004 CEDEs within 80 km of emission sources

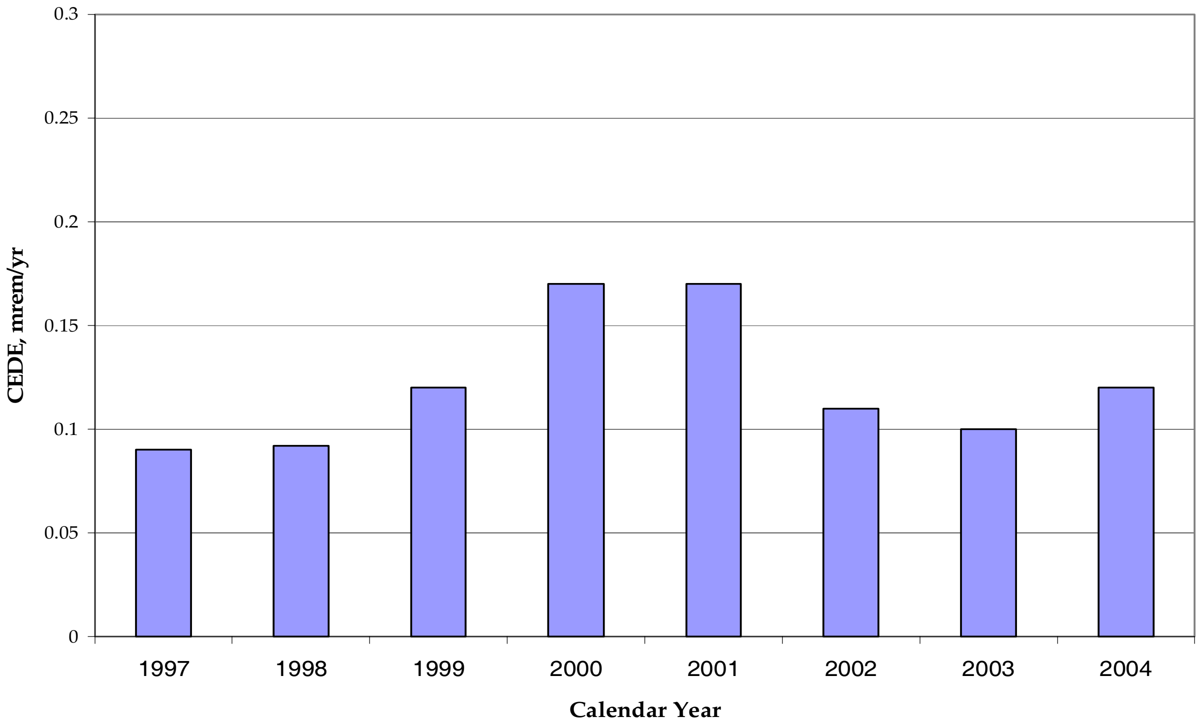

Figure 8-2. Radiation dose to MEI offsite who is not consuming game animals from the NTS

8.1.4 Calculating Dose to Humans from Ingestion of Wild Game from the NTS

Though there are few data suggesting that NTS small game animals travel offsite and become available to hunters, they are sampled on the NTS near contaminated areas as a conservative (worst case) estimate of the levels of radionuclides that hunters may consume if game animals did leave the NTS and were harvested. Radiation doses from the ingestion of game animals presented here are calculated from measurements of the radionuclide concentrations in game animals trapped near sites where the soil, vegetation, and/or water sources are known to be contaminated with radioactivity from past nuclear tests (see Section 7.0).

The only man-made radionuclide detected in muscle tissue of game animals sampled during 2004 was $^{239+240}$Pu. The concentration of $^{239+240}$Pu measured in the muscle tissue of one mourning dove sampled at Plutonium Valley and in two cottontail rabbits and one quail sampled at the Plutonium Valley control site are shown in Table 8-2. There were no man-made radionuclides detected in the muscle tissue of jackrabbits and other doves sampled from Plutonium Valley, nor in one mourning dove or other cottontail rabbits and quail sampled at the Plutonium Valley control site (see Section 7.0). The following assumptions were made for calculating the dose to an individual eating game animals sampled from the NTS during 2004:

- One individual consumed 20 doves, 20 cottontail rabbits, and 20 quail over the year (these numbers are the possession limits set for these species by the Nevada Division of Wildlife)
- Each game animal that an individual consumed contained the average concentration of radionuclides detected in muscle tissue for that species sampled
- The amount of dove meat an individual consumed per animal was the average weight of the dove breast muscle samples
- The amount of rabbit or quail meat consumed was the average weight of muscle on the animals sampled
- The moisture content of game meat consumed was equivalent to the average moisture content measured in muscle tissue samples

The CEDE was calculated using dose conversion factors (DOE, 1988) multiplied by the total activity estimated to be consumed for each of the detected radionuclides. The resultant potential doses from consuming mourning doves, cottontail rabbits, and quail are shown in Table 8-2.

Table 8-2. Hypothetical annual dose to a human consuming NTS game animals sampled in 2004

Animal Sampled	Average Wet Weight of Muscle Tissue Consumed	Average % by Weight of Water	Average $^{239+240}$Pu in Muscle (pCi/g dry wt)	Dose Conversion Factor (mrem/pCi ingested)[(a)]	CEDE (mrem)
<u>Plutonium Valley</u>					
Mourning dove	501[(b)]	71	0.007	0.0043	0.005
<u>Plutonium Valley Control</u>					
Desert cottontail	2790[(c)]	72	0.002	0.0043	0.007
Gambel's quail	946[(d)]	74	0.005	0.0043	0.005

(a) Dose conversion factors for human ingestion from DOE (1988)
(b) Assumed breast meat from 20 mourning doves was consumed and each breast weighed 25.1 g
(c) Assumed all meat from 20 cottontail rabbits was consumed and the meat on each weighed 139.5 g
(d) Assumed all meat from 20 quail was consumed and the meat on each weighed 47.3 g

Detected $^{239+240}$Pu concentrations were highest in the dove from Plutonium Valley, but the calculated dose to a hunter from consuming Plutonium Valley doves was equal to or slightly less than that computed from consuming quail or cottontails, respectively, from the control site. This is an artifact of the difference in the amount of muscle tissue on doves versus larger quail and cottontails. The amount of muscle tissue from quail and cottontails is approximately two to six times greater than from doves.

The highest CEDE from game animals sampled during 2004 was 0.007 mrem (0.00007 mSv) which is only 0.007 percent of the annual dose limit for members of the public. To put this potential dose in perspective, the dose from naturally-occurring cosmic radiation received during a one hour airplane ride at 39,000 ft is about 0.5 mrem (0.005 mSv) or over 70 times higher than the highest dose that would result from consuming game animals sampled during 2004.

Radionuclide concentrations in game animals sampled from Plutonium Valley during 2004 were not as high as in those sampled from other contaminated NTS locations in recent years (Table 8-3), and sources of contamination at other NTS locations are still present. Therefore, the dose to a maximally exposed individual was calculated by assuming one person ate game animals that would yield the highest potential dose, based on animal sampling data from 2000 - 2003 (Table 8-4). Although the probability is virtually zero that one person would eat 20 doves and 20 chukar from the E Tunnel ponds, 20 quail and 20 jackrabbits from the T2 site, and one pronghorn from Area 5; the resulting worst-case dose is 0.39 mrem (Table 8-4). This is about 0.4 percent of the annual dose limit for members of the public and still less than the dose from cosmic radiation received while on a one hour plane ride at 39,000 ft.

Table 8-3. Hypothetical annual dose to a human consuming NTS game animals sampled in 2000-2003

Year	Location	Species	Dose (mrem CEDE)	Data Reference
2000	E-Tunnel	Mourning Doves	0.16	DOE, 2001b
2001	E-Tunnel	Chukar	0.07	DOE, 2002d
2002	E-Tunnel	Mourning Doves	0.02	DOE, 2003c
	T2	Gambel's Quail	0.08	
	T2	Jackrabbit	0.11	
2003	E-Tunnel	Mourning Doves	0.02	DOE, 2004d
	Palanquin	Mourning Doves	0.01	
	Area 5	Pronghorn	0.06	

Table 8-4. Hypothetical worst-case dose to the MEI consuming NTS game animals based on all years of sampling

Species / Location	CEDE (mrem)	Assumptions
Mourning dove/E-Tunnel	0.07	Average dose from eating 20 doves from E Tunnel (2000, 2002, and 2003)
Chukar/E-Tunnel	0.07	Dose from eating 20 chukar from E Tunnel (2001)
Gambel's quail/T2	0.08	Dose from eating 20 quail from T2 (2002)
Jackrabbit/T2	0.11	Dose from eating 20 jackrabbit from T2 (2002)
Pronghorn antelope/Area 5	0.06	Dose from eating 1 pronghorn from Area 5 (2003)
Total to MEI	**0.39**	

8.1.5 Estimating Dose to the Public from Release of Property Containing Residual Radioactive Material

DOE's radiation protection framework and dose limits are centered around an "all sources and all pathways" philosophy. In addition to radiological air and water discharges to the environment reported in Sections 3.1 and 4.1, respectively, the release of property off of the NTS which contains residual radioactive material is another type of "release" to the environment. It is a potential contributor to the dose received by the public. This section describes release criteria, materials released during the reporting year, and the resultant dose to the public as a result of any releases.

No vehicles, equipment, structures, or other materials are released from the NTS unless the amount of radiological contamination on such items is less than the authorized limits specified in the NV/YMP Radiological Control Manual (Table 8-5) (DOE, 2000b). These limits are taken from DOE Order 5400.5 *Radiation Protection of the Public and the Environment.* Items proposed for unrestricted release must be surveyed to document compliance with the release criteria. The detailed survey requirements are contained in BN's Organizational Instruction (OI) 0441.212, *Controlled and Unrestricted Release.*

In 2000, DOE placed a moratorium on the release of scrap material from radiological areas for recycling. This moratorium is still in effect. Government vehicles and equipment are routinely released or excessed when they are no longer needed by NTS projects or if they are required to be replaced. They are permitted to be released based on a combination of process knowledge and direct and indirect surveys such that the release criteria of Table 8-5 are met. BN Radiological Control does not authorize the release of materials off the NTS that have detectable radioactivity above background levels, however, even if these levels are less than the criteria levels shown in Table 8-5. During 2004, no vehicles, equipment, or other materials with detectable residual radioactivity were released.

Due to the potential for volumetric contamination of building structures that once housed uncontained contamination, the surveys for release of structures are not in a procedure. Instead, the criteria for unrestricted release of structures with potential or actual residual radioactivity are determined through agreements between the affected stakeholders, e.g., DOE and the state of Nevada. There were no releases of such structures in 2004.

NTS materials released for unrestricted use in 2004 contained no residual radioactivity, therefore, no radiological dose to the public from such materials was incurred.

Table 8-5. Allowable total residual surface contamination

	Residual Surface Contamination (dpm/100 cm^2)		
Radionuclide	**Removable**	**Total (Fixed & Removable)**	**Maximum Allowable 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	1,000	5,000	15,000
Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except ^{90}Sr and others noted above	1,000	5,000	15,000

Source: DOE, 2000b

8.1.6 *Total Offsite Dose to the Maximally Exposed Individual (MEI)*

As mentioned in Section 8.1.3, the location of the MEI was Cactus Springs, Nevada, where the CEDE was 0.12 mrem/yr (0.0012 mSv/yr) based on the CAPP88-PC model. This dose of 0.12 mrem/yr is the offsite dose to the MEI due to NTS emissions from all pathways except ingestion of NTS game animals. This estimate for CY 2004 is consistent with those from 1996 to the present (see Figure 8-2).

If the MEI at Cactus Springs was also a hunter harvesting and ingesting the list of game animals shown in Table 8-4, the person would receive an estimated additional 0.39 mrem/yr (0.0039 mSv/yr) dose. Their total CEDE would be 0.51 mrem/yr (0.0051 mSv/yr).

The dose of 0.51 mrem/yr is the total offsite dose to the MEI due to NTS emissions given all feasible pathways of exposure. It is 0.51 percent of the DOE limit of 100 mrem/yr, and it is 0.15 percent of the total dose the MEI would receive from natural background radiation (340 mrem/yr) (Figure 8-3). Natural background radiation consists of cosmic radiation, terrestrial radiation, radiation from radionuclides (primarily ^{40}K) within the composition of the human body, and radiation from the inhalation of naturally-occurring radon and its progeny.

The cosmic and terrestrial components of background radiation (100 mrem/yr) were estimated from the annual mean radiation exposure rate measured with a pressurized ion chamber (PIC) at Indian Springs by the CEMP (see Section 6.0, Table 6-4). The radiation exposure in air measured by the PIC in units of mR/yr is approximately 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 as 40 mrem/yr and 200 mrem/yr, respectively, using the approximations by the National Council on Radiation Protection (NCRP, 1996) (Figure 8-3).

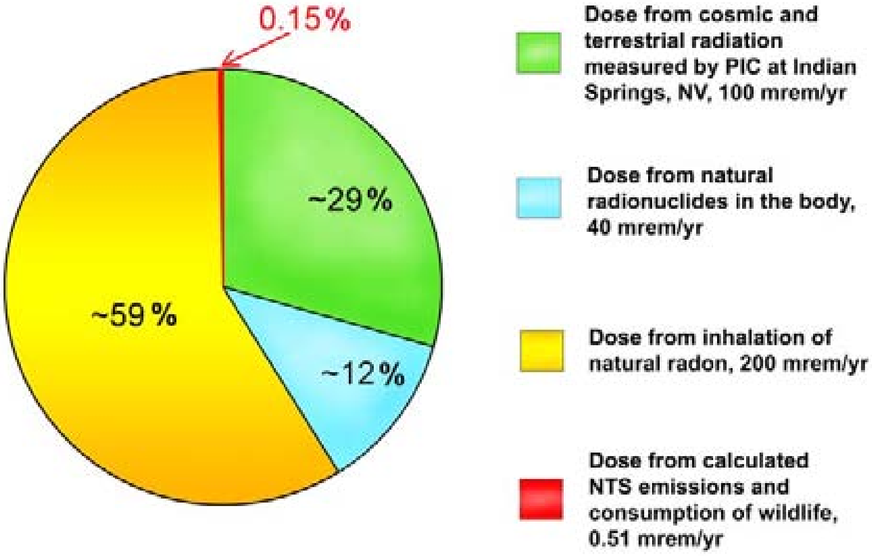

Figure 8-3. Comparison of radiation dose to the MEI and the natural radiation background (percent of total)

8.1.7 *Collective Population Dose*

Approximately 43,000 persons live within an 80-km radius of the NTS (Hardcastle, 2005). The collective population dose (see Glossary, Appendix D) from NTS operations is the sum of the CEDEs to all individuals within the 80-km radius of the NTS (see Figure 8-1). The dose calculation does not include those working onsite. It is intended to calculate doses to residents at their homes. The 2004 collective population dose attributable to NTS operations to persons living within 80 km of the NTS was estimated to be 0.47 person-rem/yr (Table 8-6). This population dose is

comparable to the population dose of 0.45 person-rem reported for 2003 (DOE, 2004d).

Table 8-6. Radiological dose to the general public from 2004 NTS operations

	Dose to Maximally Exposed Individual		Percent of DOE 100-mrem/yr Limit	Estimated Collective Population Dose(a)	
Pathway	(mrem/yr)	(mSv/yr)		(person-rem/yr)	(person-Sv/yr)
Air	0.12	0.0012	0.12	0.47(a)	0.0047
Water	0	0	0	0	0
Wildlife	0.39	0.0039	0.39	U(b)	U
All Pathways	0.51	0.0051	0.51	0.47(c)	0.0047

(a) Sum of radiation doses from all emission sources at each populated location within 80 km of emission sources multiplied by the population at each location, and then summed over all locations.

(b) Unable to make this estimate due to a lack of data on number of game animals harvested near the NTS by hunters in 2004.

(c) The dose contribution from wildlife is not included. It is likely to be negligible when averaged over the entire population within an 80-km radius.

8.2 Dose to Aquatic and Terrestrial Biota

DOE Order 450.1 *Environmental Protection Program* requires DOE facilities to evaluate the potential impacts of radiation exposure to biota in the vicinity of DOE activities. DOE Standard 1153-2002 *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (DOE, 2002a) was developed by DOE's Biota Dose Assessment Committee to assist in such an evaluation. The following radiological dose limits were established (DOE, 2002a). Dose rates equal to or less than these are expected to have no direct, observable effect on plant or animal reproduction:

- 1 rad/day (0.01 Gy/day) for aquatic animals
- 1 rad/day (0.01 Gy/day) for terrestrial plants
- 0.1 rad/day (1 mGy/day) for terrestrial animals

The goal for the NTS biota dose assessment component of radiological monitoring is to determine if the established dose limits shown above are exceeded at the NTS using the graded approach for dose evaluation described in DOE Standard 1153-2002. The standard 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 maximum concentration of a radionuclide that would not cause dose limits to be exceeded using very conservative uptake and exposure assumptions.

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

A comprehensive biota dose assessment for the NTS using the graded approach was reported in the 2003 NTSER (DOE, 2004d). This section summarizes the results of the 2003 assessment that remain valid and presents new data related to contaminated habitats (tritiated water sumps from UGTA wells drilled in 2004) and to site-specific biota monitoring conducted in 2004.

8.2.1 Summary of 2003 Dose Assessment

Surface areas on the NTS contaminated with radionuclides were identified by the Radionuclide Inventory and Distribution Program (RIDP) conducted from 1981 through 1986. These areas were used as dose evaluation areas (DEAs) for assessing potential dose to biota (Figure 8-4). RESRAD-BIOTA software (DOE, 2004e) was used to compare concentrations of radionulcides in the environment (soil, water, and sediment) to BCG values. The first evaluation step was to conduct a Level 1 screen which compared the <u>maximum</u> concentrations of radionuclides in surface soils with BCG values. The second step was to conduct a Level 2 screen which compared the <u>average</u> concentrations of radionuclides in surface soils with BCG values. Both steps demonstrated that the potential radiological dose to biota within the DEAs from sources present in 2003 was not likely to exceed dose limits (Figure 8-5). Seven DEAs passed the Level 1 screen, and all DEAs except Sedan passed the Level 2 screen (Figure 8-5). Vegetation samples collected near Sedan in 2000 (DOE, 2001), however, had radionuclide concentrations that would result in doses much lower than the dose limits. The Level 1 and 2 screens conducted in 2003 were based on data of known surface soil contamination from historical nuclear weapons testing on the NTS. No data exist to suggest that NTS surface contamination conditions have changed, therefore, the biota dose evaluation conclusion remains the same for 2004.

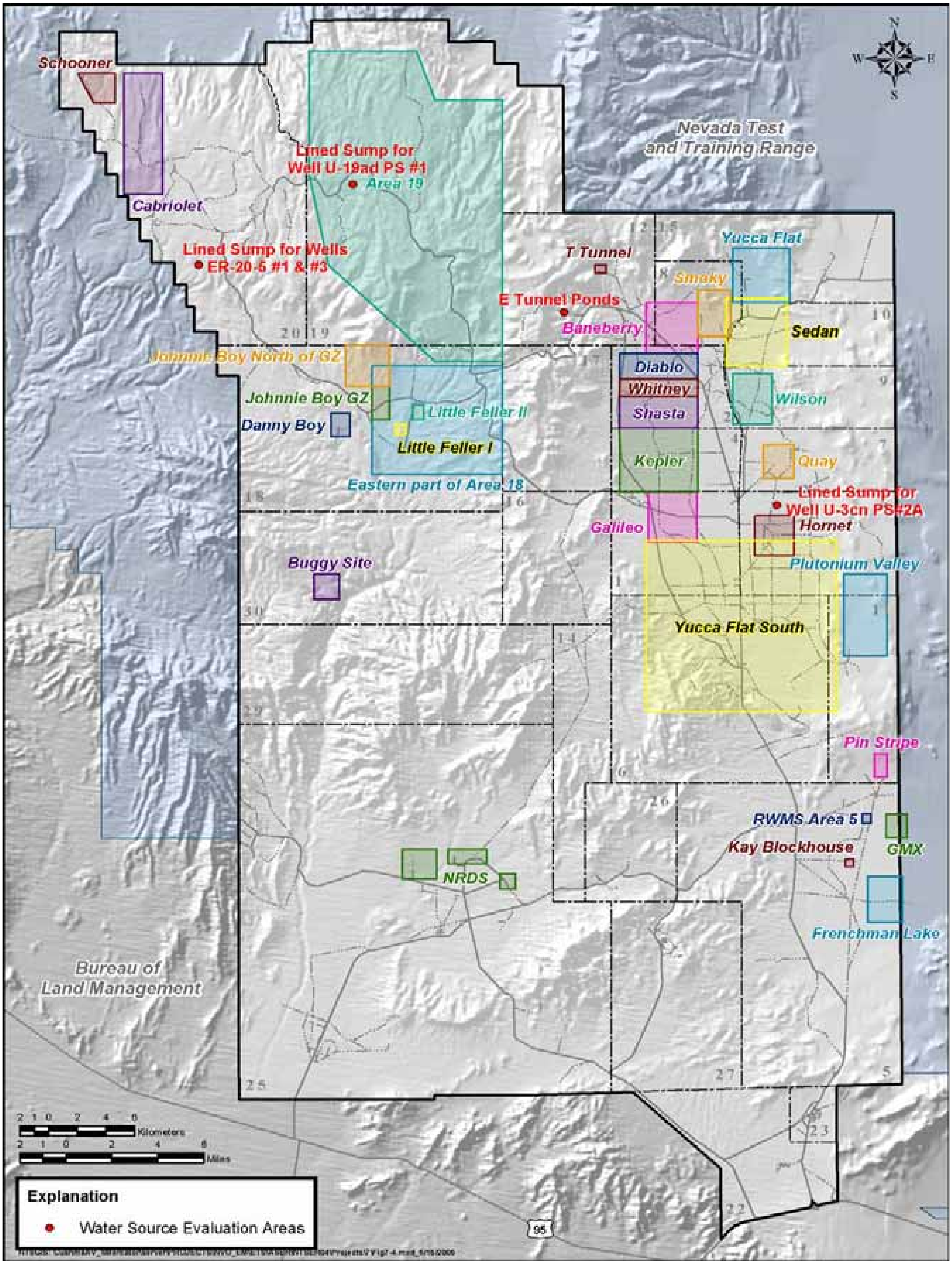

Figure 8-4. Terrestrial and aquatic dose evaluation areas for assessing potential dose to biota

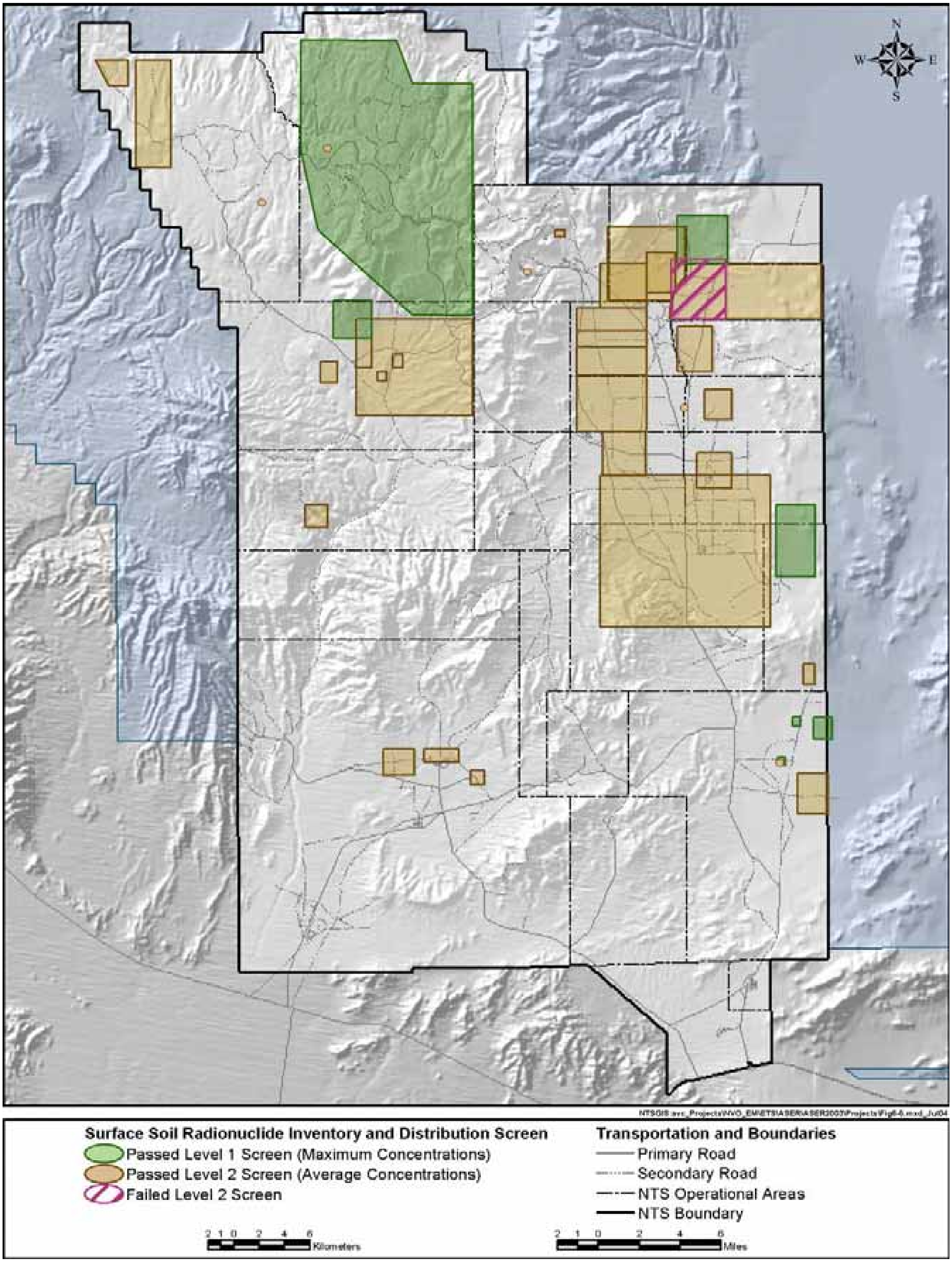

Figure 8-5. Results of Level 1 and Level 2 Screens for dose evaluation areas on the NTS

8.2.2 New Radionuclide Sources Accessible to Biota in 2004

There were four new temporary water sources created in late 2004 which contained radioactivity. These were lined sumps that received water pumped from four UGTA wells near underground nuclear weapons test locations. These were wells ER-20-5 #1, ER-20-5 #3, U-3cn PS #2A, and U-19ad PS #1A (see Section 4.1.10). Because these water sources dry up in a matter of months, they are not considered aquatic nor riparian habitat (there is no vegetation growing on the shores of these plastic-lined ponds). They are, however, water sources for terrestrial animals living in the area. Available radionuclide concentrations in these water sources were compared with BCGs. In all instances, radionuclide concentrations were well below the BCG values, suggesting that the dose limit for terrestrial biota that may drink from these sumps are not being exceeded (Table 8-7).

Table 8-7. Biota dose assessment to terrestrial biota for temporary water sources created on the NTS in 2004

	Sample Concentration		Ratio of Maximum Sample Concentration to BCG[(a)]		
Sump Water Source	**^{3}H (x 10^{5} pCi/L)**	**^{137}Cs (x 10^{5} pCi/L)**	**^{3}H**	**^{137}Cs**	**Sum of Fractions[(b)]**
ER-20-5 #1	380	NA[(c)]	0.165	-	0.165
ER-20-5 #3	1.13	NA	0.000489	-	0.000489
U-3cn PS #2A	79.0	NA	0.0342	-	0.0342
U-19ad PS #1A	220	0.530	0.0952	0.0885	0.184

Source of sample concentrations: Eaton, 2005 (personal communication)

(a) Biota Concentration Guide (BCG) for ^{3}H in water for terrestrial biota is 2.31 x 10^{8} pCi/L, and the BCG for ^{137}Cs in water for terrestrial biota is 5.99 x 10^{5} pCi/L.

(b) Per the graded approach (DOE, 2002a), biota dose limits are not exceeded if the sum of fractions of the maximum radionuclide concentrations divided by the radionuclide's BCG value is less than 1.0.

(c) Data not available.

8.2.3 2004 Site-Specific Biota Dose Assessment

Most of the graded approach for assessing dose to biota is based on radionuclide concentrations in soil, water, and sediment. The site-specific biota dose assessment phase however, centers on the actual collection and analysis of biota from DEAs. This section presents estimates of site-specific doses to biota in two DEAs from which plants and animals were sampled in 2004.

Animal samples were collected from two contaminated sites: the Plutonium Valley site in the Plutonium Valley DEA and the E Tunnel Ponds inside the E Tunnel Ponds DEA (Figure 8-4). Plant samples were collected from the Plutonium Valley site, but not the E Tunnel Ponds site. Sampling methods and radionuclide concentrations in these 2004 samples are presented in Section 7.0.

Internal and external dose coefficient factors, discussed in the graded approach methodology (Section 2, Module 3 of DOE, 2002a), were used with the measured concentrations found in the biota samples (see Section 7.0) to obtain dose rate estimates for both plants and animals. The external dose rate was estimated by summing the product of average concentrations in soil and the external dose coefficients for each detected radionuclide. The internal dose rates for biota were estimated by summing the product of average concentrations of radionuclides detected in the biota samples and the internal dose factors. The external dose rate estimate was then added to the internal estimate to obtain a total dose rate estimate for plants and animals.

Average doses were estimated to be 0.0009 rad/day for animals (0.0007 rad/day for jackrabbits and 0.001 rad/day for doves) and 0.0004 rad/day for plants in Plutonium Valley (Table 8-8). Internal dose was higher than external dose; about 87 percent and 70 percent of the estimated dose to animals and plants, respectively, came from internally deposited radionuclides. The estimated dose rates are ≤ 1.0 percent and 0.04 percent of the dose limits, respectively, for terrestrial animals and plants. For bats residing at the E Tunnel Ponds, average doses were estimated to be 5×10^{-4} rad/day which is 0.5 percent of the dose limit to terrestrial animals.

Table 8-8. Site-specific dose assessment results for terrestrial plants and animals sampled on the NTS

	Estimated Radiological Dose (rad/day)			
DEA	**Animals**		**Plants**	
Plutonium Valley	Plutonium Valley jackrabbits (a)	0.0007	Plutonium Valley vegetation (b)	0.0004
Plutonium Valley	Plutonium Valley doves (a)	0.001		
E Tunnel Ponds	E Tunnel pond bats	0.0005	(*not sampled in 2004*)	-
DOE Dose Limit		**0.1**		**1.0**

(a) See Table 6-3 of this report
(b) See Table 6-1 of this report

8.2.4 *Environmental Impact*

Based on the graded approach for assessing potential dose to biota, plants and animals on the NTS are not expected to be exposed to significantly large radiological doses that may be detrimental to their populations. Work will continue to refine this dose assessment, especially in the area of defining DEAs. Boundaries of plant and animal populations intersecting contaminated areas will be evaluated in an attempt to ensure that potential populations within currently defined DEAs are not missed.

9.0 Waste Management and Environmental Restoration

Several federal and state regulations govern the safe management, storage, and disposal of radioactive, hazardous, and solid wastes generated or received on the Nevada Test Site (NTS) for the purpose of protecting the environment and the public (see Section 2.4). This section describes both the waste management and environmental restoration operations conducted under the U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office (NNSA/NSO) Environmental Management Program and summarizes the activities performed in 2004 to meet all environmental/public safety regulations. The goals of the program are shown below. The compliance measures and actions tracked and taken to meet the program goals are also listed.

Waste Management and Environmental Restoration Goals	Compliance Measures/Actions
Manage and safely dispose of the following wastes generated by NNSA/NSO and Department of Defense (DoD) operations: Low-level radioactive waste (LLW) Mixed low-level radioactive waste (MW) Hazardous waste	Completion/maintenance of documents required for a Class II Nuclear Facility
	Establishment of Waste Acceptance Criteria for radioactive wastes received for disposal/storage
	Volume of disposed LLW
Continue to characterize, inspect, repackage, load, and ship transuranic (TRU) wastes stored on an interim basis at the NTS to the Waste Isolation Pilot Plant in Carlsbad, New Mexico	Volume of stored non-radioactive hazardous waste
	Volume of disposed MW
	Weight of approved explosive ordnance wastes detonated
Characterize and remediate historic sites contaminated by NNSA/NSO testing activities	Vadose zone monitoring
	Groundwater monitoring
Manage and safely dispose of solid/sanitary wastes generated by NNSA/NSO	Site characterization, remediation, closure, and post-closure site monitoring
	Weight and volume of solid waste disposed

9.1 Radioactive Waste Management

U.S. Department of Energy (DOE) Order 435.1 *Radioactive Waste Management* requires that DOE radioactive waste management activities shall be systematically planned, documented, executed, and evaluated. Radioactive waste is managed to protect the public, the environment, and workers from exposure to radiation from radioactive materials and to comply with all applicable federal, state, and local laws and regulations, Executive Orders, and DOE directives. The major tasks within Radioactive Waste Management include:

- Characterization of LLW and MW that has been generated by the DOE within the state of Nevada
- Disposal of LLW and MW at the Radioactive Waste Management Complex (RWMC) comprised of the Area 3 Radioactive Waste Management Site (RWMS) and the Area 5 RWMS
- Characterization, visual examination, and repackaging of TRU waste at the Waste Examination Facility (WEF) at the RWMC
- Loading of TRU waste at the Mobile Loading Unit (MLU) for shipment to the Waste Isolation Pilot Plant (WIPP) at Carlsbad, New Mexico

9.1.1 *Maintenance of Key Documents*

Table 9.1 lists the key documents which must be current and in place at each RWMS for disposal operations to occur. In 2004, all of these key documents were maintained. No key documents required revision in 2004.

Table 9-1. Key documents required for Area 3 RWMS and Area 5 RWMS operations

Disposal Authorization Statement (DAS)

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

Performance Assessment (PA)

Performance Assessment for Area 5 RWMS, Revision 2.1, January 1998
Performance Assessment/Composite Analysis for Area 3 RWMS, Revision 2.1, October 2000

Composite Analysis (CA)

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

NTS Waste Acceptance Criteria (NTSWAC)

NTS Waste Acceptance Criteria, Revision 5, October 2003.

> This document was revised in October to incorporate the transition of the RWMC from a Radiological Facility to a Category II Nuclear Facility

Integrated Closure and Monitoring Plan (ICMP)

Integrated Closure and Monitoring Plan for the Area 3 and 5 RWMSs, September 2001

Auditable Safety Analysis (ASA)

Documented Safety Analysis (DSA) for the NTS Area 5 RWMC, Revision 0, October 2002
DSA for the NTS Area 3 RWMS, Revision 0, April 2003

> The above two DSA documents were prepared to replace the ASA for the Area 3 and 5 RWMSs, August 2000 as a consequence of the transition to a Category II Nuclear Facility.

Technical Safety Requirements (TSRs) for the Area 5 RWMC LLW Activities, Revision 2, April 2003
TSR for the Area 5 RWMC TRU Waste Activities, Revision 2, April 2003
TSR for the Area 3 RWMS, Revision 0, April 2003

> The above three TSR documents were prepared to implement the new DSAs.

9.1.2 *Characterization of LLW and MW*

Waste Generator Services (WGS) characterizes LLW and MW generated by the DOE within Nevada, primarily at the NTS. Characterization is performed utilizing either knowledge of the generating process or sampling and analysis. Following the characterization of a waste stream, a Waste Profile is completed for approval by an appropriate disposal facility. 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 isotopes and their quantities, and detailed packaging information. WGS then packs and ships approved waste streams in accordance with Department of Transportation requirements to either the Area 3 or Area 5 RWMS or to an offsite treatment, storage, and disposal facility. In 2004, LLW and MW were characterized by WGS for the following waste stream categories:

- Lead Soil
- Lead Solids
- Compactable Trash
- Downdraft Table
- Polychlorinated biphenyl (PCB) Liquids

9.1.3 Disposal of LLW and MW

The RWMC operates as a Category II Nuclear Facility. The RWMC, which includes the Area 3 and the Area 5 RWMSs, is designed and operated to perform three functions:

- Dispose of LLW from NNSA/NSO activities performed on and off the NTS and from other offsite generators in the state of Nevada.
- Dispose of DOE LLW from around the DOE complex, primarily from the cleanup of sites associated with the manufacture of weapons components.
- Dispose of MW from onsite NNSA/NSO activities.

All generators of waste streams must first request to dispose of waste, submit a request to NNSA/NSO requesting to ship waste to the NTS for disposal, submit profiles characterizing specific waste streams, meet the NTS Radioactive Waste Acceptance Criteria, and receive programmatic approval for disposal by NNSA/NSO. The NTS Radioactive Waste Acceptance Criteria are based on how well the site is predicted to perform in containing radioactive waste and ensuring that the environment (including air and groundwater) and the public will not be exposed to significant radiation. The NNSA/NSO assesses and predicts the long-term performance of LLW disposal sites by conducting a Performance Assessment (PA) and a Composite Analysis (CA). A PA is a systematic analysis of the potential risks posed by a waste disposal site to the public and to the environment. A CA is an assessment of the risks posed by all wastes disposed in a LLW disposal site and by all other sources of residual contamination that may interact with the disposal site. PA and CA documents are developed as a result of these activities. The RWMC receives LLW generated within the DOE complex from numerous DOE sites across the United States, LLW from DoD sites that carry a national security classification, and MW generated within the state of Nevada for disposal or indefinite storage.

Disposal consists of placing waste in sealed containers in unlined cells and trenches. Soil backfill is applied over the waste in a single lift, which is approximately 2.4 m (8 ft) thick, as rows of containers reach approximately 1.2 m (4 ft) below the original grade.

The Area 5 RWMS includes 81 hectares (ha) (200 acres [ac]) of existing and proposed disposal cells for burial of both LLW and MW, and approximately 202 ha (500 ac) of land available for future radioactive disposal cells. Waste disposal at the Area 5 RWMS has occurred in a 37 ha (92 ac) portion of the site since the early 1960s. The Area 5 RWMS consists of 29 Disposal Cells (pits and trenches) and 13 Greater Confinement Disposal (GCD) boreholes (listed below). This site is used for disposal of waste in drums or boxes. Existing cells are expected to be filled and closed by 2010, and new cells extending to the north and west are expected to close by 2021. LLW and MW disposal services are expected to continue at Area 5 RWMS as long as the DOE complex requires the disposal of wastes from the weapons program.

29 Disposal Cells at Area 5 RWMS:
4 active which receive standard LLW
1 active and permitted to receive asbestos-form LLW (P06U)
1 active and permitted by the State to receive MW (P03U)
4 inactive (open but have not received any waste)
19 closed (containing waste and backfilled) containing LLW

13 GCD Boreholes at Area 5 RWMS:
4 inactive (open but have not received any waste)
4 closed containing TRU waste
5 closed containing LLW

The Area 3 RWMS consists of seven craters making up five disposal cells. Each subsidence crater was created by an underground weapons test. This site is used for disposal of bulk LLW waste, such as soils or debris, and waste in large cargo containers. Disposal operations at the Area 3 RWMS began in the late 1960s. Waste disposal services at Area 3 RWMS will continue as long as the DOE requires such services. The site consists of the following seven craters:

3 Active Disposal Cells:	2 Closed Cells:	2 Undeveloped Cells:
U3ah/at	U3ax/bl	U3az
U3bh		U3bg

In 2004, the Area 5 RWMS received shipments containing 45,863 m^3 (59,986 yd^3) of LLW for disposal. The Area 3 RWMS received shipments containing 57,010 m^3 (74,566 yd^3) of LLW. The majority of disposed LLW was shipped from offsite. A total of only 330 m^3 (432 yd^3) of LLW disposed in 2004 were generated onsite.

In 2004, the Area 5 RWMS received and disposed of 789.5 tons (net weight), of asbestos-form LLW at P06U. No MW was disposed at the Pit 3 Mixed Waste Disposal Unit (P03U).

9.1.4 TRU Waste Operations

The Transuranic Pad Cover Building (TPCB) at the Area 5 RWMC is a Resource Conservation and Recovery Act (RCRA) Part B interim status facility designed for the safe storage of TRU waste generated by Lawrence Livermore National Laboratory in the 1970s. The TPCB accepts no other wastes. The TPCB stores TRU waste until it is characterized, visually examined, and repackaged at the WEF at the Area 5 RWMC. Once repackaged, the TRU waste is loaded at the MLU for shipment to the WIPP at Carlsbad, New Mexico. Current agreements between NNSA/NSO and WIPP plan for TRU waste shipments to be completed by March 2005. In 2004, TRU wastes stored at the TPCB continued to be characterized, visually inspected, repackaged, loaded, and shipped for disposal to the WIPP site.

9.1.5 Assessments

Assessments are conducted at the RWMC in accordance with Bechtel Nevada (BN) Procedure OP-NOPS.003 *Nuclear Operations Conduct of Operations*. Schedules for BN management self-assessments (MSAs) are included in the Support Execution Plans for each facility. In addition to the MSAs performed internally at the RWMC, assessments are performed periodically by other BN organizations, NNSA/NSO, and the Defense Nuclear Facilities Safety Board. The results of each assessment are logged for DOE/NSO in the BN tracking system known as CaWeb. In 2004, MSAs were conducted monthly at the RWMC.

9.1.6 Groundwater Monitoring for LLW Pit P03U

P03U is operated according to RCRA Interim Status standards for the disposal of mixed LLW. Title 40 Code of Federal Regulations (CFR) 265 (Groundwater Monitoring) Subpart F (40 CFR 265.92) requires groundwater monitoring to verify the performance of P03U to protect groundwater from buried radioactive wastes. Wells UE5 PW-1, UE5 PW-2, and UE5 PW-3 are monitored for this purpose; these wells comprise 3 of the 14 onsite monitoring wells sampled periodically for radionuclide analyses of groundwater (see Section 4.1.7). Investigation levels (ILs) for five indicators of groundwater contamination (Table 9-2) were established by NNSA/NSO and the Nevada Division of Environmental Protection (NDEP) for these three wells in 1998. Further groundwater analyses will be required if a parameter's IL is exceeded. In 2004, none of the water samples collected semi-annually from the wells had contaminant levels above their ILs (Table 9-2). General water chemistry parameters are also monitored; all sample analysis results are presented in BN, 2005a. Table 4-4 of Section 4.1.7 presents the tritium results for UE5 PW-1, UE5 PW-2, and UE5 PW-3.

Table 9-2. Results of groundwater monitoring of UE5 PW-1, UE5 PW-2, and UE PW-3 in 2004

Parameter	Investigation Level (IL)	Sample Levels
pH	< 7.6 or > 9.2 S.U.	8.24 – 8.50 S.U.
Specific conductance (SC)	0.440 mmhos/cm	0.352 – 0.378 mmhos/cm
Total organic carbon (TOC)	1 mg/L	<0.5 – 0.90
Total organic halides (TOX)	50 µg/L	< 5.2 µg/L
Tritium (^3H)	2,000 pCi/L	-13 – 37 pCi/L

Source: BN, 2005a

9.1.7 Vadose Zone Monitoring

Monitoring of the vadose zone (unsaturated zone above the water table) is conducted at the RWMC in addition to groundwater monitoring 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) that there is negligible infiltration 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. All VZM conducted in 2004 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. A few components of the VZM monitoring program implemented in 2004 are presented below. For more details on the program refer to the *Nevada Test Site 2004 Waste Management Monitoring Report Area 3 and Area 5 Radioactive Waste Management Sites* (BN, 2005b).

9.1.7.1 Area 3 RWMS Drainage Lysimeter Facility

In December 2000, a Drainage Lysimeter Facility was constructed approximately 15 m (50 ft) northwest of the closed U-3ax/bl disposal unit at the Area 3 RWMS. The facility consists of eight cylindrical drainage lysimeters, each 3.1 m (10.0 ft) in diameter and 2.4 m (8.0 ft) deep. Each lysimeter is filled and packed with the same native soil used to cap the closed disposal unit. The rate and quantity of gravity-driven drainage from each lysimeter is measured by funneling the drainage through tipping bucket rain gauges. Each lysimeter is instrumented with an array of eight Time Domain Reflectometry (TDR) sensors to measure soil water content and eight heat dissipation probe (HDP) sensors to measure soil water potential and temperature. The lysimeter facility was constructed to fulfill data needs including reducing uncertainty in the expected performance of monolayer-evapotranspiration closure covers under various surface vegetation treatments and climatic change scenarios such as increased rainfall.

There are three surface vegetation treatments subject to two climate treatments on the lysimeters. The three surface vegetation treatments are bare soil, natural plant recolonization (primarily by invader species *Salsola tragus* [prickly Russian thistle], *Halogeton glomeratus* [halogeton], and *Sisymbrium alitissimum* [tumblemustard]), and revegetation with former plant community species (primarily *Atriplex confertifolia* [shadscale], *Krascheninnikovia lanata* [winterfat], *Ephedra nevadensis* [Nevada ephedra], and *Achnatherum hymenoides* [Indian ricegrass]). The bare soil lysimeters mimic operational waste covers, the invader species lysimeters mimic operational waste covers that are not maintained, and revegetation lysimeters mimic final closure covers. The climate treatments applied to each of the three surface vegetation treatments are natural precipitation and three times the amount of natural precipitation. The increased precipitation lysimeters receive natural precipitation and are irrigated at a rate equal to two times natural precipitation.

Vegetation effectively removes moisture from the lysimeters, preventing deep percolation of infiltrated precipitation. The bare soil lysimeters have more water and wetting fronts go deeper. Drainage is observed in all lysimeters with irrigation, but the vegetated lysimeters have much less drainage than the bare soil lysimeters.

9.1.7.2 Area 5 RWMS Weighing Lysimeter Facility

The Area 5 Weighing Lysimeter Facility consists of two precision weighing lysimeters located about 400 m (0.25 mi) southwest of the Area 5 RWMS. Each lysimeter consists of a 2 x 4 m (6.6 x 13 ft) by 2 m (6.6 ft) deep steel box filled with soil. The load cells in each lysimeter can measure approximately 0.1 mm (0.004 in) of precipitation or evapotranspiration. One lysimeter is vegetated with native plant species at the approximate density of the surrounding desert, and one lysimeter is kept bare to simulate the bare operational waste covers at the Area 5 RWMS. The load cells have been monitored continuously since March 1994, providing an accurate dataset of the surface water balance at the Area 5 RWMS.

The weighing lysimeter data represent a simplified water balance: the change in soil water storage is equal to precipitation minus evaporation (E) on bare lysimeters, or precipitation minus evapotranspiration (ET) on vegetated lysimeters. The water balance is simplified because no drainage can occur through the solid bottoms of the lysimeters and because a 2.5 cm (1 in) lip around the edge of the lysimeters prevents run-on and run-off. The vegetated lysimeter is considerably drier than the bare-soil lysimeter, despite the small number of plants on the vegetated lysimeter (about 15 percent plant cover). Soil water storage decreases rapidly in the vegetated lysimeter following high-rainfall periods. Increases in soil water storage observed early in the data record in the vegetated lysimeter were a result of irrigation conducted to ensure that transplanted vegetation survived. Although no water has accumulated at the bottom of the lysimeters, long-term (30-year) numerical simulations using a unit gradient bottom boundary indicate that 1.1 cm/year reaches the bottom of the bare lysimeter and <0.1 cm/year reaches the bottom of the vegetated lysimeter.

9.1.7.3 Area 5 RWMS Automated Monitoring

Automated monitoring systems are installed in the operational covers on Pit 3 (P03U), Pit 4 (P04U), Pit 5 (P05U), the floor of Pit 5 underneath the waste, and the closure cover on U-3x/bl. These monitoring systems measure moisture content depth profiles with TDR probes. The system at P05U also has heat dissipation probes to measure water potential depth profiles. The measurements in the covers show that precipitation infiltrates into the covers but does not percolate down to the bottom of the covers. The moisture is removed from the covers by evapotranspiration. No water from precipitation is percolating to the waste zone and no wetting fronts percolated below 1.5 m (4.9 ft) in the operational covers. The measurements in the floor of Pit 5 do not show any evidence of water movement.

9.1.7.4 RWMS Supplemental Automated Monitoring

Additional automated data-acquisition stations are maintained to provide ancillary data in support of the more direct monitoring of RWMS disposal units and the lysimeters in Areas 3 and 5. These stations include meteorological towers that continuously measure precipitation, air temperature, humidity, wind speed, wind direction, barometric pressure, and solar radiation. Data are also obtained from a flume north of the Area 3 RWMS and one northwest of the Area 5 RWMS for assessing, in part, the potential for surface water runoff near the RWMSs. An automated system has also been deployed within a subsidence crater in Area 3 (U3-bw) to study the potential for infiltration into the underlying chimney.

9.2 Hazardous Waste Management

Hazardous wastes (HW) (see Glossary, Appendix D) regulated under RCRA are generated at the NTS from a broad range of activities including onsite laboratories, paint shops, vehicle maintenance, communications and photo operations, and environmental restoration of historic contaminated sites (see Section 9.3). HW exclude radioactive wastes by definition; a waste which is both hazardous and radioactive is termed a Mixed Waste. All HW are presently transported to approved offsite RCRA HW treatment, storage, and disposal facilities. Nevada has issued a RCRA Hazardous Waste Operating Permit to NNSA/NSO for operation of the Hazardous Waste Storage Unit (HWSU) in Area 5. The permit allows NNSA/NSO to store HW in containers on a pad designed for the safe storage of wastes that have been generated at the NTS. The HWSU is a pre-fabricated, rigid steel framed, roofed shelter which is permitted to store a maximum of 61,600 liters (16,280 gallons) of approved waste at a time. HW generated at BN restoration sites off the NTS (e.g., at TTR) or generated at the NLVF are direct-shipped to approved disposal facilities.

The RCRA Hazardous Waste Operating Permit also covers operations at the Explosive Ordnance Disposal Unit in Area 11. Conventional explosive wastes are generated at the NTS from tunnel operations, the NTS firing range, the resident national laboratories, and other activities. The permit allows NNSA/NSO to treat explosive ordnance wastes, which are hazardous wastes as defined under 40 CFR (Sections 261.21, 261.23, 261.24, and 261.33), by open detonation in a specially constructed and managed area designed for the safe and effective treatment of explosive HW. The permit allows a maximum of 45.4 kg (100 lbs) of approved waste to be detonated at a time, not to exceed one detonation event per hour.

The RCRA Hazardous Waste Operating Permit also covers the disposal of mixed wastes generated from NTS activities (such as environmental remediation) at P03U located at the Area 5 RWMS.

The amounts of waste managed at each of these three permitted units are tracked and reported to the state in quarterly reports. NNSA/NSO pays fees to the state based on the number of tons of waste managed.

In 2004, a total of 23.549 metric tons (mtons) (25.958 tons) of non-radioactive HW was managed on the NTS, which includes 19.187 mtons (21.150 tons) managed at the NTS HWSU. Most of this waste came from routine activities, such as facility housekeeping, demolitions, and renovations. A small volume of HW (4.362 mtons [4.808 tons]) consisted of bulk shipments (i.e., roll-off boxes) direct-shipped from their points of generation. The HWSU manages only packaged (non-bulk) HW. The volumes managed at the HWSU in 2004 included 2.868 mtons (3.161 tons) of light ballasts and oil, both containing PCBs. Table 9-3 shows the mtons/tons of non-radioactive HW that came to the HWSU, were temporarily stored there, and then shipped offsite in 2004. The table also shows the quantities of waste disposed of at the two permitted disposal units in 2004. The volume of waste managed at each unit per quarter was reported to the state of Nevada. No HW storage or disposal limits were exceeded in 2004.

Table 9-3. Hazardous waste stored or disposed at the NTS in 2004

Permitted Unit	Waste Managed
Hazardous Waste Storage Unit	19.187 mtons (21.151 tons)$^{(a)}$
Explosive Ordnance Disposal Unit	2.2 kg (4.85 lbs)
Pit 3 Mixed Waste Disposal Unit (P03U)	0 m^3

(a) The permitted storage limit for HW at the HWSU is 61,600 liters (16,280 gallons), however, the reporting units are tons (short tons), on which quarterly fees to the State are based.

9.3 Underground Storage Tank (UST) Management

By 1998, the NTS UST program met all regulatory compliance schedules for the reporting, upgrading, or removal of documented USTs. The NNSA/NSO operates one deferred UST and three excluded USTs at the Device Assembly Facility. The NNSA/NSO also maintains a fully-regulated UST at the Area 6 helicopter pad which is not in service.

9.4 Environmental Restoration - Remediation of Historic Contaminated Sites

In April 1996, the DOE, DoD, and the state of Nevada entered into a Federal Facilities Agreement and Consent Order (FFACO) to address the environmental restoration of historic contaminated sites at the NTS, parts of TTR, parts of the Nellis Air Force Range (now known as the Nevada Test and Training Range [NTTR]), the Central Nevada Test Area, and the Project Shoal Area. These sites, known as Corrective Action Sites (CASs), may be contaminated with both radioactive and non-radioactive wastes. Appendix VI of the FFACO describes the strategy that will be employed to plan, implement, and complete environmental corrective actions at facilities where nuclear-related operations were conducted. Stoller-Navarro Joint Venture conducts site characterization activities, while BN Environmental Restoration conducts site remediation.

9.4.1 Corrective Actions

The corrective action strategy is based on four steps: (1) identifying the CASs, (2) grouping the CASs into Corrective Action Units (CAUs), (3) prioritizing the CAUs for funding and work, and (4) implementing the corrective action investigations (CAIs) and/or corrective actions, as applicable. CASs are broadly organized into the following four categories based on the source of contamination:

- Industrial Sites – CASs located on the NTS and TTR where activities were conducted that supported nuclear testing activities
- Underground Test Area (UGTA) Sites – CASs located where underground nuclear test have resulted or might result in local or regional impacts to groundwater resources

- Soil Sites – CASs where tests have resulted in extensive surface and/or shallow subsurface contamination
- Nevada Off-Sites – Additional CASs associated with underground nuclear testing at the Project Shoal Area and the Central Nevada Test Area, located in northern and central Nevada respectively

Identifying CASs – The first step in the strategy is to identify CASs potentially requiring CAIs and/or corrective actions. As CASs are identified, a literature search may be completed and each CAS is verified on aerial photographs or in the field to confirm its condition and location. A data repository has been created containing or referencing all information currently available for each CAS.

Grouping CASs into CAUs – A CAU may have several CASs or only one. In addition to the four categories noted above, criteria for grouping CASs into CAUs include the following:

- Potential source of contamination
- Agency responsible for cleanup of the CAS
- Function of the CAS and the nature of the contamination
- Geographic proximity of CASs to one another
- Potential for investigation or cleanup of grouped CASs to be accomplished within a similar time frame

Implementing Corrective Action Investigations and/or Corrective Actions – When a CAU is assigned priority and funding, environmental restoration activities follow a formal work process beginning with a Data Quality Objectives (DQO) meeting between the NNSA/NSO, the Defense Threat Reduction Agency, NDEP, and contractors. The DQO process is a strategic planning approach based on the scientific method used to plan data collection activities to ensure that the data collected will provide sufficient and reliable information to identify, evaluate, and technically defend the recommended corrective actions. If existing information about the nature and extent of contamination at the CASs in question is insufficient to evaluate and select preferred corrective actions, a CAI will be conducted. A Corrective Action Investigation Plan (CAIP) is prepared that provides a conceptual model of the site and defines how the site is to be characterized in conformance with the DQO process.

Site characterization is carried out in the field and documented in a Corrective Action Decision Document (CADD). This document provides the information that either confirms or modifies the preliminary conceptual model. If suitable information is available to make a decision, a remedial alternative is selected that best provides site closure. In some instances, additional site characterization may be required before the CADD can be prepared.

If a site requires remediation, a Corrective Action Plan (CAP) is prepared that provides the necessary design and other information on the method of remediation. A CAP includes the proposed methods to be used to close a site, quality control measures, waste management strategy, design drawings (when appropriate), verification sampling strategies (for clean closures), and other information necessary to perform the closure. Some sites also require a Post Closure Plan as the site or parts of the site are closed in place. Information on inspections and monitoring are provided in an Annual Post Closure Monitoring Report.

Once the closure has been completed, a Closure Report is prepared. This report provides information on the work performed, results of verification sampling, as-built drawings, waste management, etc. Some sites are closed under the Streamlined Approach for Environmental Restoration (SAFER) process identified in the FFACO. These sites typically have suitable information available and can be remediated under a shorter schedule. For such sites, a SAFER plan is prepared providing the methods to be used to close the site. After closure, a SAFER closure report is prepared that documents the work performed.

The NDEP is a participant throughout the remediation process. The Community Advisory Board is also kept informed by NNSA/NSO of the progress made. The Board's comments are strongly considered before final prioritization of corrective actions. In addition, a public participation working group made up of representatives from DOE, DoD, the state of Nevada, and the Community Advisory Board meets twice each year to discuss upcoming environmental restoration activities and the level of public involvement required. These meetings focus on the quarterly progress reports and priority-setting activities established under the FFACO.

Table 9-4 lists all CAUs for which some step of the site remediation process was completed in calendar year 2004. All 2004 milestones were met. A total of 56 CASs were closed, either under the SAFER process or the standard closure process. For DOE UGTA CAUs, 2004 milestones included well development and testing of new wells, model calibration and development, data documentation and evaluations, and completion of draft and final reports.

9.4.2 Post-Closure Monitoring and Inspections

There are nine sites on the NTS for which remediation was indicated or completed under RCRA regulations prior to enactment of the FFACO. Eight have been closed and are referred to as historic RCRA closure units. For the ninth site, the Area 5 Retired Mixed Waste Pits and Trenches, the NDEP has determined that NNSO/NSA shall close the site (in the future) subject to the conditions of 40 CFR 265.310. Three of the eight RCRA closure units require no further post-closure monitoring (Area 23 Building 650 Leachfield, Area 6 Steam Cleaning Effluent Ponds, and Area 2 U-2bu Subsidence Crater). Two of the eight closed units require periodic site inspections only (Area 2 Bitcutter Containment and Area 6 Decon Pond), and three require post-closure inspections as well as VZM. These three sites and the methods of VZM required by state permit are:

CAU 91, Area 3 U-3fi Injection Well – Neutron logging of the ER-3-3 Borehole is conducted and analyzed quarterly. Annual reports of Post-Closure Monitoring and Inspections include monthly precipitation data and are issued to the NDEP by the last day of February each reporting year. VZM is conducted to detect statistically significant changes in raw neutron counts exceeding an action level of 200 counts in the residual raw neutron count. Data analysis is based on the calculated residual raw neutron counts obtained by subtracting the first year's average raw neutron count from the quarterly raw neutron count on a depth basis within the regulated interval of 73.1 meters (240 feet) to 82.3 meters (270 feet) below ground surface. The average raw neutron count used is the average of nine baseline values obtained during logging runs conducted July 1995 to July 1996.

CAU 110, U-3ax/bl Subsidence Crater – Post-closure inspections are done quarterly and consist of visual observations to check that the cover is intact. The U-3ax/bl Subsidence Crater cover is designed to limit infiltration into the disposal unit and is monitored using TDR soil water content sensors buried at various depths within the waste cover to provide water content profile data. The soil water content profile data are used to demonstrate whether the cover is performing as expected. Annual reports of post-closure monitoring include monthly precipitation data for the reporting period and are submitted to NDEP by the last day of August.

CAU 112, Area 23 Hazardous Waste Trenches – Soil moisture monitoring data are collected and analyzed semiannually (January and July); site inspections are conducted quarterly. Soil moisture data are obtained from 30 neutron access tubes specified in the permit. Annual reports of post-closure monitoring include monthly precipitation data for the reporting period and are submitted to NDEP by the last day of January.

All required VZM and inspections of closed sites were conducted in 2004 as specified by RCRA permit or by each site's closure report. VZM results for the RCRA closure sites CAU 91, CAU 110, and CAU 112 indicated that surface water is not migrating into buried wastes. VZM reports were submitted to the state prior to their due dates.

The sites at which physical inspections were conducted in 2004 are:

CAU 90	Area 2 Bitcutter Containment
CAU 91	Area 3 U-3fi Injection Well
CAU 92	Area 6 Decon Pond Facility
CAU 110	Area 3 U-3ax/bl Subsidence Crater
CAU 112	Area 23 Hazardous Waste Trenches
CAU 143	Area 25 Contaminated Waste Dumps
CAU 254	Area 25 R-MAD Decontamination Facility
CAU 261	Area 25 Test Cell A Leachfield System
CAU 262	Area 25 Septic Systems and UDP
CAU 333	U-3auS Disposal Site
CAU 335	Area 6 Injection Well and Drain Pit
CAU 339	Area 12 Fleet Operations Steam Cleaning Effluent

Table 9-4. Environmental restoration activities conducted in 2004

CAU	CAU Description	Number of CASs	Milestone	Due Date	Date Submitted
		DP Industrial Sites			
355	Area 2 Cellars/Mud Pits	15	Closure Report	8/31/2004	11/20/2003
358	Areas 18, 19, 20 Cellars/Mud Pits	17	Closure Report	9/30/2004	1/8/2004
396	Area 20 Spill Sites	4	Closure Report	11/1/2004	9/13/2004
536	Area 3 Release Site	1	CADD	12/31/2004	11/22/2004
		DTRA/DOE - Industrial Sites			
383	Area 12 E Tunnel Sites	3	CAIP	1/30/2004	12/22/2003
		DOE Industrial Sites			
5	Landfills	8	CAP	11/1/2004	8/2/2004
115	Area 25 Test Cell A Facility	4	SAFER Plan	9/30/2004	7/26/2004
127	Areas 25 and 26 Storage Tanks	12	CAP	11/1/2004	10/5/2004
140	Waste Dumps, Burn Pits, and Storage Area	9	CAP	11/1/2004	4/1/2004
145	Wells and Storage Holes	6	CAIP	10/19/2004	9/30/2004
165	Area 25 and 26 Dry Well and Washdown Areas	8	CAP	7/30/2004	7/1/2004
167	Contaminated Materials and Trash Pits	2	Closure Report	5/31/2004	5/25/2004
168	Area 25 and 26 Contaminated Materials and Waste Dumps	12	CAP	5/31/2004	5/14/2004
204	Storage Bunkers	6	CAP	11/1/2004	10/5/2004
			CADD	4/30/2004	4/1/2004
210	Storage Areas and Contaminated Material	2	Closure Report	9/30/2004	7/29/2004
214	Bunkers and Storage Areas	9	CADD	8/31/2004	8/16/2004
224	Decon Pad and Septic Systems	9	CAIP	5/31/2004	4/22/2004
271	Areas 25, 26, and 27 Septic Systems	15	Closure Report	8/31/2004	8/26/2004
300	Surface Release Areas	7	CAIP	9/30/2004	6/15/2004
484	Surface Debris, Waste Sites, and Burn Area (TTR)	6	SAFER Plan	9/30/2004	6/9/2004
496	Buried Rocket Site - Antelope Lake (TTR)	1	SAFER Plan	7/30/2004	6/9/2004
516	Septic Systems and Discharge Points	6	CADD	8/31/2004	3/18/2004
527	Horn Silver Mine	1	CADD	9/30/2004	8/16/2004
528	Polychlorinated Biphenyl Contamination	1	CADD	8/2/2004	3/15/2004
529	Area 25 Contaminated Materials	1	Closure Report	9/15/2004	9/10/2004
			CADD	9/15/2004	9/10/2004

Table 9-4. (continued)

CAU	CAU Description	Number of CASs	Milestone	Due Date	Date Submitted
		DOE Industrial Sites, cont.			
543	Liquid Disposal Units	7	CAIP	6/1/2004	5/3/2004
551	Area 12 Muckpiles	4	CAIP	6/30/2004	6/8/2004
552	Area 12 Muckpile and Ponds	1	CAIP	4/30/2004	4/6/2004
		DOE UGTA Sites			
97	Yucca Flat/Climax Mine	720	Submit draft Contaminant Boundary Phase I Modeling Approach/Strategy	4/30/2004	3/18/2003
			Complete well development and testing of new wells	9/17/2004	9/13/2004
98	Frenchman Flat	10	Complete Transport Parameter Phase II Analysis and Evaluation	9/3/2004	8/19/2004
			Submit Draft Hydrology Phase II Report	9/30/2004	9/2/2004
99	Rainier/Shoshone	66	CAIP	12/31/2004	12/22/2004
101	Central Pahute Mesa	64	Complete the calibration of the Flow Model	7/31/2004	7/20/2004
			Submit Final Source Term Report	8/30/2004	8/19/2004
102	Western Pahute Mesa	18	Complete the calibration of the Flow Model	7/31/2004	7/20/2004
			Submit Final Source Term Report	8/30/2004	8/19/2004

CAU 342	Mercury Fire Training Pit
CAU 400	Bomblet Pit and Five Points Landfill (TTR)
CAU 404	Roller Coaster Lagoons and Trench (TTR)
CAU 407	Roller Coaster RadSafe Area (TTR)
CAU 417	Central Nevada Test Area -Surface
CAU 423	Area 3 Underground Discharge Point, Building 0360 (TTR)
CAU 424	Area 3 Landfill Complexes (TTR)
CAU 426	Cactus Spring Waste Trenches (TTR)
CAU 427	Area 3 Septic Waste Systems 2, 6 (TTR)
CAU 453	Area 9 UXO Landfill (TTR)
CAU 487	Thunderwell Site (TTR)

9.5 Solid and Sanitary Waste Management

9.5.1 Landfills

The NTS has three landfills for solid waste disposal that are regulated and permitted by the State (see Table 2-12 for list of permits). No liquids, hazardous waste, or radioactive waste are accepted in these landfills. They include:

- Area 6 Hydrocarbon Disposal Site – accepts hydrocarbon-contaminated wastes, such as soil and absorbents.
- Area 9 U10c Solid Waste Disposal Site – designated for industrial waste such as construction and demolition debris.
- Area 23 Solid Waste Disposal Site – 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-issued permits. The NDEP visually inspects the landfills and checks the records on an annual basis to ensure compliance with the permits.

The vadose zone is monitored at two of the permitted sanitary landfills: the Area 6 Hydrocarbon Disposal Site and the Area 9 U10c Solid Waste Disposal Site. VZM is performed in lieu of groundwater monitoring to demonstrate that contaminants from the landfills are not leaching into the groundwater. In previous years, semiannual reports containing VZM data, rainfall data, and conclusions were sent to the State, as specified in the landfill permits. In July 2004, the State granted a reduction in the frequency of VZM at these landfills. Monitoring will now take place annually instead of semiannually. VZM of the Area 6 and Area 9 landfills in 2004 indicated that there was no soil moisture migration and therefore no waste leachate migration to the water table.

Water from Well SM-23-1 was last sampled in 2002 for the purpose of monitoring the Area 23 Solid Waste Disposal Site. In 2004, a No-Migration Petition, based on EPA530-R-99-008 *Preparing No-Migration Demonstrations for Municipal Solid Waste Disposal Facilities: A Screening Tool*, was prepared and submitted to the NDEP. In June 2004, the NDEP granted a groundwater monitoring exclusion for the Area 23 landfill. Well SM-23-1 was sampled in 2004, however, to satisfy permit requirements for the Area 23 Mercury sewage lagoons (see Section 9.5.2).

The amount of waste disposed of in each solid waste landfill in 2004 is shown in Table 9-5. An average of 4 tons/day was disposed at the Area 23 landfill, well within permit limits. State inspections of the three permitted landfills were conducted in March 2004. No out-of-compliance issues were noted.

Table 9-5. Quantity of solid wastes disposed in NTS landfills in CY 2004

	Metric Tons (Tons) of Waste	
Area 6 Hydrocarbon Disposal Site	Area 9 U10c Solid Waste Disposal Site	Area 23 Solid Waste Disposal Site
1,012 (1,166)	6,638 (7,319)	927 (1,022)

9.5.2 *Sewage Lagoons*

The NTS also has three state-permitted sewage lagoons that are operated by BN Waste Management, as are the solid waste landfills. They are the Area 6 Yucca Lake, Area 12 Camp, and Area 23 Mercury lagoons. The operations and monitoring requirements for these sewage lagoons are specified by Nevada water pollution control regulations. Because of this, the discussion of their operations and monitoring of their water and sediments are presented in Section 4.2.3. A groundwater monitoring well in Area 23 (SM-23-1) is monitored once a year under Nevada permit requirements for the Area 23 Mercury sewage lagoons. The purpose of monitoring is to demonstrate that waste from this system is not reaching the groundwater. Monitoring results for Well SM-23-1 are presented in Table 4-13 of Section 4.2.3.3.

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10.0 Hazardous Materials Control and Management

Hazardous materials used or stored on the Nevada Test Site (NTS) are controlled and managed through the use of a Hazardous Substance Inventory database. Bechtel Nevada (BN) and all other U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office (NNSA/NSO) subcontractors who use or store hazardous materials utilize this database and are required to comply with the operational and reporting requirements of the Toxic Substances Control Act (TSCA); Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA); the Emergency Planning and Community Right-to-Know Act (EPCRA); and the Nevada Chemical Catastrophe Act (see Section 2.5). Chemicals to be purchased are subject to a requisition compliance review process. BN's Environmental Services personnel review each chemical purchase to ensure that restricted chemicals are not purchased when less hazardous chemical substitutes are commercially available. Requirements and responsibilities for the use and management of hazardous/toxic chemicals are provided in company documents and are aimed at meeting the goals shown below. The reports or activities that are prepared or performed annually to document compliance with hazardous materials regulations are also listed below.

Hazardous Materials Control and Management Goals	*Compliance Activities/Reports*
Minimize the adverse effects of improper use, storage, or management of hazardous/toxic chemicals	Use of Hazardous Substance Inventory database
	Annual TSCA report
	FIFRA management assessments
	Annual EPCRA Toxic Release Inventory (TRI) Report, Form R
Ensure compliance with applicable state and federal environmental regulations related to hazardous materials	Annual Nevada Combined Agency (NCA) Report
	Nevada Division of Environmental Protection (NDEP)-Chemical Accident Prevention Program (CAPP) Annual Registration Form
	Use of electronic hazardous material tracking database called HAZTRAK

10.1 TSCA Program

There are no known pieces of polychlorinated biphenyl (PCB)-containing electrical equipment (transformers, capacitors, or regulators) at the NTS. The TSCA program consists mainly of properly characterizing, storing, and disposing of various PCB wastes generated through remediation activities and maintenance of fluorescent lights. The remediation waste is generated by BN and Stoller-Navarro Joint Venture at Corrective Action Sites during environmental restoration activities (see Section 9.4) and during maintenance activities and building decontamination and decommissioning activities performed by BN. These activities can generate PCB contaminated fluids and bulk product waste containing PCBs.

Waste classified as bulk product waste (BPW) generated on the NTS can be disposed of onsite in the U10c landfill with prior state approval. PCB-containing light ballasts removed during normal maintenance can also go to an onsite landfill, but when remediation or upgrade activities generate several ballasts, these must be disposed of offsite at an approved PCB disposal facility. Soil and other materials contaminated with PCBs must also be sent offsite for disposal.

About 22.9 m^3 (30 yd^3) of BPW containing less than 50 ppm PCB were disposed of onsite in the U10c landfill in 2004. During 2004, one drum of diesel fuel containing PCB, and two drums of PCB light ballasts were shipped offsite for disposal. Offsite disposal was required because the drums contained more than 50 ppm of PCB.

When PCB equipment or PCB fluids are managed during a calendar year, NNSA/NSO has been submitting an annual report to the EPA by July 1 of the following year. On March 22, 2004, an Annual Report was prepared which reported the quantity of articles and containers containing PCBs that were generated during a site remediation project and were disposed of offsite during 2003.

In 2003, NNSA/NSO determined that annual reports were not required to be sent to regulators since the NTS is not considered a commercial storer or disposer of PCBs. On March 22, 2005, an Annual Report was generated for calendar year 2004, but was not sent to outside regulators.

There were no TSCA inspections by outside regulators performed at the NTS in 2004.

10.2 FIFRA Program

BN Environmental Services performs the following oversight functions to ensure FIFRA compliance: (1) screens all purchase requisitions for restricted-use pesticides, (2) reviews operating procedures for handling, storing and applying pesticide products, and (3) conducts facility inspections for unauthorized pesticide storage/use. On the NTS, pesticides are applied under the direction of a state of Nevada certified applicator. This service is provided by BN Solid Waste Operations (SWO). BN SWO maintains appropriate Commercial Category (Industrial) certifications for applying restricted-use pesticides. Pesticide applications in food service facilities are subcontracted to state-certified vendors.

BN SWO did not purchase any restricted-use pesticides during 2004. The SWO procedure for pesticide application was updated in 2003, and training was provided to affected personnel during 2003 and 2004. Certifications were kept current in 2004 for Industrial Category application(s) of restricted use pesticides. Facility inspections were conducted and indicated that there were no restricted use pesticides being used or stored in violation of federal/state requirements. There were no FIFRA inspections by an outside regulator during 2004.

10.3 EPCRA Program

In response to the EPCRA requirements, all chemicals that are purchased are entered into a hazardous substance inventory database and assigned specific hazard classifications (e.g., corrosive liquid, flammable, diesel fuel). Annually, this database is updated to show the maximum amounts of chemicals that were present in each building at the NTS, the NPTEC, the NLVF (see Section B.1.4), and the RSL (see Section B.3.3). This information is then used to complete the Nevada Combined Agency (NCA) Report. This report provides information to the state, community, and local emergency planning commissions on the maximum amount of any chemical, based on its hazard classification, present at any given time during the preceding year. This report also provides the commissions with new chemicals or chemical classes that were not previously on site. The State Fire Marshall then issues permits to store hazardous chemicals on the NTS, as well as at the RSL and the NLVF.

In 2004, the chemical inventory at NTS facilities was updated and submitted to the state in the NCA Report on February 25, 2005. No accidental or unplanned release of an extremely hazardous substance (EHS) occurred on the NTS in 2004.

The hazardous substance inventory database is also used to complete the Toxic Release Inventory (TRI) Report, Form R. This report provides EPA and the State Emergency Response Commission information on any toxic chemical that enters the environment above a given threshold. It also provides these agencies with the amounts of toxic chemicals that are recycled. NNSA/NSO submitted this report for calendar year 2004 to EPA on June 22, 2005. Lead was the only listed toxic chemical released into the NTS environment in 2004 that was reportable. Total air emissions of lead from the NTS was 10.4 pounds (lbs), and 5,868.7 lbs of lead ammunition were released at the Mercury firing range. Lead which either is recovered during site remediation activities or is excess to NTS operational needs (e.g., lead bricks, lead shielding) is sent offsite for recycling or proper disposal. A total of 107,512 lbs of lead was sent offsite for recycling in 2004.

There were no EPCRA inspections by outside regulators performed at the NTS in 2004.

HAZTRAK is a tracking system that monitors hazardous materials while they are in transit. When a truck transporting hazardous material enters the NTS, all information concerning the load is entered into the tracking system. Once the delivery is complete, the information provided at the time of entry is removed from the tracking system.

10.4 Nevada Chemical Catastrophe Prevention Act

If EHSs are stored in quantities which exceed threshold quantities established by the NDEP, then NNSA/NSO submits a report notifying the state. During 2004, no NTS facility stored EHSs in quantities which required state notification. Therefore, no Nevada Chemical Accident Prevention Program Report was prepared regarding calendar year 2004 NTS operations.

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11.0 Pollution Prevention and Waste Minimization

The U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office (NNSA/NSO) has Pollution Prevention (P2) and Waste Minimization (WM) initiatives. These initiatives establish a process to reduce the volume and toxicity of waste generated by the NNSA/NSO on the Nevada Test Site (NTS) and its satellite facilities. They also ensure that proposed methods of treatment, storage, and disposal of waste minimize potential threats to human health and the environment. These initiatives also address the requirements of several federal and state regulations applicable to operations on the NTS (see Section 2.7). The following information provides an overview of the P2/WM goals, major accomplishments during the reporting year, a comparison of the current year's waste generation to prior years, a description of efforts undertaken during the year to reduce the volume and toxicity of waste generated by the NNSA/NSO, and a description of the Secretary of Energy's P2 Goals and NNSA/NSO's status towards reaching those goals.

11.1 P2 and WM Goals and Components

It is the priority of NNSA/NSO to minimize the generation, release, and disposal of pollutants to the environment by implementing cost-effective P2 technologies, practices, and policies. A commitment to P2 minimizes the impact on the environment, improves the safety of operations, improves energy efficiency, and promotes the sustainable use of natural resources. This commitment includes providing adequate administrative and financial materials on a continuing basis to ensure goals are achieved.

Source Reduction – When economically feasible, source reduction is the preferred method of handling waste, followed by reuse and recycling, treatment, and as a last resort, landfill disposal. NNSA/NSO's Integrated Safety Management System requires that every project address waste minimization issues during the planning phase and ensure that adequate funds are allocated to perform any identified waste minimization activities.

To minimize the generation of waste, project managers are required to incorporate waste minimization into the planning phase of their projects. Waste generating processes must be assessed to determine if the waste can be economically reduced or eliminated. Waste minimization activities that are determined to be cost effective should be incorporated into the project plan and adequate funding allocated to ensure their implementation.

Recycling – For wastes that are generated, an aggressive recycling program is maintained. Items recycled through the NNSA/NSO recycling program include paper, cardboard, aluminum cans, toner cartridges, inkjet cartridges, tires, used oil, food waste from the cafeteria, plastic, scrap metal, rechargeable batteries, lead-acid batteries, alkaline batteries, fluorescent light bulbs, mercury lamps, metal hydride lamps, sodium lamps, and electronic media (diskettes, audio and video tapes, backup tapes, reel-to-reel tapes, etc.).

An effective method for reuse is the coordination of the Material Exchange Program. Created in 1998, the Material Exchange Program diverts supplies, chemicals, and equipment from landfills. Unwanted chemicals, supplies, and equipment are made available through electronic mail or postings on the intranet Material Exchange Database so that individuals in need can obtain the items at no cost. These materials are destined for disposal, either as solid or hazardous waste, as a result of process modification, discontinued use, or shelf life expiration. Rather than disposing of these items, the majority of them are provided to other employees for their intended purpose, thus avoiding disposal costs and costs for new purchases. If items are not placed with another user, they can be returned to the vendor for recycle/reuse, or given to other U.S. Department of Energy (DOE) sites, other government agencies, or local schools.

As required by Resource Conservation and Recovery Act (RCRA), Section 42 USC 6962, the NNSA/NSO maintains an Affirmative Procurement process that stimulates a market for recycled content products and closes the loop on recycling. RCRA section 42 USC 6962 requires the U.S. Environmental Protection Agency (EPA) to develop a list of items containing recycled materials that should be purchased. The EPA is also required to determine what the minimum content of recycled material should be for each item. Once this EPA-designated list was developed, federal facilities were required to ensure that a process was in place for purchasing the EPA-designated items containing the minimum content of recycled materials. Executive Order (EO) 13101 *Greening the Government through Waste Prevention, Recycling and Federal Acquisition* went one step further and requires federal facilities to ensure that 100 percent of purchases of items from the EPA-designated list contain recycled materials at the specified minimum content. Of the items NNSA/NSO currently purchases from the EPA-designated list, about 68 percent of those purchases contain recycled materials.

Assessments – Pollution Prevention Assessments are conducted twice a year. These assessments look at facilities or processes throughout the complex and focus on what waste streams are generated, what waste minimization activities are practiced, if there is room for improvement, and if these activities are tracked and reported in order to document that a waste minimization program is in place and operating as required. The assessments also look for new P2 opportunities.

Employee and Public Awareness – The NNSA/NSO P2 and WM initiatives also include an employee and public awareness program. Awareness of P2/WM issues is accomplished by dissemination of articles through both electronic mail and the NNSA/NSO site newsletters, the maintenance of a P2/WM intranet website, employee training courses, and participation at employee and community events. These activities are intended to increase awareness of P2/WM and environmental issues and point out the importance of P2/WM for improving environmental conditions in the workplace and community.

11.2 Major P2/WM Accomplishments in 2004

- Decommissioned buildings destined for disassembly and disposal were donated or sold to other agencies/schools that disassemble and remove the buildings from the NTS for reuse at new offsite locations. This waste minimization effort diverted approximately 27.9 mtons (30.8 tons) of waste from the NTS landfills.
- The Material Exchange Program reused 1.97 mtons (2.17 tons) of solid waste in 2004.
- The Bechtel Nevada Payroll Department converted to a paperless, electronic time keeping system. This new process eliminated the need for paper timecards which reduced the amount of paper waste by approximately 2.0 mtons (2.2 tons).

11.3 Waste Generation in 2004 Compared To Prior Years

For the purpose of comparison, the waste generation activities are presented in two source categories: routine waste and cleanup waste. Routine waste is operational waste generated from routine activities, both ongoing and new. Cleanup waste is waste generated from clean-up activities including investigation, site characterization, remediation from Environmental Restoration (ER) projects, and Deactivation and Disposal (D&D) projects.

Table 11-1 compares radioactive waste generated on site in 2004 with prior years. NNSA/NSO does not routinely generate radioactive waste, except for occasional events. With the addition of the Joint Actinide Shock Physics Experimental Research (JASPER) Project, routine radioactive waste will be generated in the future. Clean-up radioactive waste has decreased recently as the accelerated clean-up schedule for ER and D&D projects begins to wind down.

Table 11-1. Volume of radioactive waste generated by year

	Radioactive Waste Generated (m^3)[(a)]		
Calendar Year	**Routine**	**Clean-up**	**Total**
2004	0	334.7	334.7
2003	0.23	647.2	647.4
2002	0	1,270.3	1,270.3
2001	0	354.4	354.1
2000	0.46	67.1	67.6

(a) m^3 = Cubic meters; 1 m^3 = 1.3 cubic yards (yd^3)

Routine hazardous waste has fluctuated slightly up and down over the past five years (Table 11-2). Clean-up hazardous waste decreased in 2004 as the accelerated clean-up schedule for ER and D&D projects begins to wind down.

Table 11-2. Mass of hazardous waste generated by year

	Hazardous Waste Generated (mtons)[a]		
Calendar Year	**Routine**	**Clean-up**	**Total**
2004	18.4	36.0	54.4
2003	10.4	518.9	529.3
2002	7.0	127.5	134.5
2001	10.2	1.6	11.8
2000	24.5	22.5	47.0

(a) 1 mton = 1.1 ton

Routine solid waste has shown a slight decrease over the year (Table 11-3), mainly due to no new major projects coming online during the year. Solid clean-up wastes have decreased as the accelerated clean-up schedule for ER and D&D projects begins to wind down.

Table 11-3. Mass of solid waste generated by year

	Solid Waste Generated (mtons)[a]		
Calendar Year	**Routine**	**Clean-up**	**Total**
2004	4,092	6,346	10,438
2003	4,502	16,975	21,477
2002	3,305	14,006	17,311
2001	1,622	8,145	9,767
2000	4,401	4,381	8,782

(a) 1 mton = 1.1 ton

11.4 Waste Reductions in 2004 Compared To Prior Years

P2/WM techniques and practices are implemented for all activities that may generate waste. These P2/WM activities result in reductions to the volume and/or toxicity of waste actually generated on site. Table 11-4 compares the amounts of radioactive, hazardous, and solid wastes reduced in 2004 to prior years.

Table 11-4. Volume of waste reduced through P2/WM activities by year

Calendar Year	Radioactive Waste Reduced (m^3)[a]	Hazardous Waste Reduced (mtons)[b]	Solid Waste Reduced (mtons)
2004	0	114.8	1,437.5
2003	40.0	207.3	1,547.2
2002	63.2	177.2	904.2
2001	79.6	123.5	799.0

(a) 1 m^3 = 1.3 yd^3 (b) 1 mton = 1.1 ton

Table 11-5 shows a summary of the estimated volume reductions of radioactive, hazardous, and solid waste accomplished during 2004, through implementation of P2/WM activities. An estimated 127 ton (115 mton) reduction of hazardous waste including RCRA, Toxic Substance Control Act, and state-regulated hazardous waste; and a 1,585 ton (1,438 mton) reduction of solid waste (sanitary waste) occurred in 2004.

Table 11-5. Volume of waste reduced through recycling and reuse activities in 2004

Activity	Volume Reduction (mtons)[(a)]
Hazardous Waste	
Bulk used oil was sent to an offsite vendor for recycling	80.7
Lead scrap metal was sold for reuse/recycling	23.0
Lead acid batteries were shipped to an offsite vendor for recycling	4.4
Spent fluorescent light bulbs, mercury lamps, metal hydride lamps, and sodium lamps were sent to an offsite vendor for recycling	3.3
Used antifreeze was recycled onsite and reused	3.0
Lead tire weights were reused instead of being disposed as hazardous waste	0.2
Rechargeable batteries were sent to an offsite vendor for recycling	0.2
Total	**114.8**
Solid Waste	
Scrap ferrous metal was sold to a vendor for recycling	751.2
Mixed paper and cardboard was sent offsite for recycling	518.7
Scrap non-ferrous metal was sold to a vendor for recycling	37.2
Food waste from the cafeterias was sent offsite to be reused as pig feed for a local pig farmer	51.6
Shipping materials including pallets, styrofoam, bubble wrap, and shipping containers were reused	22.9
Tires were sent to a vendor for recycling	18.4
Decommissioned buildings destined for disassembly and disposal were donated or sold to other agencies/schools that disassemble and remove the buildings from the site for reuse	27.9
Non-hazardous chemicals, equipment, and supplies were relocated to new users through the Material Exchange program, diverting them from landfill disposal	2.0
Spent toner cartridges were sent offsite for recycling	4.9
Aluminum cans were sent offsite for recycling	0.6
Electronic media were sent offsite for recycling	2.0
Number 1 plastic was sent offsite for recycling	0.1
Total	**1,437.5**

(a) 1 mton = 1.1 ton

11.5 Secretary of Energy's P2/WM Leadership Goals

On November 12, 1999, the Secretary of Energy set numerous pollution prevention and energy efficiency goals that each DOE Site is required to meet. The following are the P2/WM goals:

- Reduce waste from routine operations by 2005, using a 1993 baseline, for the following waste types:
    - Hazardous by 90 percent
    - Low Level Radioactive by 80 percent
    - Low Level Mixed Radioactive by 80 percent
    - Transuranic (TRU) by 80 percent

- Reduce solid waste from routine operations by 75 percent by 2005 and 80 percent by 2010, using a 1993 baseline
- Reduce releases of toxic chemicals subject to Toxic Chemical Release Inventory (TRI) reporting by 90 percent by 2005, using a 1993 baseline
- Reduce waste resulting from cleanup, stabilization, and decommissioning activities by 10 percent on an annual basis
- Recycle 45 percent of solid waste from all operations by 2005 and 50 percent by 2010
- Increase purchases of EPA-designated items with recycled content to 100 percent, except when not available competitively at a reasonable price or if items do not meet performance standards

NNSA/NSO generated 20.3 tons (18.4 mtons) of hazardous waste in 2004 as part of routine operations. Using the 1993 baseline of 4,105 tons (3,724 mtons), NNSA/NSO reduced hazardous waste by 99.5 percent. Therefore, NNSA/NSO has already met the 2005 goal of 90 percent.

The 1993 baselines for low level radioactive, low level mixed radioactive, and TRU waste were all 0 m^3. However, the JASPER project will generate routine TRU waste in the future. As long as this project generates routine radioactive waste, NNSA/NSO will not be able to meet the goal for this waste type.

The routine solid waste generated by the NNSA/NSO in 2004 was 4,511 tons (4,092 mtons). Using the 1993 baseline of 15,140 tons (13,735 mtons), NNSA/NSO reduced solid waste by 70 percent during 2004. The 2005 goal is 75 percent.

In 1993, NNSA/NSO released 0 pounds of chemicals subject to TRI reporting into the environment. Effective January 1, 2001, the EPA lowered the reporting threshold for lead. With this lower threshold limit, NNSA/NSO had releases of lead generated from lead bullets at the Wackenhut Services, Inc. (WSI) firing range that now have to be reported. NNSA/NSO will not be able to meet the TRI release goal as long as the WSI firing range continues to use lead bullets. A total of 5,868.7 lbs of lead ammunition was released at the Mercury firing range. Also, total air emissions of lead from the NTS was 10.4 pounds (lbs).

The NNSA/NSO generated 8,330 tons (7,556 mtons) of radioactive, hazardous, and solid waste from cleanup operations at the NTS. Additionally, 925 tons (839 mtons) were recycled, amounting to 11 percent reduction in cleanup waste. The goal for recycling all cleanup waste is 10 percent annually.

In 2004, the solid waste generated by all operations (routine and cleanup activities) was 13,092 tons (11,875 mtons). NNSA/NSO recycled 1,586 tons (1,438 mtons) of solid waste, or about 12 percent of the solid waste generated. The 2005 goal is 45 percent. Almost 6,996 tons (6,346 mtons) of solid waste were generated due to the accelerated cleanup schedule at the NTS, increasing the waste generation totals and lowering the percentage of solid waste recycled.

EO13101 requires that 100 percent of purchases of items found on the EPA-designated list be purchased containing recycled materials. In 2004, 68 percent of NNSA/NSO's purchases of EPA-designated items contained recycled materials.

The tabulated summary of NTS progress towards meeting these leadership goals, as discussed above, are presented in Chapter 2.0, Compliance Summary (Table 2-7b).

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12.0 Historic Preservation and Cultural Resources Management

The historic landscape of the Nevada Test Site (NTS) contains archaeological sites, buildings, structures, and places of importance to American Indians and others. These are referred to as "cultural resources". U.S. Department of Energy (DOE) Order 450.1 *Environmental Protection Program* requires that NTS activities and programs comply with all applicable cultural resources regulations (see Section 2.8) and that such resources on the NTS be monitored. The Cultural Resources Management (CRM) program has been established and is implemented by the Desert Research Institute (DRI) on the NTS to meet this requirement. The CRM program is designed to meet the specific goals shown below.

Cultural Resources Management Program Goals
Ensure compliance with all regulations pertaining to cultural resources on the NTS (see Section 2.8)
Inventory and manage cultural resources on the NTS
Provide information that can be used to evaluate the potential impacts of proposed projects and programs to cultural resources on the NTS and mitigate adverse effects
Curate archaeological collections in accordance with 36 CFR Part 79
Conduct American Indian consultations related to places and items of importance to the Consolidated Group of Tribal Organizations

In order to achieve the program goals and meet federal and state requirements, the CRM is multi-faceted and contains the following major components: (1) surveys, inventories, and historical evaluations; (2) curation of archaeological collections; and (3) the American Indian Program. The guidance for the CRM work is provided in the Cultural Resources Management Plan for the Nevada Test Site (Drollinger et al., 2002). Historic preservation personnel and archaeologists of DRI who meet the Secretary of the Interior standards conduct the work and the archaeological efforts are permitted under the Archeological Resources Protection Act (ARPA).

A brief description of the CRM program components and their 2004 accomplishments are provided in this chapter. The methods used to conduct surveys, inventories, and historical evaluations in support of NTS operations were summarized in last year's NTS environmental report (DOE, 2004). The reader is directed to Appendix A, Section A.5 for a summary of the known human occupation and use of the NTS from the Paleo-Indian Period, about 12,000 years ago, until the mining and ranching period of the twentieth century, just before NTS lands were withdrawn for federal use.

12.1 Cultural Resources Surveys, Inventories, Historical Evaluations, and Associated Activities

Cultural resources surveys are conducted at the NTS to meet the requirements of the National Historic Preservation Act (NHPA) and the ARPA. The surveys are completed prior to proposed projects that may disturb or otherwise alter the environment. The following information is maintained in databases:

- Number of cultural resources surveys conducted
- Location of each survey
- Number of acres surveyed at each project location
- Types of cultural resources identified at each project location
- Number of cultural resources determined eligible to the National Register of Historic Places (NRHP)
- Eligible properties avoided by project activities
- Cultural resources requiring mitigation to address an adverse effect
- Final report on results

12.1.1 Cultural Resources Surveys

In 2004, five surveys were conducted for proposed projects: the Yucca Lake Aerial Operations Facility Project, the Underground Test Area Well Pad ER-12-3 area, the Underground Test Area Well Pad ER-12-4 area, the Underground Test Area Well Pad ER-12-4 relocation, and the Area 6 Borrow Pit Expansion Project. Eight prehistoric sites were identified within the project areas. During earlier surveys, six of these sites had been determined eligible to the NRHP. In the course of these projects, the site forms for the six sites were updated with current information. All six sites were re-evaluated, with four of the sites now considered not eligible. In addition, a historic wooden structure was identified within the project area for the Yucca Lake Aerial Operations Facility, but no reliable information was found regarding its origin. As a result, the structure is being treated as eligible until information becomes available regarding its purpose and age. When this information is acquired, the wooden structure can be evaluated for eligibility to the NRHP.

12.1.2 Cultural Resources Inventories

There were three cultural resources inventories conducted in 2004. The archaeological survey and inventory of the prehistoric and historic remains at Tippipah Spring were completed during the summer. This research identified prehistoric use areas and documented the extent of the early 20th century historic occupation. Analysis of the field data is in progress. An inventory was conducted of sets of historic wooden benches at the primary atmospheric test viewing locations in Frenchman Flat and Yucca Flat. Six sets of benches were identified and each set was mapped and photographed. The area surrounding BREN Tower in Area 25 was surveyed with equipment and all associated remains inventoried. BREN stands for Bare Reactor Experiment Nevada, an early 1960s project to develop a way to accurately estimate the radiation doses received by survivors of the World War II atomic bombings of Hiroshima and Nagasaki through the use of a small, unshielded reactor on BREN Tower. Near the base of the original tower location in Area 4, an analog Japanese village was built with various types of Japanese structures. Inside the structures, instruments were placed to measure the dosage from the reactor. In 1966, the tower was moved to its current location in Area 25 where it was used for Operation HENRE (High Energy Neutron Reactions Experiment), a series of radiation measurement experiments using a small linear accelerator. BREN Tower has been determined eligible to the NRHP; the current effort is intended to document the associated equipment and land use areas for Project HENRE.

12.1.3 Evaluations of Historic Structures

Three historic evaluations were conducted in 2004. The structures evaluated were the Super Kukla Control Building in Area 27, Station 7-800 (Bunker 7-800) in Area 7, and the Japanese House near BREN Tower in Area 25. The Super Kukla Building once housed a prompt burst nuclear reactor to irradiate and measure a wide variety of specimens and samples used in the nuclear weapons testing program from 1964 to 1979. Station 7-800, currently known as Bunker 7-800, was constructed in 1956 as the main winch and guy cable winch shelter for Station B-7b.

Station B-7b was ground zero for five balloon shots conducted under the Plumbbob program and eight balloon shots conducted under Operation Hardtack II. The Japanese House was part of the BREN project in Area 4. When BREN Tower was moved to Area 25, this Japanese House also was moved and is the most complete structure from the Japanese Village that survives today.

As summarized in Table 12-1, a total of 220 hectares (538 acres) were examined during cultural resources surveys, inventories, and historical evaluations. Nine prehistoric and historic archaeological sites were studied with four eligible to the NRHP with one determination pending. Eleven nuclear testing related structures were documented with three eligible to the NRHP and eight determinations pending.

Table 12-1. Summary data for cultural resources surveys, inventories, and historical evaluations conducted in 2004

Survey/Inventory/Historic Evaluation	Prehistoric/Historic Sites Found	Structures Evaluated	Sites Determined NRHP Eligible	Area Surveyed	
				Acres	Hectares
Yucca Lake Aerial Operations Facility	0	1	P[(a)]	151	61.1
ER-12-3 Well Pad	2	0	0	9.7	3.9
ER-12-4 Well Pad	6	0	4	15.7	6.35
ER-12-4 Well Pad Relocation	0	0	0	4.69	1.90
Area 6 Borrow Pit Expansion	0	0	0	88.74	35.91
Bench Inventory	0	6	P	1.32	0.53
Station 7-800	0	1	1	0.02	0.008
Super Kukla Control Building	0	1	1	0.06	0.02
Bren Tower	0	1	1	224	90.6
Japanese House	0	1	P	2.0	0.81
Tippipah Spring	1	0	P	50	20.2
Total	**9**	**11**	**7**	**537.53**	**220.14**

(a) P = determination is pending

12.1.4 Associated Cultural Resources Activities

12.1.4.1 Adverse Effect Assessments and Mitigation Activities

There were no determinations of adverse effect to cultural resources in 2004. No mitigation activities were undertaken or were in progress.

12.1.4.2 General Reconnaissance

General reconnaissance and other activities, without systematic field recording, were also conducted in 2004. There were two field visits. One was to look at the Neptune Ant Mound project area in Area 3 and the other was to a road location in Area 30. Another field activity involved photographing the relocation of an Army Tank from Frenchman Flat to Area 1. This tank was not used in the atmospheric testing program. Only one project required a background search but no survey. This was a 6,000 ft (1,829 m) diameter circle centered on the DAF, an area proposed for vegetation removal and leveling. Background research indicated that the area had been previously surveyed in 1984 and there were no significant sites or structures.

12.1.4.3 Reports

Four survey reports, two historical evaluations, and one letter report were completed and are listed in Table 12-2. Site location information is protected from public distribution and those reports containing such data are not available to the public. Technical reports can be obtained from the DOE's Office of Scientific and Technical Information at email address <http://www.osti.gov/bridge>.

The data on NTS archaeological activities also were provided to DOE Headquarters in the formal Archeology Questionnaire for transmittal to the Secretary of the Interior and, ultimately, to the U.S. Congress as part of the federal agency archaeology report.

Table 12-2. Short reports, historical evaluations, technical reports, and letter reports prepared in 2004

Project	Report No.	Author(s)
Yucca Lake Aerial Operations Facility	SR071304-1	Holz, B.A. 2004
Well Pad ER-12-3	SR080204-1	Jones, R.C. 2004b
Well Pad ER-12-4 and Access Road	SR080304-1	Jones, R.C. 2004c
Well Pad ER-12-4 Relocation	SR091504-1	Jones, R.C. 2004d
Neptune Ant Mound	LR112304-1	Jones, R.C. 2004e
Historical Evaluation Station 7-800	HE042004-1	Jones, R.C. 2004a
Historical Evaluation Super Kukla Building 5430	HE042104-3	Drollinger, H. 2004a

12.2 Curation

The NHPA requires that archaeological collections and associated records be maintained at professional standards; the specific requirements are delineated in 36 CFR Part 79, Curation of Federally-Owned and Administered Archeological Collections. Requirements for curation of the NTS archaeological collection include the following:

- Maintain a catalog of the items in the NTS collection
- Package the NTS collection in materials that meet archival standards (e.g., acid-free boxes)
- Store the NTS collection and records in a facility that is secure and has environmental controls
- Establish and follow curation procedures for the NTS collection and facility
- Comply with the Native American Graves Protection and Repatriation Act

In the 1990s, the NNSA/NSO completed the required inventory and summary of NTS cultural materials accessioned into the NTS Archaeological Collection and distributed the inventory list and summary to the tribes affiliated with the NTS and adjacent lands. Consultations followed, and all artifacts the tribes requested were repatriated to them. This process was completed in 2002; it will be repeated for any new additions to the NTS collection in the future. The known locations of American Indian human remains at the NTS continued to be protected from NTS activities in 2004.

The NTS Archaeological Collection contains over 400,000 artifacts and is curated in accordance with 36 CFR Part 79. For the past decade these materials and the associated records were housed in a remote facility. In 2003, the artifacts were moved into a newly constructed building on the DRI campus that provides additional security and environmental controls for the collection. Archaeologists, American Indians, NNSA/NSO personnel, and facilities staff worked on the move from the remote facility to the new building. The boxes of artifacts were logged in and out of the facilities, and the move was accomplished without incident. Following the relocation of the artifacts, a draft of new curation procedures was completed and distributed for review.

In 2004, the curation procedures were revised. The new procedures provide guidelines to follow in order to comply with 36 CFR Part 79 (Drollinger, 2004b). The reorganization of the records associated with the collection was initiated; this effort will be on-going for at least one more year. In anticipation of the YMP land withdrawal, the artifacts and records associated with several sites formerly under the jurisdiction of YMP were transferred into the NTS collection. Also, 16 historic ranching and mining artifacts were placed on loan to the Atomic Testing Museum for display in the museum.

12.3 American Indian Program

The NNSA/NSO has had an active American Indian Program since the late 1980s. The function of the program is to conduct consultations between NNSA/NSO and NTS-affiliated American Indian tribes. Such consultation occurs through the Consolidated Group of Tribes and Organizations (CGTO). The CGTO is comprised of 16 groups of Southern Paiute, Western Shoshone, and Owens Valley Paiute-Shoshone, along with the Las Vegas Indian Center, a Pan-Indian organization (see Table 12-3). 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 forum of the CGTO to express and discuss issues of importance
- Provide the CGTO with opportunities to actively participate in decisions that involve places and locations that hold significance for them
- Involve the CGTO in the curation and display of American Indian artifacts
- Enable the CGTO and its constituency to practice their religious and traditional activities

Table 12-3. Culturally affiliated tribes and organizations in the CGTO

Ethnic Group	Tribe/Band
Southern Paiute	Chemehuevi Indian Tribe
	Colorado River Indian Tribes
	Kaibab Paiute Tribe
	Las Vegas Paiute Tribe
	Moapa Paiute Tribe
	Paiute Indian Tribe of Utah
	Pahrump Band of Paiutes
Western Shoshone	Duckwater Shoshone Tribe
	Ely Shoshone Tribe
	Timbisha Shoshone Tribe
	Yomba Shoshone Tribe
Owens Valley Paiute-Shoshone	Benton Paiute-Shoshone Tribe
	Big Pine Paiute Tribe
	Bishop Paiute Tribe
	Fort Independence Indian Tribe
	Lone Pine Paiute-Shoshone Tribe
Pan-Indian Organization	Las Vegas Indian Center

In September 2004 an American Indian Field Study was conducted at a canyon within the area of Wunjiakuda, an important traditional property on the NTS. Wunjiakuda is documented in an early 20th century ethnographic study as the location of the annual regional fall festival for the Western Shoshone and Southern Paiute. This gathering occurred at the time when the pine nuts were ready to harvest and provided the opportunity for ceremonial activities, festivities, and regular interaction between the various Indian groups. A small number of people lived at the location year round. The 2004 field study focused on a small canyon and the surrounding terrain, a location identified in 1997 as having special significance to the Indian people. There were two three-day field sessions and interviews were conducted with 14 tribal elders and cultural specialists at various places within and near the canyon regarding their knowledge and stories about the area.

In 2003, the CGTO established an Atomic Testing Museum (ATM) subgroup to work with the museum on the content of a planned exhibit for the NTS American Indian history, culture, and views regarding the NTS landscape. The subgroup had two meetings in 2003. In 2004, there was one meeting between the subgroup and the museum director, facilitated by NNSA/NSO, during which the concept for the exhibit was finalized. Following the meeting, late 19th and early 20th century photographs of Western Shoshone and Southern Paiute were identified for possible inclusion in the exhibit. Also, efforts were made to locate recently made American Indian items that could represent traditional life ways, with some identified for purchase. The exhibit was planned for completion in 2005.

13.0 Ecological Monitoring

U.S. Department of Energy (DOE) Order 450.1 *Environmental Protection Program* requires ecological monitoring and biological compliance support for activities and programs conducted at the DOE facilities. The Bechtel Nevada (BN) Ecological Monitoring and Compliance Program (EMAC) provides this support for the Nevada Test Site (NTS). The major sub-programs and tasks within EMAC include: (1) the Desert Tortoise Compliance Program, (2) biological surveys at proposed construction sites, (3) ecosystem mapping and data management, (4) monitoring of sensitive species and habitats, (5) the Habitat Restoration Program, and (6) biological impact monitoring at the Non-Proliferation Test and Evaluation Complex (NPTEC). A brief description of these program components and their 2004 accomplishments are provided in this chapter. More detailed information may be found in published fiscal year EMAC reports which are distributed to several state and federal natural resource agencies (e.g., BN, 2005c). These annual reports are available electronically at <http://www.osti.gov/bridge>.

Ecological Monitoring and Compliance Program Goals
Ensure compliance with all state and federal regulations and stakeholder commitments pertaining to NTS flora, fauna, wetlands, and sensitive vegetation and wildlife habitats (see Section 2.9)
Delineate NTS ecosystems
Provide ecological information that can be used to evaluate the potential impacts of proposed projects and programs on NTS ecosystems

13.1 Desert Tortoise Compliance Program

The desert tortoise inhabits the southern one-third of the NTS at fairly low estimated densities (Figure 13-1). This species is listed as threatened under the Endangered Species Act. In December 1995, the NNSA/NSO completed consultation with the U.S. Fish and Wildlife Service (FWS) concerning the effects of U.S. Department of Energy, National Nuclear Security Administration (NNSA/NSO) activities on the desert tortoise, as described in the *Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada* (DOE, 1996a). A final Biological Opinion (Opinion) (FWS, 1996) was received from the FWS in August 1996. The Opinion concluded that the proposed activities on the NTS were 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. The Opinion established compliance limits for the numbers of accidentally injured and killed tortoises, captured and displaced tortoises, and acres of tortoise habitat that can be disturbed. All terms and conditions listed in the Opinion must be followed when activities are conducted within the range of the desert tortoise on the NTS.

The Desert Tortoise Compliance Program within EMAC was developed to implement the terms and conditions of the Opinion, to document compliance actions taken by NNSA/NSO, and to assist NNSA/NSO in FWS consultations. The compliance measures which are monitored include:

- Number of tortoises accidentally injured or killed due to NTS activities
- Number of tortoises captured and displaced from project sites
- Number of tortoises injured or killed on NTS paved roads
- Number of total acres of desert tortoise habitat disturbed by NTS construction
- Adherence to 23 operational terms and conditions of the Opinion

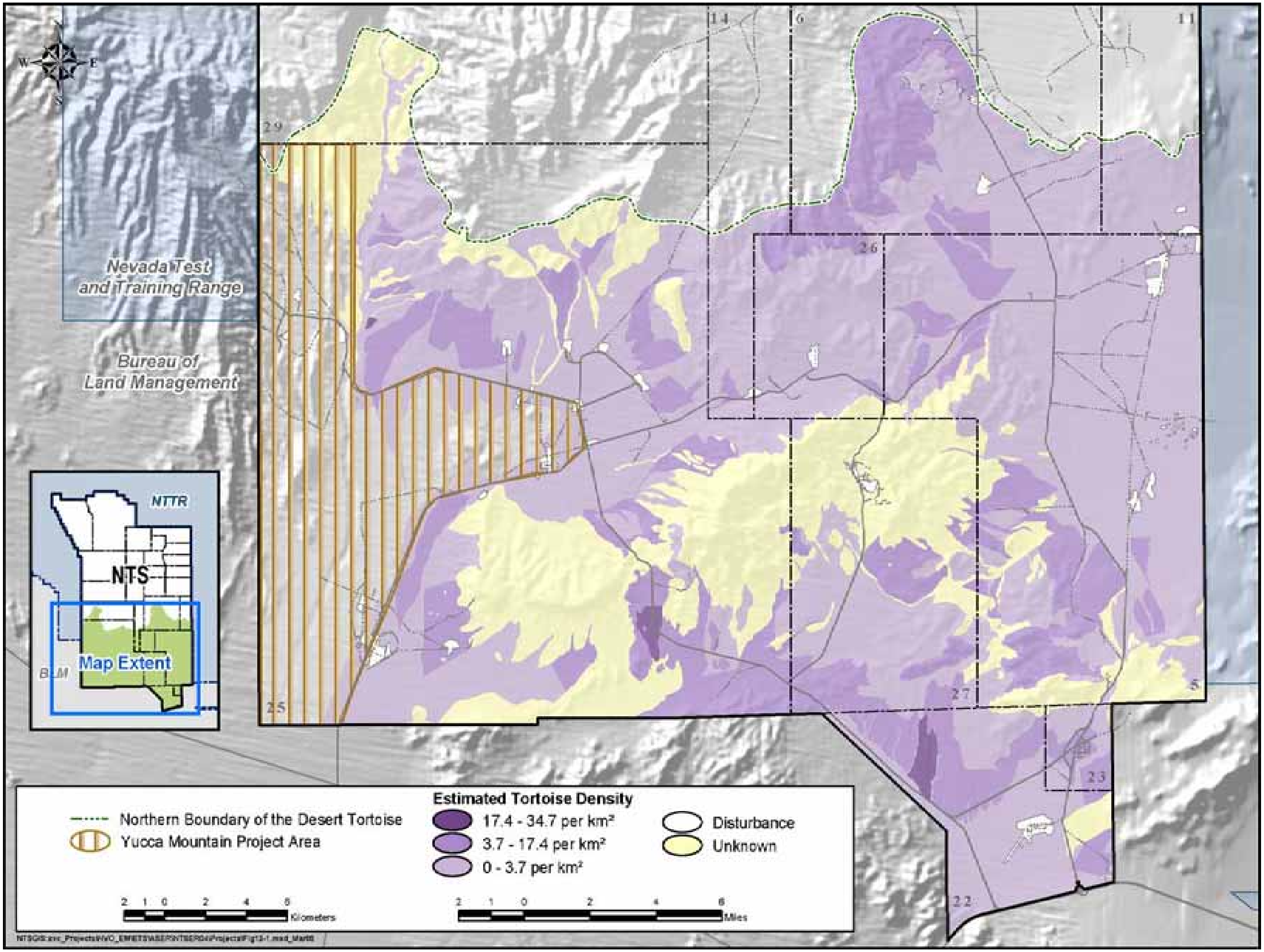


Figure 13-1. Desert tortoise distribution and abundance on the NTS

In 2004, biologists conducted desert tortoise clearance surveys at 40 sites for 20 proposed projects. Flagged tortoise burrows were avoided during surface-disturbing activities. On-site construction monitoring was conducted by a designated EM at all sites, where required.

A total of 9.02 hectares (22.30 acres) of tortoise habitat were disturbed in 2004. No desert tortoises were accidentally injured or killed, nor were any captured or displaced from project sites. A cumulative total of 97.13 hectares (240.01 acres) of tortoise habitat on the NTS has been disturbed since the desert tortoise was listed as threatened in 1992. A mitigation fee for the loss of 101 hectares (250 acres) of habitat was prepaid in 1992 into the Desert Tortoise Habitat Conservation Fund Number 236-8290. During 2004, none of the threshold levels established by the FWS in the Opinion for compliance measures were exceeded (Table 13-1). In January 2005, NNSA/NSO submitted a report to the FWS Southern Nevada Field Office that summarized tortoise compliance activities conducted on the NTS from January 1 through December 31, 2004.

Table 13-1. Compliance limits and status for NTS operations in tortoise habitat

Monitored Parameter	Threshold Value	CY 2004 Value of Monitored Parameter
Number of tortoises accidentally injured or killed as a result of NTS activities per year	3	0
Number of tortoises captured and displaced from NTS project sites per year	10	0
Number of tortoises taken in form of injury or mortality on paved roads on the NTS by vehicles other than those in use during a project	Unlimited	3
Number of total hectares (acres) of desert tortoise habitat disturbed during NTS project construction since 1992	1,220 (3,015)	97.13 (240.01)

In October 2004, a tortoise habitat revegetation plan for the NTS was approved by the FWS. Revegetation is an approved mitigation for the loss of tortoise habitat on the NTS in lieu of paying for acreage disturbed. Since 1992, NNSA/NSO has been using the balance of $81,000 that NNSA/NSO pre-paid for the future disturbance of 101 hectares (250 acres) of tortoise habitat on the NTS. This fund is almost depleted. In the future, BN biologists will now have the option to revegetate disturbed tortoise habitat whenever it is feasible.

13.2 Biological Surveys at Proposed Project Sites

Biological surveys are performed at proposed project sites where land disturbance will occur. The goal is to minimize the adverse effects of land disturbance on important plant and animal species and their associated habitat, on important biological resources (i.e., nest sites, active burrows), and on wetlands. Biological surveys comply with the terms and conditions of the Opinion and with the mitigation measures specified in the *Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada* (DOE, 1996a) and its final Record of Decision.

Species considered important include those protected or managed under state or federal regulations and species considered "sensitive." Sensitive species include those whose long-term viability has been identified as a concern by natural resource experts. The important species known to occur on the NTS include 19 plants (all sensitive) and 42 animals (Tables 13-2 and 13-3). All NTS sensitive species are evaluated for their inclusion in long-term monitoring activities on the NTS. Important biological resources include such things as cover sites, nest or burrow sites, roost sites, wetlands, or water sources important to sensitive species. The biological survey parameters which are documented include:

- Number of biological surveys conducted

- Number of hectares/acres surveyed per proposed project
- Types and numbers of important species and biological resources found
- Mitigation recommendations and actions taken to protect species/resources

In 2004, surveys at 145 sites for 40 projects were conducted (Figure 13-2). The summary of survey results are shown in Table 13-4. No wetlands or important species were impacted by these projects. Some resources used by important species were impacted: six inactive bird nests were removed from buildings which were demolished.

Table 13-2. Important plants which are known to occur on or adjacent to the NTS

Flowering Plant Species	**Common Name**	**Status**[(a)]
Arctomecon merriamii	White bearpoppy	S, IA
Astragalus beatleyae	Beatley's milkvetch	S, A
Astragalus funereus	Black woolypod	S, A
Astragalus oopherus var. *clokeyanus*	Clokey's egg milkvetch	S, A
Camissonia megalantha	Cane Spring suncup	S, IA
Cymopterus ripleyi var. *saniculoides*	Ripley's springparsley	S, IA
Eriogonum concinnum	Darin's buckwheat	S, A
Eriogonum heermannii var. *clokeyi*	Clokey's buckwheat	S, A
Frasera albicaulis var. *modocensis*(b)	Modoc elkweed	S, IA
Galium hilendiae ssp. *kingstonense*	Kingston Mountain bedstraw	S, IA
Hulsea vestita ssp. *inyoensis*	Inyo hulsea	S, IA
Ivesia arizonica var. *saxosa*	Whitefeather ivesia	S, A
Lathyrus hitchcockianus	Hitchcock's peavine	S, A
Penstemon pahutensis	Pahute penstemon	S, IA
Phacelia beatleyae	Beatley's phacelia	S, A
Phacelia mustelina	Weasel phacelia	S, IA
Phacelia parishii	Parish's phacelia	S, IA
Sclerocactus polyancistrus	Hermit cactus	S, IA
Moss Species		
Entosthodon planoconvexus	Planoconvex enthosthodon	S, E

(a) Status Codes:

State of Nevada

S - Nevada Natural Heritage Program – Sensitive Plant Taxa

Long-term Sensitive Plant Monitoring Status under EMAC

A - Active: currently included in long-term population monitoring activities

IA - Inactive: not currently included in long-term population monitoring activities

E - Evaluate: species for which more information on distribution, abundance, and susceptibilities to threats on the NTS must be gathered before deciding to include in long-term monitoring activities

(b) Nevada Natural Heritage Program calls this plant *Frasera pahutensis*

Note: The State of Nevada protects all cactus, yucca, and "Christmas trees" from unauthorized collection on public lands. Such plants are not protected from harm on private lands or on withdrawn public lands.

Table 13-3. Important animals which are known to occur on or adjacent to the NTS

Mollusk Species	Common Names	Status [a]
Pyrgulopsis turbatrix	Southeast Nevada springsnail	S, A
Reptile Species		
Eumeces gilberti rubricaudatus	Western red-tailed skink	S, E
Gopherus agassizii	Desert tortoise	LT, NPT, S, IA
Bird Species[b]		
Accipiter gentilis	Northern goshawk	S, NP, IA
Alectoris chukar	Chukar	G
Aquila chrysaetos	Golden eagle	EA, NP
Athene cunicularia hypugaea	Western burrowing owl	S, NP, A
Buteo regalis	Ferruginous hawk	S, NP, IA
Buteo swainsoni	Swainson's hawk	S, NP, A
Callipepla gambelii	Gambel's quail	G
Charadrius montanus	Mountain plover	PT, NP
Chlidonias niger	Black tern	S, NP, IA
Coccyzus americanus	Western yellow-billed cuckoo	S, NP, IA
Falco peregrinus anatum	American peregrine falcon	<LE, S, NPE, IA
Gavia immer	Common loon	S, NP, IA
Haliaeetus leucocephalus leucocephalus	Southern bald eagle	LT-PD, EA, S, NPE, IA
Ixobrychus exillis hesperis	Western least bittern	S, NP, IA
Phainopepla nitens	Phainopepla	S, NP, IA
Plegadis chihi	White-faced ibis	S, NP, IA
Mammal Species		
Antrozous pallidus	Pallid bat	M, A
Antilocapra americana	Pronghorn antelope	G
Corynorhinus townsendii pallescens	Townsend's big-eared bat	S, H, A
Equus asinus	Burro	HB
Equus caballus	Horse	HB
Euderma maculatum	Spotted bat	S, M, NPT, A
Felis concolor	Mountain lion	G
Lasionycteris noctivagans	Silver-haired bat	S, M, A
Lasiurus blossevillii	Western red bat	S, H, A
Lasiurus cinereus	Hoary bat	S, M, A
Lynx rufus	Bobcat	F
Myotis californicus	California myotis	S, M, A
Myotis ciliolabrum	Small-footed myotis	S, M, A
Myotis evotis	Long-eared myotis	M, A
Myotis thysanodes	Fringed myotis	S, H, A

Table 13-3. (Continued)

Mammal Species (continued)	Common Name	Status[(a)]
Myotis yumanensis	Yuma myotis	M, A
Ovis canadensis nelsoni	Desert bighorn sheep	G
Odocoileus hemionus	Mule deer	G
Pipistrellus hesperus	Western pipistrelle	M, A
Sylvilagus audubonii	Audubon's cottontail	G
Sylvilagus nuttallii	Nuttall's cottontail	G
Urocyon cinereoargenteus	Gray fox	F
Vulpes velox macrotis	Kit fox	F

(a) Status Codes:

U. S. Fish and Wildlife Service, Endangered Species Act

LT - Listed Threatened
PT - Proposed for listing as Threatened
PD - Proposed for delisting
<LE- Former listed endangered species

U.S. Department of Interior

HB - Protected under Wild Free Roaming Horses and Burros Act
EA - Protected under Bald and Golden Eagle Act

State of Nevada

S - Nevada Natural Heritage Program-Sensitive Animal Taxa
NPE - Species protected as endangered under NAC 503
NPT - Species protected as threatened under NAC 503
NP - Species listed as protected under NAC 503
G - Regulated as game species
F - Regulated as fur-bearer species
Note: The State of Nevada protects all birds that are protected by federal laws in addition to the species listed above

Long-term Sensitive Animal Monitoring Status under EMAC

A - Active: currently included in long-term population monitoring activities
IA - Inactive: not currently included in long-term population monitoring activities
E - Evaluate: species for which more information on distribution, abundance, and susceptibilities to threats on the NTS must be gathered before deciding to include in long-term monitoring activities

Nevada Bat Conservation Plan – Bat Species Risk Assessment Designations

H - High: species imperiled or at high risk of imperilment and having the highest priority for funding, planning, and conservation actions
M - Moderate: species which warrant closer evaluation, more research, and conservation actions and lacking meaningful information to adequately assess species' status

(b) All bird species on the NTS are protected by the Migratory Bird Treaty Act except for the following five species: Gambel's quail, chukar, English house sparrow, rock dove, and European starling

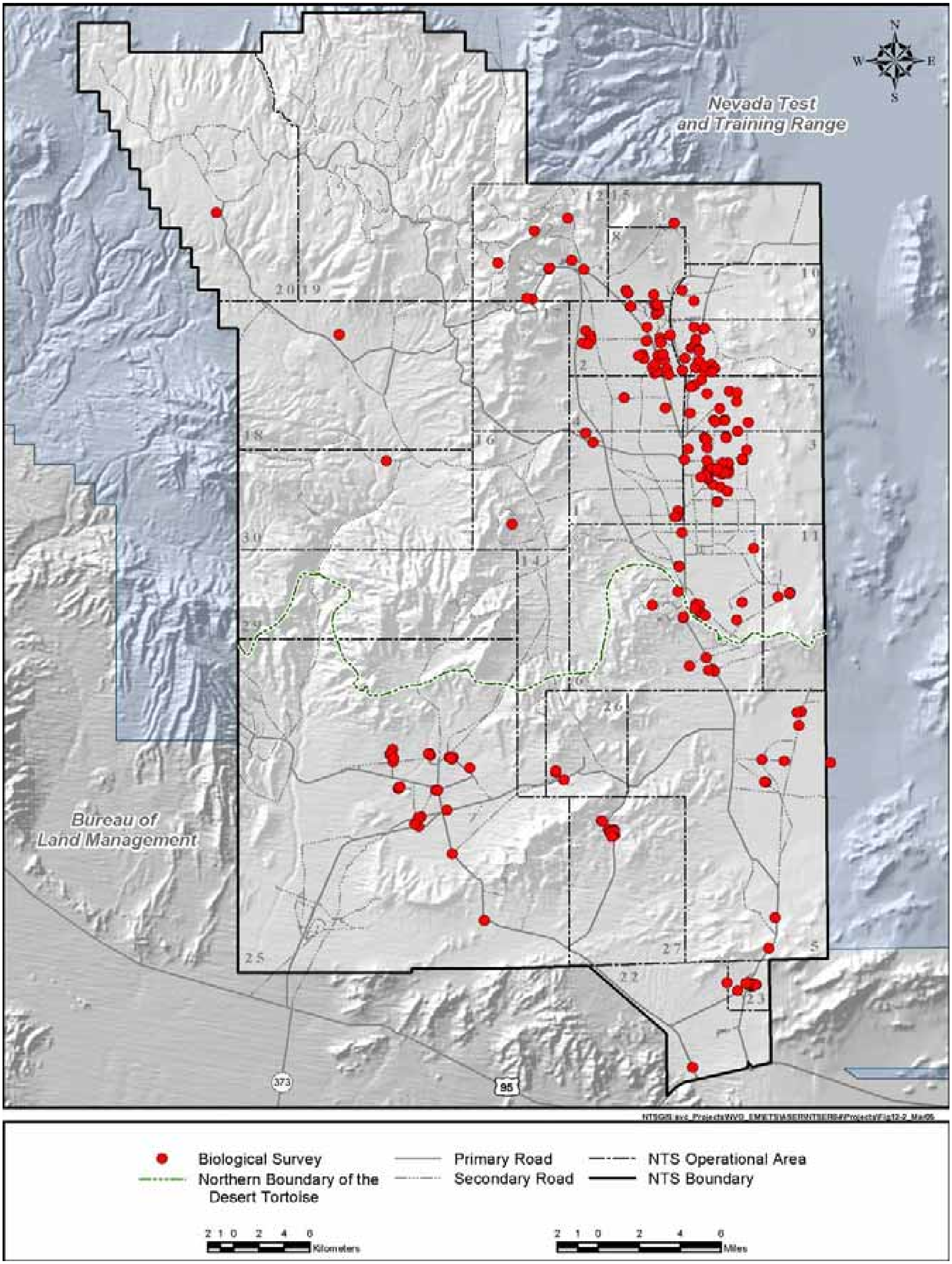


Figure 13-2. Location of biological surveys conducted on the NTS in 2004

Table 13-4. Summary of 2004 biological survey results

Measure	Result
Number of biological surveys conducted	145 for 40 projects
Area surveyed	Total: 220.87 ha (545.7 ac) Undisturbed habitat: 101.67 ha (251.23 ac) Previously-disturbed habitat: 119.20 ha (294.47 ac)
Important species/biological resources found	1 population of Ripley's springparsley plants 6 inactive nests of migratory birds 1 barn owl 1 unidentified bat 2 potential burrowing owl burrows 6 inactive tortoise burrows 2 kit fox burrows 27 predator burrows
Mitigation actions taken	Ripley's springparsley plants avoided Bird nests removed prior to building demolitions Ensured no birds or bats present prior to building demolitions Potential burrowing owl burrows avoided Inactive tortoise burrows avoided Kit fox/predator burrows avoided or verified inactive prior to construction

13.3 Sensitive Species and Habitat Monitoring

Over the last three decades, NNSA/NSO has taken an active role in collecting or supporting the collection of information on the status of sensitive plants and animals and their habitat on the NTS and has produced numerous documents reporting their occurrence, distribution, and susceptibility to threats on the NTS (see *Ecology of the Nevada Test Site: An Annotated Bibliography* [Wills and Ostler, 2001]). In 1998, NNSA/NSO prepared a Resource Management Plan (DOE, 1998). One of the many natural resources goals stated in the plan is to protect and conserve sensitive plant and animal species found on the NTS and to minimize cumulative impacts to those species as a result of NNSA/NSO activities. The EMAC goals of species and habitat monitoring on the NTS are to:

- Ensure that impacts caused directly by NTS projects can be detected, quantified, and managed so that a species' occurrence on the NTS is not threatened by such projects
- Ensure adherence to state and federal regulations aimed at protecting wild horses, migratory birds, wetlands, and wildlife habitat

Data collected for monitored species include:

- Distribution on the NTS
- Relative abundance, density, or population size on the NTS
- Susceptibility to threats from NTS projects
- Location of nest burrows, nests, or roost sites of sensitive animals
- Location of preferred habitats
- Incidence and cause of mortality

In 2004, the major accomplishments under this EMAC task are presented below. Detailed descriptions of these actions and results can be found in BN, 2005c.

13.3.1 Sensitive Plants

Known populations and potential habitat of three sensitive plant species were visited to document plant abundance, population distributions, habitat features, and potential threats to the populations (Figure 13-3). The species were *Eriogonum concinnum,* an annual herb; *Ivesia arizonica* var. *saxosa*, a perennial herb; and *Lathyrus hitchcockianus*, a perennial forb (see Table 13-1). Between 150 and 1,600 *E. concinnum* plants were found at six of eight known population locations visited. Two new populations were found in 2004, extending the known NTS distribution of *E. concinnum*. Although commonly found on the NTS, this species is rarely found off the NTS. About 150 *I. arizonica* var. *saxosa* were found at one of two known population sites; none were found at an area of potential habitat surveyed in 2004. A total of about 225 *L. hitchockianus* plants were found in the Pinyon Pass area within 1.6 km (1.0 mi) west of the NTS western boundary in Area 25. This is the only known population location for *L. hitchockianus* on or near the NTS. Habitat features such as elevation, vegetation association, soils, and slope were recorded at each site where plants were found. No human threats to any populations of these three sensitive plant species were documented. Future field surveys will be conducted to better identify each species' distribution and abundance on the NTS.

13.3.2 Sensitive Bats

Night monitoring surveys for bats were conducted at 18 water sources and 41 potential roost sites (Figure 13-4) to identify the distribution of sensitive bat species and bat roosts on the NTS. Bat monitoring involves a variety of techniques including direct capture with mist nets, recording ultrasonic echolocation calls using the Anabat II™ system (Titley Electronics, Ballina, Australia), recording bat activity with a special night vision camera equipped with NightSight™ technology attached to a camcorder, and observing bat activity with night vision goggles.

Thirteen of the monitored water sources were human-made and five were natural. Bats were detected at all but one water source, U2gg sump. The lack of bat sightings at this sump was presumably due to high winds and stormy conditions at the time of monitoring. At the water sources, 81 individual bats were captured by mist net (representing 7 sensitive and 3 non-sensitive species) and 11 sensitive and 3 non-sensitive bat species were detected acoustically.

Bat activity was detected at all of the 41 potential roost sites but one (Mine Mountain Shaft 1). At the monitored sites, 49 bats were captured by mist net (representing 3 sensitive species) and 7 sensitive and 2 non-sensitive species were detected acoustically. Three maternity roosts, 6 day roosts, 12 night roost/night foraging sites, and 20 "indeterminate" roost sites were identified as a result of monitoring in 2004. The three maternity roosts are used by both Townsend's big-eared bats and fringed myotis (both sensitive species) based on capture and acoustic data.

13.3.3 Wild Horses

An annual horse census was conducted by driving selected roads along the boundaries of the suspected annual horse range in the northern portion of the NTS (Figure 13-5). Thirty-seven adult horses and six foals were counted in 2004. Five horse bands (composed of stallions, subordinate males, females, and their offspring) were observed. The bands ranged in size from 5 to 11 individuals excluding foals. The population showed a small increase in number over last year due to the recent survival of several younger-aged horses (yearlings and 2 year olds).

The feral horse population has declined since 1995 when over 50 individuals were known to inhabit the NTS. The decline is mainly the result of poor foal survival and a lack of immigration of new adults. Presently, the surviving population of NTS horses is still dominated by older-aged individuals (10 to >16 years) (Figure 13-6). Most of the living males are older horses; mortality of these individuals will be expected to increase in the near future. Over the past ten years, the causes of mortality, when observed among adult horses, have included unknown causes (four), predation (one), collisions with vehicles (two), and drowning (one). Among young horses (1-2 year olds), two have died from unknown causes and one presumably from dehydration at a dried up spring.

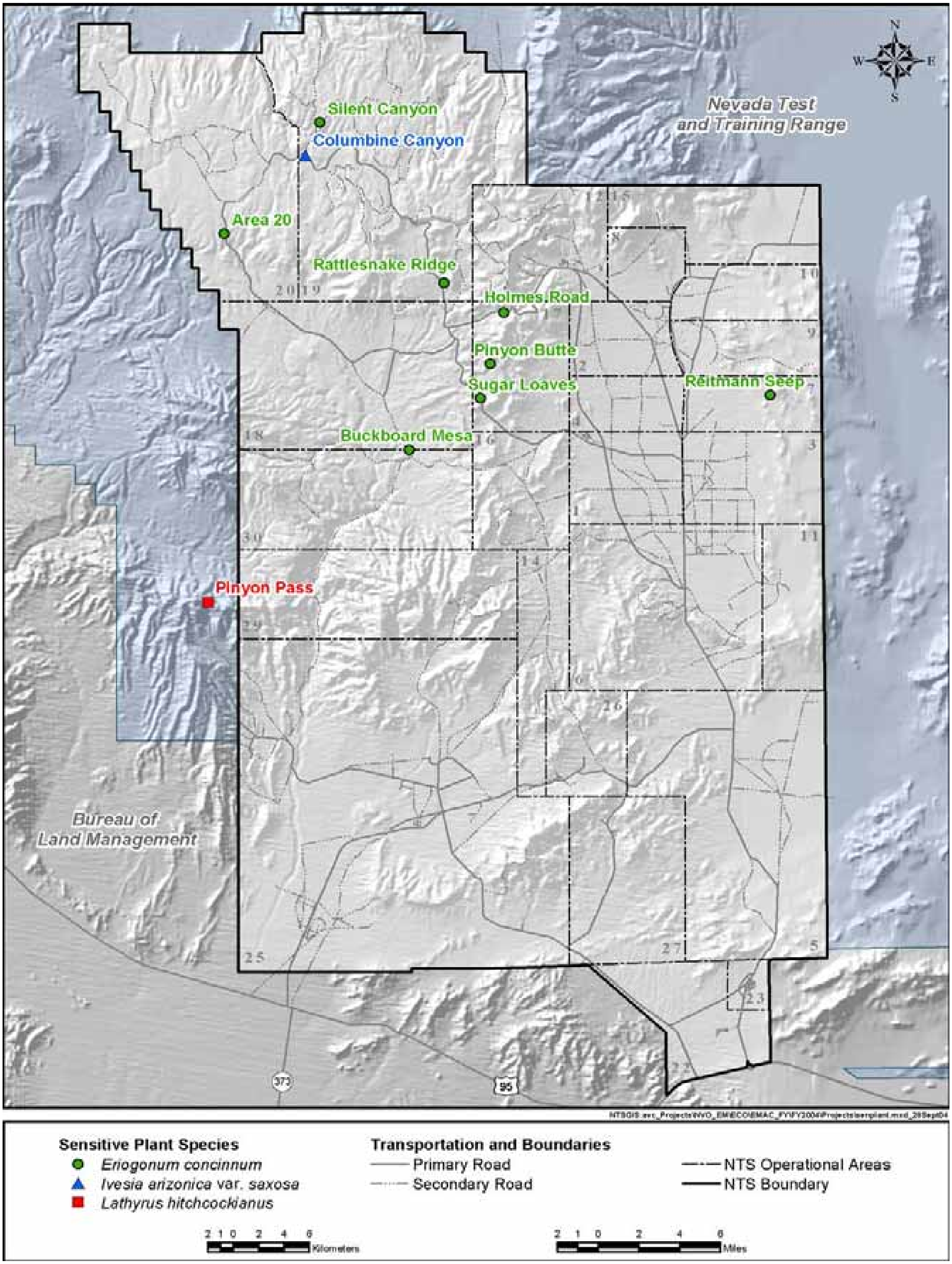


Figure 13-3. Sensitive plant populations monitored on the NTS in 2004

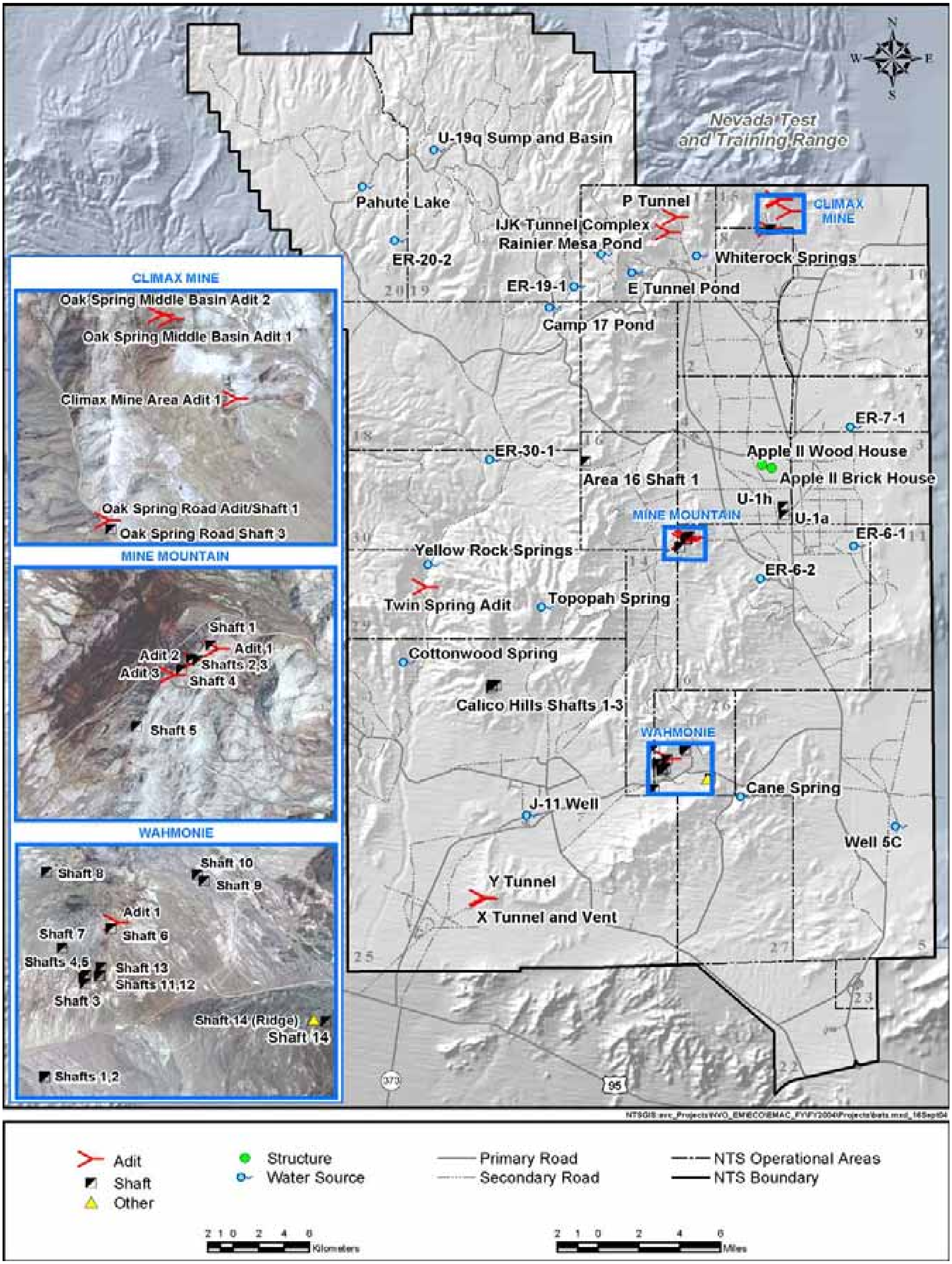


Figure 13-4. Sites monitored on the NTS for bat activity in 2004

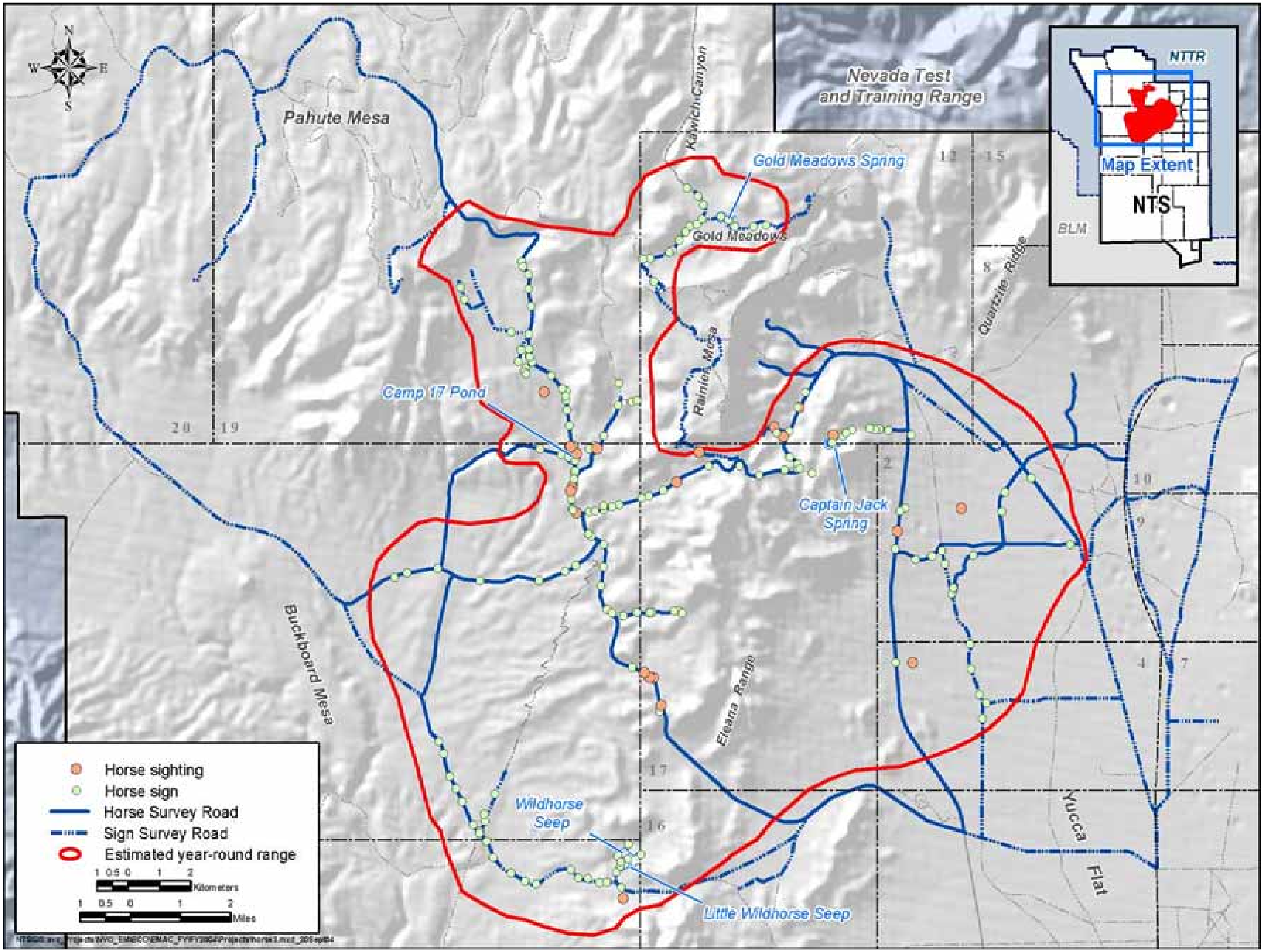


Figure 13-5. Feral horse range on the NTS and sighting locations of horses and horse sign in 2004

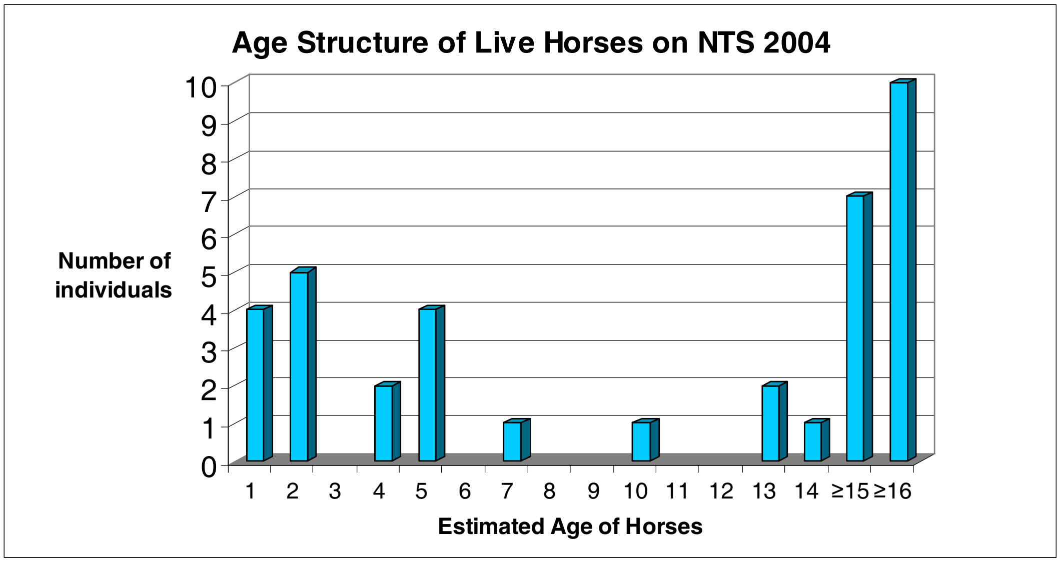


Figure 13-6. Number of wild horses observed by age category in 2004

13.3.4 Birds

All but 5 of the 239 bird species observed on the NTS are migratory birds protected under the Migratory Bird Treaty Act or are regulated by the state of Nevada as game birds (see footnote b of Table 13-3). No field surveys for birds were conducted in 2004. However, opportunistic sightings of birds including raptors, raptor nests, and any reported or observed bird mortalities were entered into wildlife databases. Rare sightings in 2004 included a juvenile peregrine falcon (formerly listed as endangered) and a southern bald eagle (currently listed as threatened). More common raptor sightings included red-tailed hawks, turkey vultures, golden eagles, American kestrels, prairie falcons, Cooper's hawks, and great horned owls. In 2004, 19 birds were found dead; 16 of the deaths were human-related (i.e., not due to predation or unknown causes) (Table 13-5). The four nest mortalities were common raven chicks which starved after their parents were electrocuted (Table 13-5). Mitigation actions were taken as a result of the chukar deaths to ensure that no other birds could be exposed to open oil containers. No other feasible mitigation actions were identified in 2004 that may reduce the incidence of bird mortality on the NTS. The overall reported number of bird deaths on the NTS related directly to NTS activities over the past 14 years is low and the causes are varied (Figure 13-7).

In September, an adult female red-tailed hawk was hit by a car and injured on Frenchman Flat. Biologists transported the bird to a North Las Vegas animal hospital for examination and treatment. It was later released in the Las Vegas area. In early October, an adult female golden eagle was observed on the ground in Frenchman Flat. It was captured and taken to the North Las Vegas animal hospital for examination. It appeared to be weak from lack of food. It tested negative for West Nile virus. It was cared for by Wild Wings and later released near Corn Creek on the Desert National Wildlife Range.

Table 13-5. Records of bird injury or mortality on the NTS in 2004

	Cause of Death					
Species	**Electrocution**	**Road kill/injury**	**Nest Mortality**	**Other[a]**	**Unknown**	**Predation**
American coot (*Fulica americana*)					1	
Chukar (*Alectorus chukar*)		2		2		
Common raven (*Corvus corax*)	2		4			
Common poorwill (*Phalaenoptilus nuttallii*)		2				
Gambel's quail (*Callipepla gambelii*)		2				
Horned lark (*Eremophila alpestris*)		1				
Loggerhead shrike (*Lanius ludovicianus*)		1				
Mourning dove (*Zenaida macroura*)			2			2
Red-tailed hawk (*Buteo jamaicensis*)		1[b]				
Total	**2**	**8/1**	**2**	**4**	**1**	**2**

Red text indicates causes of mortality related to NTS activities

(a) Found dead in oil pan

(b) Hit by vehicle, transported to animal hospital, and later released

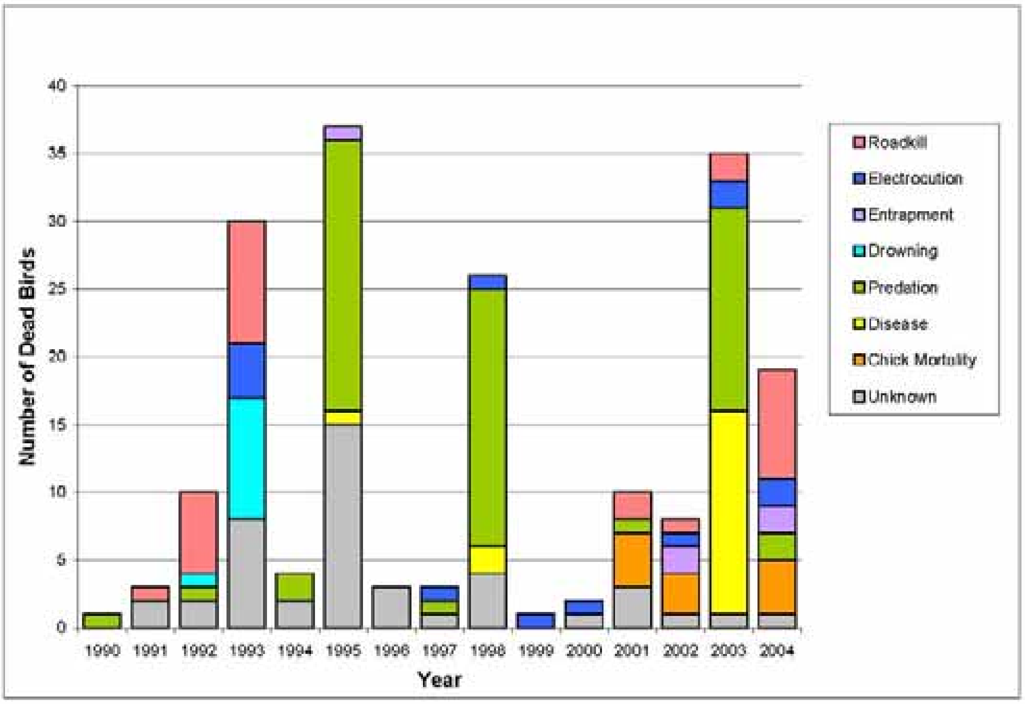


Figure 13-7. Number of bird deaths recorded on the NTS by year and by cause

13.3.5 Natural and Human-Made Water Sources

Natural wetlands (e.g., vegetated seeps and springs) and human-made water sources (e.g., sumps and sewage lagoons) provide unique habitats for vegetation and wildlife. In prior years, natural wetlands on the NTS were evaluated for their potential to qualify as "jurisdictional wetlands" regulated by the U.S. Army Corps of Engineers (USACE) under the Clean Water Act. In 2004, a formal request was initiated to obtain confirmation from the USACE that there are no jurisdictional wetlands on the NTS under the current interpretation of recent wetland-related rulings. Regardless of their potential non-jurisdictional status, NTS wetlands are monitored and are protected when feasible as unique and important habitats for plants and wildlife per the intent of EO 11990 *Protection of Wetlands*. Characterization of these mesic habitats and periodic monitoring of their hydrologic and biotic parameters was started in 1997. Monitoring will help identify annual fluctuations and ranges in measured parameters that are natural versus those related to NNSA/NSO activities.

Monitoring activities in 2004 included: (1) the identification and characterization of 12 human-made wetlands on Frenchman Lake which had not been previously described by Hansen, et al. (1997), (2) documenting surface area, surface flow, observed disturbances, and wildlife use at 18 selected natural wetlands, and (3) documenting wildlife use and mortality observed at 39 plastic-lined sumps, 7 sewage treatment ponds, 8 unlined well ponds, and 1 radioactive containment pond. The total areas of wetland habitat and surface area of standing water among the 12 human-made wetlands on Frenchman Lake were 2.38 ha (5.88 ac) and 0.99 ha (2.46 ac), respectively. Sizes of wetlands monitored varied greatly from very small areas (<1 m^2) to moderately sized springs and playa ponds ($>3,000$ m^2). Surface flow rates were low (<3 L/min) at most wetlands where flow was measurable. Disturbances noted at the 18 natural wetlands were trampling and grazing of vegetation by horses at five sites. No NNSA/NSO projects disturbed these natural water sources. Overall, 6 mammal species (excluding bats) and more than 40 species of birds were detected at water sources in 2004. Detailed results are reported in BN, 2004a.

13.4 Habitat Restoration Monitoring Program

The native vegetation and wildlife habitat at disturbed NTS sites are sometimes restored by seeding and/or planting native plant species. This effort is called revegetation. NNSA/NSO evaluates revegetation as a potential method to stabilize soils at a site based on site size, future use, nature of soils, annual precipitation, slope, aspect, and site location (DOE, 1996a). Revegetation supports the intent of Executive Order 13112 *Invasive Species,* which is to prevent the introduction and spread of invasive (non-native) species and restore native species to disturbed sites. To date, the majority of NNSA/NSO projects for which revegetation has been pursued are abandoned industrial or nuclear test support sites that have been characterized and remediated under the Environmental Restoration (ER) Program. Also, the ER Program has funded revegetation of soil cover caps to protect against soil erosion and water percolation into buried waste. In 2003, a wildland fire burn site in Area 12 (Egg Point Fire burn site) was revegetated to help minimize soil erosion and the invasion of non-native species which would make the site more prone to future wildland fires. In addition to conducting all revegetation efforts on the NTS, the Habitat Restoration Monitoring Program conducts short- and long-term monitoring of revegetated sites. The summary of this program's goals are to:

- Design and implement site-specific revegetation plans at approved disturbed sites
- Monitor the short- and long-term outcome of revegetation efforts
- Monitor the long-term outcome of natural vegetation succession at disturbed sites where revegetation has not occurred
- Develop a site-wide habitat restoration plan based on evaluations of past revegetation efforts, natural succession processes, and wildlife habitat requirements
- Monitor the effectiveness of revegetation to restore wildlife habitat

The field measures routinely used to monitor revegetation success and the status of natural succession at sites include:

- Plant density

- Percent survival
- Plant cover (percent of ground covered by living plant material) by species or by plant type (e.g., annual grasses, forbs)
- Presence of wildlife species and their sign (e.g., burrows, scat, and ant mounds)

The Egg Point Fire burned approximately 121 hectares (ha) (300 acres [ac]) in Area 12 on August 16, 2002. Revegetation of the site began in November 2002 and was completed in March 2003. A total of 1,681 kg (3,705 lb) of bulk native seed of 14 different species was distributed over the site. The total area seeded is estimated to be 93 - 101 ha (230 to 250 ac). About 5,000 transplants of native shrubs were planted along drainages. Vegetation monitoring of the burn site was conducted in June 2003 (BN, 2004a) and again in 2004 (BN, 2005c). Monitoring focused on assessing the success of seed germination and plant establishment on the steep upper slopes and the lower slopes and bottoms. There was an increase in 2004 in the number of shrubs that established on the upper slopes. On the lower slopes, the density of perennial plant species declined slightly from 2003. Detailed results of 2004 activities are reported in BN, 2005c.

Over the past several decades, various reclamation research trials have been conducted on the NTS to evaluate different reclamation techniques or to test the performance of certain plant species in this environment. In 2004, 28 such trial sites were identified from literature and files. The sites were visited in 2004; 15 of the sites were selected for future monitoring to further refine the reclamation techniques used on the NTS.

13.5 Biological Monitoring of the NPTEC

Biological monitoring at NPTEC on the playa of Frenchman Lake in Area 5 will be performed as an EMAC task whenever there is a risk of significant exposure to downwind plants and animals from planned test releases of hazardous materials. The Desert National Wildlife Refuge (DNWR) lies just east of the NTS border, approximately 5 km (3 mi) downwind from the NPTEC. The National Wildlife Refuge Administration Act forbids the disturbance or injury of native vegetation and wildlife on any National Wildlife Refuge lands unless permitted by the Secretary of the Interior; the DNWR is administered within this System. Biological monitoring is conducted to verify that approved tests do not disperse toxic chemicals that could harm biota on DNWR. This is also a requirement of the facility's Programmatic Environmental Assessment (DOE, 2002c). An unpublished BN document titled *Biological Monitoring Plan for Hazardous Materials Testing at the Liquefied Gaseous Fuels Spill Test Facility on the Nevada Test Site,* prepared in 1996 and updated in 2002, describes how field surveys will be conducted to meet the following two goals: (1) document significant impacts of chemical testing on plants and animals and (2) verify that NPTEC operations comply with the National Wildlife Refuge Administration Act (see Section 2.9). Monitoring will entail sampling established transects both downwind and upwind of the NPTEC. The parameters to be measured whenever transects must be sampled will include:

- Number and type of dead animals observed
- Number and type of wildlife observed
- Presence of observed vegetation damage

In 2004, BN reviewed chemical spill test plans for the following three activities this year: Divine Invader 53-54, Rattler, and Roadrunner III. Chemicals were released at such low volumes or low toxicity that there was no need to monitor downwind transects for biological impacts. Baseline monitoring was conducted at established control-treatment transects near the NPTEC in May and September. This sampling noted the condition of plants and the presence of wildlife sign during the period of vegetative growth and summer drought, respectively. No differences in biota were noted along downwind versus upwind transects. Baseline monitoring data are collected to document any cumulative impacts over time of test center activities on biota downwind of the facility. These data are made available to neighboring land managers upon request. Noticeable cumulative impacts on biota are not expected.

14.0 Underground Test Area Project

The Underground Test Area (UGTA) Project is the largest project in the Environmental Restoration Division. It addresses groundwater contamination resulting from past underground nuclear testing conducted in shafts and tunnels on the Nevada Test Site (NTS). From 1951 to 1992 more than 800 underground nuclear tests were conducted at the NTS (DOE, 2000). Most of these tests were conducted hundreds of feet above groundwater; however, over 200 of the tests were within or near the water table. Underground testing was limited to specific areas of the NTS including Pahute Mesa, Rainier Mesa, Shoshone Mountain, Frenchman Flat, and Yucca Flat.

The UGTA Project collects data to define groundwater flow rates and direction to determine the nature and location of aquifers (geologic formations of permeable rock containing or conducting groundwater). In addition, project team members gather information regarding the hydrology and geology of the area under investigation. Data from these studies will help in determining whether or not radionuclides resulting from nuclear testing have moved appreciable distances from the original test locations. Numerous surface and subsurface investigations are ongoing to ensure that these issues are addressed.

Surface investigations include:

- Evaluating discharges from springs located downgradient of the NTS
- Assessing surface geology

Subsurface investigations include:

- Drilling deep wells to access groundwater hundreds to thousands of feet below the surface
- Sampling groundwater to test for radioactive contaminants
- Assessing NTS hydrology and subsurface geology to determine possible groundwater flow direction

14.1 Aquifer Tests

A long-term multi-well aquifer/tracer test was conducted at the ER-6-1 well cluster site during 2004. It involved the wells ER-6-1, ER-6-1 #1, and ER-6-1 #2. Approximately 64 million gallons of water were pumped from the ER-6-1 #2 well while tracers were injected into the other two wells.

14.2 Groundwater Sampling

Well development, testing, and sampling operations were conducted at ER-6-2 and at ER-6-1 prior to the start of the multi-well aquifer/tracer test. Groundwater samples were also collected from the RNM #1 well and from four post-shot/cavity wells, or “Hot Wells”: ER-20-5 #1, ER-20-5 #3, U-3cn PS #2A, and U-19ad PS #1A. The results of sampling in 2004 are presented in Section 4.1.10 of this report along with all other radiological groundwater monitoring results.

14.3 3D Hydrostratigraphic Framework Models

A regional 3D computer groundwater model (IT, 1996) has been developed to identify any immediate risk and to provide a basis for developing more detailed models of specific NTS test areas designated as individual Corrective Action Units (CAUs). The regional model constituted Phase I of the UGTA project. The CAU-specific models, of which up to four are planned (geographically covering each of the six former NTS testing areas), comprise Phase II. To date, two have been built:: Frenchman Flat (IT, 1998 and BN, 2005d) and the Pahute Mesa-Oasis Valley model

(BN, 2002a). A model for the Yucca Flat CAU is in progress. These more detailed CAU-specific groundwater flow and contaminant transport models will be used to determine contaminant boundaries based on the maximum extent of contaminant migration. The results of the individual CAU groundwater models will be used to refine the Routine Radiological Environmental Monitoring Plan groundwater monitoring network to ensure public health and safety.

15.0 Hydrologic Resources Management Program

The primary responsibility of the Hydrologic Resources Management Program (HRMP) is to provide the U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office (NNSA/NSO) with hydrologic data and information on groundwater supplies to support ongoing activities and to assist in planning new uses for the Nevada Test Site (NTS). The main objective of this program is to provide a sound technical basis for NTS groundwater use decisions regarding the quality and quantity of water resources available on and around the NTS on a long-term scale.

15.1 Program Goals

The goal of the HRMP is to support national security operations at the NTS by the investigation of site hydrology, radionuclide migration, and protection of NTS water resources. The HRMP meets this goal through long-term research activities including data collection, analysis, evaluation, modeling, and documentation. These activities provide reliable information for decision-making on groundwater utilization, stewardship, and environmental protection. Research and technology development activities essential to the achievement of these goals are an integral part of the HRMP.

15.2 Program Activities

Results of program activities are available as technical reports and documents. Project participants also disseminate information and transfer technologies through publication in technical reports and peer-reviewed journals, presentations at professional meetings and symposia, and educational outreach activities.

15.2.1 Hydrology and Radionuclide Investigations for Operations

The HRMP assists NNSA/NSO in maintaining capabilities in hydrology and radiochemistry to support test readiness and science-based stockpile stewardship through applied field and laboratory studies of the occurrence, distribution, and movement of radionuclides in groundwater at the NTS. Scientific expertise is utilized in the assembly, analysis, and evaluation of data to produce requested hydrologic and radionuclide information. State of Nevada regulations require NNSA/NSO to provide detailed information on hydrologic conditions of the NTS. At the request of NNSA/NSO management, the HRMP gathers, analyzes, and transfers science-based information to the state of Nevada and other external customers.

Hydrologic services, provided upon request to NNSA/NSO programs, include depth-to-groundwater estimates, water level measurements, containment evaluations, and determining emplacement hole integrity. Technology development projects and research investigations are conducted to address gaps in the capabilities and knowledge required to support safe conduct of operations for stockpile stewardship, nuclear test readiness, and national security. Previous and current activities include:

- Determining the steady state and transient hydrologic conditions in the subsurface, such as the location of the groundwater table, perched water zones, and regions of enhanced permeability
- Using and developing state-of-the-art radiochemical instrumentation to analyze rock and water samples to assist in predicting the fate and transport of radioactive isotopes deposited from subsurface experiments
- Achieving a more fundamental understanding of chemical fractionation in underground nuclear tests through sample analysis and experimentation
- Investigating the subsurface geology and fracture propagation in the vicinity of underground nuclear tests for containment issues
- Building public confidence by conducting public and government outreach and education programs on the hydrologic environment and the impact of nuclear testing on water resources at the NTS

- Investigating the free water and bound water relationships in boreholes and cores

15.2.2 Long-Term Groundwater Stewardship

A major element of the HRMP mission is the protection and long-term stewardship of NTS groundwater resources. Numerous activities are conducted to accomplish this element. These include the following: monitoring of groundwater levels, quality and consumption; evaluating monitoring wells; and maintaining a wellhead protection program. HRMP supports the development and ongoing refinement of groundwater flow models for both the Death Valley Region (which includes the NTS) and for the NTS specifically. Based upon hydrologic investigations and modeling, HRMP will evaluate proposed new groundwater uses on and near the NTS for their potential impacts on NTS groundwater reserves, quality, flow paths, and radionuclide migration. The HRMP protects NTS groundwater by implementing a well installation and maintenance program to ensure:

- Reliability of the potable water supply.
- Optimal location, design, and construction of new potable water wells.
- Long-term reliability of monitoring wells to supply representative water samples.
- Integrity of emplacement and groundwater boreholes.

The HRMP also provides assistance to NNSA/NSO regarding the impact of NTS water usage on offsite water supplies and springs, such as Devil's Hole. In addition, the HRMP assists in addressing compliance issues and is responsive to the needs of NNSA/NSO that result from state and federal regulations not within the purview of other programs or which may be well-addressed by the capabilities of the HRMP. For example, implementation of the Safe Drinking Water Act dictates substantial compliance efforts both on and outside the boundaries of the NTS, a process to which HRMP can provide valuable support.

HRMP also has a groundwater review and advice capability with a unique NTS perspective that is invaluable to NNSA/NSO. HRMP scientists conduct competent, informed, and independent reviews of NNSA/NSO groundwater-related program documents prior to their release to extensive regulatory and public scrutiny. This capability enhances both the protection of NTS groundwater resources and the accuracy and credibility of NNSA/NSO program documentation.

16.0 Meteorological Monitoring

16.1 Meteorological Monitoring Goals

Meteorological and climatological data are collected on the Nevada Test Site (NTS) by the Air Resources Laboratory, Special Operations and Research Division (ARL/SORD). Data are collected through the Meteorological Data Acquisition (MEDA) system, a network of approximately 30 mobile meteorological towers located primarily on the NTS. The MEDA system became operational in 1981, replacing an older system. MEDA is used to measure, transmit, and display vital meteorological data to SORD meteorologists and U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office (NNSA/NSO) customers. These data are used daily for operational support to a wide variety of projects on the NTS and from the climatological database for the NTS. The data are also used in safety analysis reports, emergency response activities, radioactive waste remediation projects, environmental reports, and consequence assessments. Section A.3 of Appendix A presents descriptive NTS climatological data collected by the MEDA system.

16.2 MEDA Station Locations

A standard MEDA unit consists of an enclosed trailer, a portable 10 m (32.8 ft) tower, an electric generator (when needed), a microprocessor, and a microwave radio transmitter. An example of a MEDA unit is shown in Figure 16-1. Locations of the MEDA stations at the time of the preparation of this report are shown in Figure 16-2. All towers were sited according to standards set by the Federal Meteorological Handbook No. 1 (NOAA, 1995) and the World Meteorological Organization (WMO, 2002) so as not to be influenced by natural or man-made obstructions or by heat dissipation and generation systems. MEDA station locations are based on the following criteria: (1) availability of power, (2) access by road, (3) line-of-sight to a microwave repeater, and (4) project support. A primary goal of the network is to provide details in the surface wind field for emergency response activities related to the transport and dispersion of hazardous materials. Another primary goal is to provide data used in computing off-site radiological dose estimates (see Section 8.0)

Figure 16-1. Example of a typical MEDA station with a 10 meter tower

16.3 MEDA Station Instrumentation

MEDA station instrumentation is located on booms oriented into the prevailing wind direction and at a minimum distance of two tower widths from the tower. Wind

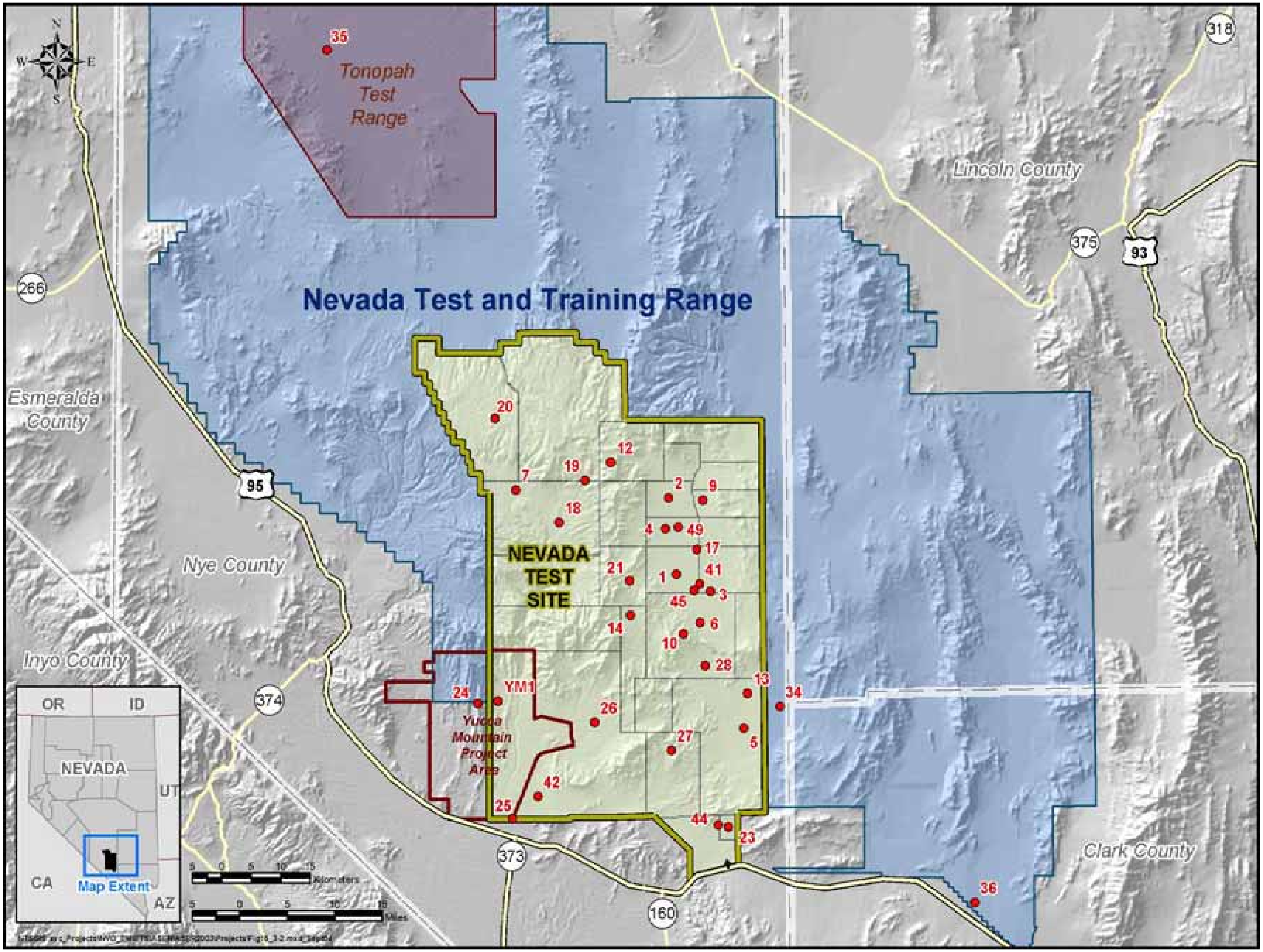


Figure 16-2. MEDA station locations on and near the NTS

direction and at a minimum distance of two tower widths from the tower. Wind direction and speed are measured at the 10-m level, in accordance to ANS/ANSI 3.11 (American Nuclear Society, 2000) specifications. Ambient temperature, relative humidity, and atmospheric pressure measurements are taken at approximately the 2-m level so as to be within the surface boundary layer. Observations are collected and transmitted every 15 minutes on the quarter hours. Wind data are 5-minute averages of speed and direction. The peak wind speed is the fastest instantaneous gust measured within the 15-minute time interval. Temperature, relative humidity, and pressure are instantaneous measurements.

16.4 Rain Gauge Network

ARL/SORD also operates and maintains a climatological rain gauge network on the NTS. This network consists of 17 Belford Series 5-780 Universal Precipitation Gauges (Figure 16-3). These are strip chart recorders that are read at least every 30 days. Once read and checked, the data are entered into the SORD precipitation climatological database. Data are recorded as daily totals. Under special circumstances, 1- to 3-hour totals can be obtained.

16.5 Data Access

The meteorological parameters measured at each station are listed on the SORD website <http://www.sord.nv.doe.gov> along with other information. MEDA data are also processed and archived in the ARL/SORD climatological database. Climatological data summaries are posted on the ARL/SORD website under the "Climate" section. SORD meteorologists provide specially tailored climatological summaries by request through NNSA/NSO. Wind data from the MEDA stations are used each year to calculate radiological doses from NTS air emissions to members of the public residing near the NTS (see Section 8.1.3).

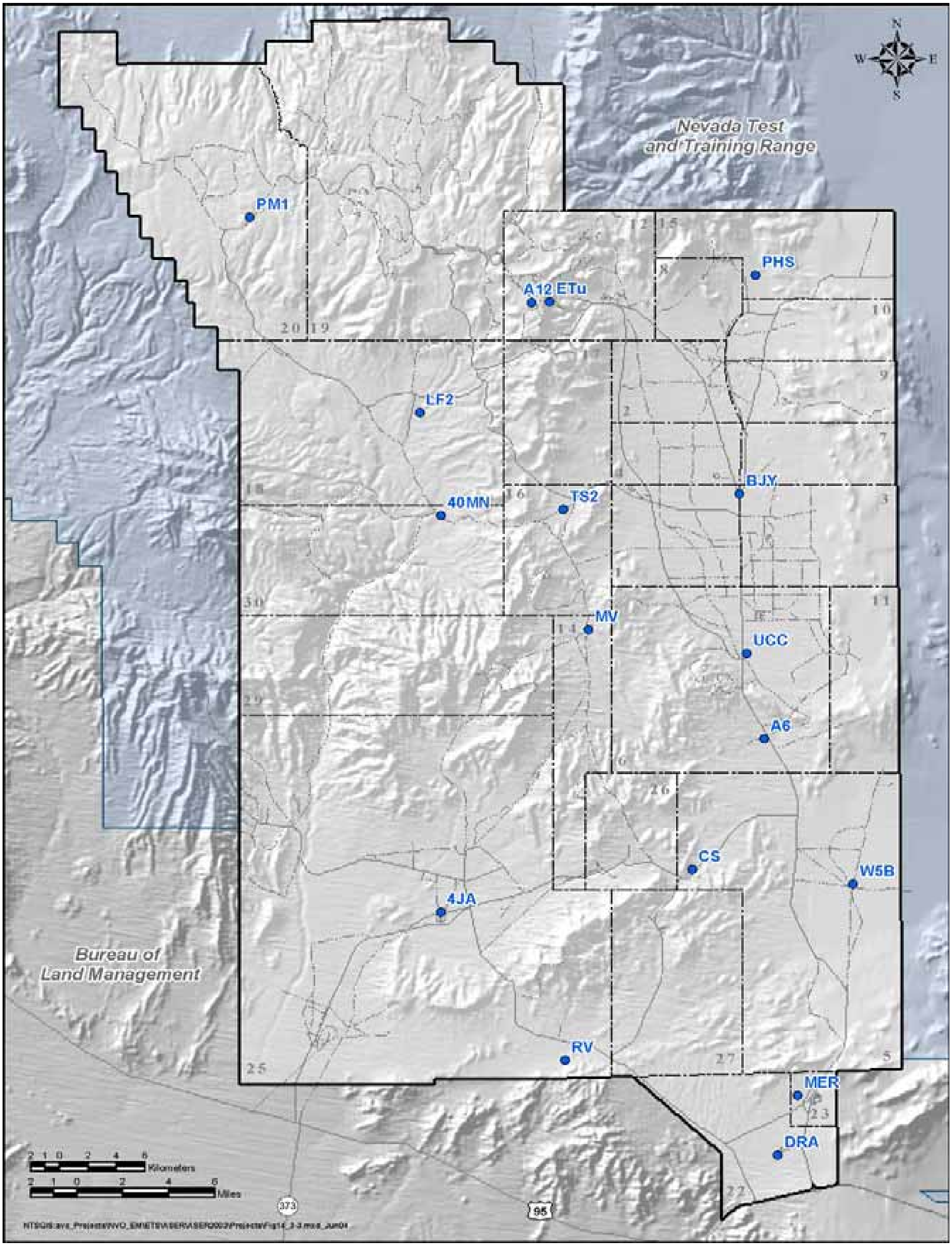


Figure 16-3. Climatological rain gauge network on the NTS

17.0 Integrated Safety Management System and Environmental Management System

A plan to integrate environmental, safety, and health (ES&H) management programs at the Nevada Test Site (NTS) was developed and initiated at the NTS in 1996. The NTS Integrated Safety Management System (ISMS) is designed to ensure the systematic integration of ES&H concerns into management and work practices so that missions are accomplished safely. The term *safety* is used synonymously with *environment, safety, and health* throughout the NTS ISMS implementation policies to encompass protection of the public, the workers, and the environment. The seven guiding principles of ISMS and the five core functions are presented below.

Seven Guiding Principles	*Five Core Functions*
Line management is directly responsible for the protection of the public, the workers, and the environment	Define the scope of work
Clear roles and responsibilities for ES&H are established and maintained	Identify and analyze the hazards and environmental aspects associated with the work
Personnel competence is commensurate with their responsibilities	
Resources are effectively allocated to address ES&H, programmatic, and operational considerations with balanced priorities	Develop and implement hazard and aspect controls
ES&H standards and requirements are established that ensure adequate protection of the employees, the public, and the environment	Perform work within the controls
Administrative and engineering controls to prevent and mitigate ES&H hazards are tailored to the work being performed	Provide feedback on the adequacy of the controls for continuous improvement
Operations are authorized	

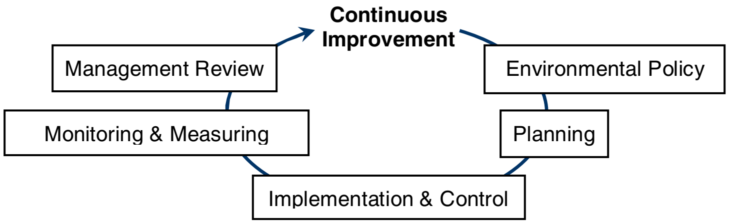
The use of an ISMS helps ensure that (1) all levels of program organizations are accountable for environmental protection, (2) all projects are planned with ES&H concerns in mind, and (3) continuous improvements in program implementation occur.

Implementation of an ISMS at the NTS was verified by the NNSA/NSO in July, 2001. NNSA/NSO oversees ISMS implementation through the ISM Council. Each Council member performed a self-assessment in September, 2004 and verified that the ISMS continues to be effectively implemented at the NTS.

Work Smart Standards (WSS) are an integral part of the ISMS whereby hazards and environmental aspects of work are identified and standards of operation are established that are specific to the work environment, its associated hazards, and its threats to the environment. WSS are approved at the management level with the most expertise in the work. NNSA/NSO approved the initial complete set of Bechtel Nevada (BN) WSS in September, 1996. The approved WSS identify within each program of BN, the contractual commitment to meet applicable laws, regulations, and policies which protect the public and the environment. Compliance with Work Smart Standards is tracked through management assessments.

In 2000, President Clinton issued Executive Order (EO) 13148 *Greening of the Government Through Leadership in Environmental Management*. This EO requires all federal agencies to adopt an environmental management system (EMS). An EMS is a globally embraced business management practice that allows an organization to strategically address its environmental, health and safety matters. EMSs are designed to incorporate concern for environmental performance throughout an organization, with the ultimate goal being continual reduction of the organization's impact on the environment. EMS implementation reflects accepted quality management principles based on the

"Plan, Do, Check, Act" model (shown below), using a standard process to identify goals, implement them, determine progress, and make improvements to ensure continual improvement.



In an EMS, this effort focuses on:

- **Environmental policy** development and endorsement
- **Planning** activities by identifying environmental impacts and related legal and other requirements and developing objectives and targets to control and improve performance related to environmental issues
- **Implementing** activities and operations, including training and documentation, to achieve the objectives and maintain control over environmental issues
- **Monitoring and measuring** the status of environmental parameters, status of objectives and targets, compliance status, and the health of the EMS itself, and providing procedures for corrective action in cases where data indicate non-conformance
- **Management review** of information for action, including enhancing the EMS towards the goal of continual improvement.

EO 13148 applies to most of the NNSA as well as to DOE and NNSA contractors. DOE requires contractors who operate DOE sites to develop an EMS and expects full integration of their EMS into their ISMS by December 2005.

BN's EMS is modeled after ISO 14001 while simultaneously being revised to satisfy DOE Order 450.1 *Environmental Protection Program*. BN Process Description PD-0442.001 *Environmental Management System Description* discusses how each of the seventeen elements of ISO 14001 is addressed, including controlling documents and organizations. This EMS Description is not a procedure, but rather a roadmap to all the environmental processes and governing documents in the different EMS elements. The EMS Description is being revised to reflect system improvements, updated procedures, and the blending in of the DOE Order 450.1 requirements. BN has an Environmental Policy that was updated in 2004 to reference DOE Order 450.1 as a driver and model for the environmental program. During 2003, progress was made in the areas of aspect identification and mitigation. During 2004 aspect identification and mitigation were incorporated into a hazard analysis procedure that is required for Work Execution Plans. This is an example of integrating the environmental program into an existing ISMS process. After DOE Order 450.1 was approved in 2003, BN evaluated it and identified Order requirements that were not fully implemented on the NTS. These were primarily in the pollution prevention areas, where DOE funding has been greatly reduced in the last few years. There were also areas such as resource protection from wildland and operational fires that are not traditionally thought of as environmental programs that will now need to be included in the EMS. A table was prepared that lists all the requirements in the Order and identifies how each requirement is or will be met and what organization is responsible for implementation and/or oversight. During 2004 an outside consultant was brought in to evaluate progress toward satisfying each of these requirements. The final report verified the progress that has been made and provided suggestions for satisfying the last few requirements.

A key goal of DOE Order 450.1 is to incorporate the EMS program into the existing ISMS. During 2004 the ISMS Program Plan was updated to specify that the EMS and DOE Order 450.1 are the methods by which the environmental part of ISMS is implemented. An example of how this is being accomplished is that the BN procedure and form for performing a hazard analysis for a new work activity was modified to include environmental aspects and their mitigations. Identifying potential environmental impacts and mitigating them in the planning phase of doing work is the single most important part of a successful EMS.

Goal setting is also included in the planning phase of performing work. Each year BN has several environmental goals identified in the Contractor Performance and Fee Award Program. These are measurable goals where performance is tracked and reported to ensure the maximum chance for successful completion. Affirmative Procurement goals are also tracked and reported annually. During 2004 a committee was formed that represented all programs. This committee identified priority areas of improvement (Objectives) and is starting to identify organization specific goals (Targets) within these priority areas. These will be reviewed by the Executive Safety Committee; once they have been approved, progress toward meeting them will be tracked and reported.

During 2004 the employee environmental awareness program was expanded. Copies of the revised Environmental Policy were mailed to all mail stops and posted on many bulletin boards, as well as on the BN intranet home page. Articles about the new Policy and the EMS were put in employee publications, and a section on environmental issues was added to the project manager training course.

Work will continue to strengthen the EMS program. All the elements of ISO 14001 and DOE Order 450.1 are already in place to some degree, so full integration of EMS into ISMS and full implementation of DOE Order 450.1 should be complete by the deadline of December 31, 2005.

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18.0 Compliance Quality Assurance

The Bechtel Nevada (BN) Quality Assurance Program (QAP) establishes the requirements necessary to comply with (1) Title 10 CFR 830, Subpart A *Quality Assurance Requirements*, (2) U.S. Department of Energy (DOE) Order 414.1A *Quality Assurance*, (3) contractual Work Smart Standards (WSS), and (4) other relevant requirements documents for the operation, process, or program to which they apply. The BN QAP requires a graded approach to quality, which provides for determining the level of rigor that effectively provides assurance of performance and conformance to requirements.

In the conduct of environmental management activities employing sampling and analysis, the U.S. Environmental Protection Agency (EPA)-developed Data Quality Objectives (DQO) process is generally used to provide the quality assurance (QA) structure for designing, implementing, and improving upon environmental monitoring efforts. 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 operations conducting work at or having authority over those locations in order to de-conflict activities and communicate hazards to better ensure successful execution of the work and 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 onsite and to offsite laboratories are conducted in accordance with Department of Transportation (DOT) and International Air Transport Association (IATA) 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, American Standard for Testing and Materials (ASTM) International, and others. Key quality-affecting procedural areas cover sample preparation, instrument calibration, instrument performance checking, testing for precision and accuracy, and laboratory data review. BN data users perform review as demanded by the project-specific objectives before they are used to support decision making. The *Routine Radiological Environmental Monitoring Plan* (RREMP) (DOE, 2003b) provides a formalized process to ensure that all sampling and analytical objectives are appropriate, economically feasible, reliable, and defensible within its area of application.

Elements of the QAP are listed below. A discussion of these program elements follows, together with the results of the 2004 assessment.

- **Data and Measurement Quality Objectives are developed** to ensure that clear goals and objectives are established for data collection, analyses, and projected data use.
- **A Sampling Plan is developed** to ensure that an appropriate plan of action is developed to execute scope in accordance with DOE, administrative, or legal requirements such as environmental, safety, and health concerns.
- **Laboratory Sample Analyses are implemented** to ensure that analysis of samples for required parameters meet BN, customer, and regulatory-defined requirements.
- **Data Management Procedures are used** to ensure that all data are readily retrievable, protected through a system of checks and balances, and defensibly archived.
- **Data Review and Systematic Assessments are made** to ensure that analytical data quality are improved and enhanced, and to adequately assess procedures, identify nonconforming items, implement corrective actions, monitor for corrective action effectiveness, and provide feedback and lessons learned.

18.1 Data and Measurement Quality Objectives

The DQO process is a strategic planning approach used to plan a data collection activity. It provides a systematic process for defining the criteria that a data collection design should satisfy, including when to collect samples, where to collect samples, tolerable level of decision errors for the study, and how many samples to collect.

Measurement Quality Objectives (MQOs) can generally be considered as DQOs for the analytical process. MQOs provide direction to the laboratory concerning performance objectives or requirements for specific method performance characteristics. Default MQOs are established in the subcontract, but may be altered on a project-by-project basis in order to satisfy the DQOs. MQOs may generally be described in terms of precision, accuracy, representativeness, completeness, and comparability requirements. The following discussion includes brief statements on these terms as they apply to the overall monitoring effort to provide correlation with laboratory efforts. The RREMP (DOE, 2003b) provides additional discussions on monitoring, precision, accuracy, representativeness, completeness, and comparability.

18.1.1 Precision

Precision refers to "the degree of mutual agreement characteristic of independent measurements as the result of repeated application of the process under specified conditions" (Taylor 1987). Practically, precision is determined by comparing the results obtained from performing the sample analysis on split samples, or on duplicate samples taken at the same time from the same location, maintaining sampling and analytical conditions as nearly identical as possible. Precision related to the overall monitoring effort is evaluated by comparing results for field duplicate samples of particulates in air, tritiated water vapor, thermoluminescent dosimeters (TLDs), and some water samples. Precision related to laboratory operations is evaluated by comparing the agreement of laboratory duplicates/replicates with established control limits. The laboratory is directed in the subcontract to establish and maintain precision control limits for various matrices and analytes. Control limits may be specified in the subcontract or by the specific method, but are more commonly generated and maintained by the laboratory in order to develop controls specific to their operations. In most cases, however, laboratory specific limits should not be less stringent than those published in the standard methods.

18.1.2 Accuracy

Accuracy refers to "the degree of agreement of a measured value with the true or expected value of the quantity of concern" (Taylor, 1987), and may be defined as the ratio of the measured value divided by the true value, expressed as a percent. Accuracy related to the overall monitoring effort is evaluated by comparing field sample results with historic data to determine whether the data points fall within acceptable statistical trends, or by other criteria. Accuracy related to laboratory operations is monitored by performing measurements and evaluating results of control samples containing known quantities of the analytes of interest. Control samples are analyzed using the same sample preparation and analytical methods as employed for project samples. The subcontract may provide required control limits or may direct the laboratory to establish control limits. Control limits may be specified for a specific analytical method, but may be generated and maintained by the laboratory in order to develop controls specific to their operations. In cases where a laboratory is authorized to establish in-house limits, those limits may not be less stringent than those published in the standard methods. Compliance with accuracy control limits is usually required in order for data to be considered acceptable for use in further analyses.

18.1.3 Representativeness

Representativeness is the degree to which a sample is truly representative of the sampled medium (i.e., the degree to which measured analytical concentrations represent the concentrations in the medium being sampled) (Stanley and Verner 1985). From a sample collection standpoint representativeness is managed through sampling plan design and execution. Representativeness related to laboratory operations is managed primarily through direction to the laboratory. For example, sample of a heterogeneous matrix (soil, sludge, solids, etc.) should be homogenized prior to aliquoting for preparation or analysis. Water samples are generally considered homogeneous unless observation suggests otherwise. Individual and composite air samples are necessarily homogenized by the laboratory during the preparation process. Field sample duplicate analyses are additional controls allowing the evaluation of sample representativeness and medium heterogeneity.

18.1.4 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 sampling design, sample collection and handling, laboratory analyses, and data review which are performed in accordance with established Organization Instructions (OIs) and Procedures and standardized methodologies. Comparability regarding laboratory operations is managed through direction to the laboratory requiring that standard methods will be used when available. When a standard method is not available, or when analytes may be determined by multiple techniques, equivalent QA controls must be applied; in these cases, more attention should be paid to review in order to draw conclusions on comparability.

18.2 Sampling Plan

Quality assurance in field operations includes development of an execution sampling plan, sampling assessments, surveillances, and oversight. Key elements of this plan include: (1) development of a Sample Package; (2) data management; and (3) appropriate training.

18.2.1 Sample Packages

For each data collection activity, a Sample Package is prepared containing the data quality objectives, execution sampling plan or statement of work (SOW), organizational instructions, and field logs. Sample packages must be prepared prior to conducting any sampling and may include the following items:

- Checklists to include:
  - Routing list showing all personnel who must review and approve the sample package
  - Pre-job and post-job checklists describing personal protective equipment, safety, etc.
  - Sample package task lead summary
  - Requested analyses
  - Performance evaluation or certification for all labs that do the requested analyses
  - Signature page which documents signatures of all personnel associated with the work
- Field Logs for all samples required to be taken
- Work Package, including a "Traveler" sheet (a work notification and authorization tool) if required
- Specific, detailed Work Instructions
- Material Safety Data Sheets for all chemicals that are being used for the job
- Authorization Basis Documents including Execution Plans (Facility, Project, Support) that apply to the sampling effort as well as Real Estate/Operations Permits that identify NNSA/NSO real property assets and operations involved in the sampling effort
- Chains-of-Custody forms

This managed approach to sampling ensures that the sampling is traceable and enhances the value of the final results to project managers. The sample package also ensures that the sampler is prepared for the sampling event. The manager or QA Officer routinely performs assessments or surveillances of each type of sampling event to ensure that samplers are adhering to the OIs and sampling protocol and that the OIs represent what is actually being done.

18.2.2 Database Support

Database support includes the Bechtel Environmental Integrated Data Management System (BEIDMS) for field data and laboratory results. In addition, completed Sample Packages, analysis results, data review checklists, etc., are optically scanned and entered into the Optix Data Base to enhance accessibility to these documents. The Optix system is used for scanning, long-term storage, and retrieval of the Sample Package as a graphic image. Data obtained in the course of executing field operations are entered into the Sample Package during field work, and then in the BEIDMS after completion of the field activities.

18.2.3 Training

BN ensures that all personnel are properly trained and qualified prior to doing work under the RREMP. BN-provided training is documented and maintained in the company tracking system (currently the PLATEAU system). In addition, an organizational training matrix is maintained to efficiently identify training required for each individual and their current status.

18.3 Laboratory Sample Analyses

Because most of the laboratory sample analyses are not done internally, but through subcontracts for laboratory services, BN ensures that DOE Order 414.1A *Quality Assurance* requirements are met by structuring subcontracts for services that emphasize quality assurance. This is accomplished through a multifaceted approach that focuses on three areas: (1) Procurement; (2) Initial and Continuing Assessment; and (3) a Laboratory Quality Assurance Plan (LQAP).

18.3.1 Procurement

Laboratory services are procured through subcontract. The subcontract specifies the requirements and technical specifications needed to determine compliance with those requirements and to evaluate overall performance of the subcontractor. Subcontracts are established through a competitive bid process and a formal request for proposal (RFP) process. They are awarded on a "best value" basis. The RFP generally requires a prospective vendor to submit a proposal. Successful proposals include:

- All procedures pertinent to subcontract scope
- An Environmental, Safety and Health Plan
- Examples of deliverables, both hardcopy and electronic
- Proficiency Testing (PT) results from previous year participation in recognized PT programs
- Resumes of those conducting the work
- A description of the facility or its design
- Accreditations and certifications
- Licenses
- Audits performed within the last year by the DOE Consolidated Audit Program (DOECAP), other DOE sites, or other audits (DoD, etc.) covering comparable scope and acceptable to BN
- Past performance surveys
- A LQAP
- Pricing

Proposal evaluations are conducted and scored as detailed in the RFP. Pricing evaluation is performed by the procurement representative separately from the technical evaluation. The BN technical evaluation team does not receive pricing information. Rather, it bases its evaluation solely on technical capability, ensuring that the technical evaluation is not biased by pricing.

18.3.2 Initial and Continuing Assessment

An initial assessment is made during the RFP process above, including a pre-award audit. If an acceptable audit has not been performed within the past year, BN will consider performing an audit (or participating in a DOECAP audit) of those laboratories awarded the contract. However, in no instance does BN initiate work with a laboratory without approval of BN personnel authorized 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:

- Tracking schedule compliance
- Review of analytical data deliverables (Appendix F of DOE, 2003b)
- Conducting regular audits or participating in evaluation of DOECAP audit products
- Monitoring for continued successful participation in PT programs; the subcontract requires or suggests participation in the following PT programs:
  - National Institute of Standards and Technology Radiochemistry Intercomparison Program
  - Studies equivalent to the former EPA Water Pollution and EPA Water Supply programs that support certification by the state of Nevada for analyses performed in support of Clean Water Act and Safe Drinking Water Act monitoring
- Monitoring of the lab's adherence to the LQAP

18.3.3 Laboratory Quality Assurance Plan

Each laboratory must develop a LQAP. The LQAP is a statement of the laboratory's policies and approach to the implementation of DOE Order 414.1A for ensuring the generation of quality data. Elements of the plan include: (1) LQAP requirements; (2) LQAP management responsibilities; and (3) additional subcontract requirements.

18.3.3.1 LQAP Requirements

The LQAP must do the following:

- Establish that senior management shall be responsible for the scope of the LQAP and implementing, assessing, and continually improving an effective quality system.
- Designate an individual responsible for developing, implementing, and routinely monitoring the LQAP program.
- Describe the organizational structure, functional responsibilities, levels of authority, and interfaces for those managing, performing, and assessing the work.
- Define the organization's policies regarding, and its commitment to, ethical standards, client confidentiality, and the implementation of safety and quality standards.
- Establish that line management shall be responsible for achieving quality in specific activities.
- Establish that all personnel, including samplers, field analysts, laboratory technicians, scientists, researchers, principal investigators, operators, craftspeople, clerical/support staff, and internal auditors shall retain responsibility for the quality of their work.
- Establish that regulatory actions toward the organization or its parent corporation shall be reported immediately to cognizant management and affected clients. This includes actions, such as suspension of contracts with other federal agencies, notices of investigations, and legal actions against the organization or its personnel.
- Establish that functional responsibilities shall include the following activities as a minimum:
  - Participating with the client for planning and developing analytical work scope
  - Training and personnel development
  - Preparing, reviewing, approving, and issuing instructions, procedures, schedules, and procurement documents; identifying and controlling hardware and software

- Managing and operating facilities
- Calibrating and controlling the equipment used to measure and test
- Conducting investigations and improving methods
- Acquiring, evaluating, and reporting data
- Performing maintenance, repair, and improvements
- Controlling records

18.3.3.2 LQAP Management Responsibilities

QA and/or QC positions shall report to the highest level of management (e.g., manager or director). The QA program identifies personnel positions that are given the responsibility and authority to do the following:

- Stop unsatisfactory work. The plan shall identify the chain of command through which any employee may initiate a stop-work order where detrimental ethical, contractual, quality, safety, or health conditions exist.
- Initiate action to prevent reporting laboratory results from a measurement system that is out of control.
- Prevent further reporting of measurements until corrective action has been completed.
- Identify any method or procedure that poses quality problems.
- Recommend, initiate, or provide solutions through designated channels and monitor effectiveness of corrective actions.

18.3.3.3 Additional Subcontract Requirements

Additional requirements are placed on the laboratory through the subcontract. Compliance with these requirements is verified through Initial and Continuing Assessment. These requirements include the following items.

Personnel Training and Qualification – The Laboratory organization shall be clearly structured with well-defined responsibilities for each individual in the management system. This system shall ensure that sufficient resources are maintained to perform the requirements specified in the subcontract. Personnel performing services specified by the subcontract SOW and personnel performing QA activities shall receive suitable and timely training in such things as technical skills, laboratory analytical methods, QC procedures, safety policies, and waste management practices and essential elements of the QA Program prior to performing work. Records of the training shall include descriptions of the training provided, attendance sheets, training logs, and personnel training records.

Quality Improvement – A system shall be established and implemented to identify, document, correct, and prevent quality problems; this system shall be subject to ongoing documented review by management to assess its effectiveness.

Documents and Records – Activities affecting quality shall be prescribed by documented instructions, procedures, or drawings that include quantitative or qualitative acceptance criteria that can be used to determine whether activities are satisfactorily accomplished. Revisions to instructions, procedures, and drawings that affect the process or are technical in nature shall receive the same level of review and approval by the affected parties as the original document. Editorial changes may be made to instructions, procedures, and drawings without review and approval. Document control shall include measures by which documentation can be controlled, tracked, and updated in a timely manner to ensure that applicability and correctness are established. Control measures shall be used to ensure that documents are reviewed for adequacy, approved for release by authorized personnel, and distributed to and used at the location of the prescribed activity.

Work Processes – Work shall be performed to established technical standards and administrative controls. Work shall be performed under controlled conditions using approved instructions, procedures, or instructions. Analytical procedures shall be listed by method number and matrix. Any method variances employed by the laboratory shall be documented. The laboratory shall specify protocols for reporting any incident that delays sample processing for a period of time, affects holding times, or delays work, and also specify the corrective action implemented. Examples of forms used to document out-of-control events are to be provided in the LQAP.

Analysis of QC Samples and Documentation – A summary of QC procedures and documentation to be employed in the day-to-day operation of the laboratory shall be included. The discussion will emphasize the following as they relate to the different QC levels:

- Analysis of method and reagent blanks
- Analysis of duplicates, spiked samples, spiked laboratory blanks, and reference or control standards such as EPA, National Institute of Standards and Technology, or other recognized authority check standards
- The criteria used to establish warning and control limits for the above types of QC samples
- Documentation and examples of control data and control charts
- The frequency of analyzing blanks and other QC samples
- How data from QC samples are reported and reviewed
- Who reviews and makes decisions relative to QC data

Procurement – A process shall be established and implemented to control purchased items and services; this process shall be subject to ongoing review by management to assess its effectiveness. Subcontract documents require that suppliers of all tiers comply with technical and QA requirements, including but not limited tostandards, measuring and test equipment, calibration services, and analytical test activities. Contracted items and services that have the potential to affect the quality of analytical tests shall be controlled to ensure conformance with contractual requirements. Such control shall include one or more of the following: source evaluation and selection (pre-performance/pre-award survey); source verification; audit; and examination of items or services before use. Procurement documents shall specify the quality system elements for which the supplier is responsible and how the supplier's conformance to the customer's requirements will be verified. Procurement documents shall be reviewed for accuracy and completeness by qualified personnel prior to release. Changes to procurement documents shall receive the same level of review and approval as the original documents.

Inspection and Acceptance Testing – Inspection and acceptance testing of items, services, and processes shall be conducted using established acceptance and performance criteria. Equipment used for inspection and testing shall be calibrated and maintained. There shall be a current list of available (on hand) equipment types, models, and years along with a general description of the facility. General information shall be included as to who performs major, preventative, and day-to-day equipment maintenance and how this maintenance is documented. A schedule of preventive maintenance activities shall be developed and the performance of preventive maintenance shall be documented. A documented inventory of critical spare parts and/or equipment necessary to minimize the downtime of measurement systems related to analytical test samples that have a holding time of 48 hours or less shall be maintained. A documented evaluation of the usage of such inventory shall be performed at least annually. Control processes shall be maintained for all instrument spikes, replicates/splits, blanks, and other standards.

Management Assessment – A method shall be established whereby management with executive authority assesses the adequacy of the QAP at least annually to ensure its continuing suitability and effectiveness in satisfying the requirements of the SOW and the supplier's stated policies and objectives. The method shall include provisions for reporting the results of management assessments, including the distribution of those reports. Problems that hinder the organization from achieving its objectives shall be identified and corrected.

Independent Assessment – Designated persons or organizations shall be responsible for ensuring that an appropriate QAP is established and for verifying that activities affecting the quality of the services specified in the SOW have been correctly performed. Such person or organization shall have sufficient authority, access to work areas, and organizational freedom necessary to independently assess all activities affecting quality and to report the results of such assessments. Persons conducting independent assessments shall be technically qualified and knowledgeable in the areas assessed. Assessment results shall be documented, reported to and reviewed by the level of management with authority to affect any necessary corrective actions. Assessments shall be conducted of subcontractors that perform work affecting the integrity of analytical results and to assure continued conformance to contractual requirements.

18.4 Data Management Procedures

The RREMP describes the need for and the details of the collection and analysis of environmental data to support various drivers at the NTS. A data management system is essential for understanding and sustaining the quality of data collected under the program, allowing programs to identify data gaps or data requirements for other environmental efforts, and eliminating unnecessary duplication of data collection efforts. Because decisions are based on environmental data, and the effectiveness of operations is measured at least in part by environmental data, reliable and accurate records of defensible environmental data are essential. Detailed records that must be kept include temporal, spatial, numerical, geotechnical, chemical, and radiological data, and all sampling and analytical 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 from regulators and third parties.

BEIDMS is a hierarchical relational database management system developed by Bechtel Environmental, Inc. that is designed to achieve standardization and integrity in managing environmental data. The primary objective of BEIDMS is to store and manage unclassified environmental data that are directly or indirectly tied to field sampling events. This includes information on construction, analytical, geotechnical, and field parameters at the NTS. Database integrity and security are enforced through the assignment of role memberships and the provision of available menu items.

18.5 Data Review and Systematic Assessments

The final element of the process-based QA is the review of data and systematic assessments than can be used to evaluate data quality and usability. Four components of this review and assessment are: data checks, data verification, data validation, and data quality assessment. A description of these components follows.

18.5.1 Data Checks

Data checks are conducted to ensure the accuracy and consistency of data collected during field operations prior to and upon data entry into the BEIDMS.

18.5.2 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, sample temperature, chain-of-custody, and other field sampling documentation shall also be reviewed during the verification process. Data verification ensures that the reported results entered in BEIDMS correctly represent the sampling and/or analyses performed and includes evaluation of quality control sample results. A Tier I review form and/or a Verification Checklist is completed for all data packages.

18.5.3 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 OIs. 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. The process of data validation consists of:

- Evaluating the quality of the data to ascertain whether all project requirements are met.
- Determining the impact on data quality of those requirements that are not met, if any.
- Verifying compliance with QA requirements.
- Checking QC values against defined limits.
- Applying qualifiers to analytical results in BEIDMS for the purpose of defining the limitations in use of the reviewed data.
- Documenting the results of the data validation.

It is the goal to conduct data validation on 20 percent of laboratory data (10 percent using laboratory reported calibration data, QC results, and sample results, and 10 percent recalculating the laboratory results using submitted raw data to verify laboratory reported results). OIs and Procedures, applicable project specific work plans, field sampling plans, Quality Assurance Project Plans, analytical method references, and laboratory SOW may all be used in the process of data validation. Documentation of data validation includes: checklists, qualifier assignment, and summary forms.

18.5.4 Data Quality Assessment

Data Quality Assessment (DQA) is the scientific evaluation of data to determine if data obtained from environmental data operations are of the right type, quality, and quantity to support their intended use. DQA requires a systematic review against pre-established criteria to verify that the data are valid for their intended use. DQA is conducted by the technical lead and is the final review performed.

The overall effectiveness of the QA program is determined through systematic assessments and surveillances of the plan execution work flow (e.g., sampling plan development and execution, chain of custody, sample receiving, shipping, subcontract laboratory analytical activities, and data review) as well as the program requirements. Deficiencies are addressed on assessment/surveillance checklist, and if warranted will be tracked for corrective action and disposition (e.g., using the CaWeb Issues Tracking System).

18.6 Results

A brief discussion of the 2004 results for field duplicates, laboratory control samples, blank analysis, and interlaboratory comparison studies are provided within this section. Summary tables are also included. Based on implementation and evaluation of the QA/QC program and the results presented below, it can be concluded that the analytical data reported in the Nevada Test Site Environmental Report 2004 are reliable and of high quality.

18.6.1 Field Duplicates

Field duplicates obtained at nearly the same locations and times is their primary samples are used to evaluate the precision of the data. A field duplicate is collected, handled, and analyzed in the same fashion as the primary sample. The Relative Percent Difference (RPD) between the field duplicate result and 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 derive the final result. The average absolute RPD, expressed as a percentage, was determined and listed in Table 18-1. The Relative Error Ratio (RER) is the standardized absolute difference between the sample and its field duplicate. The RER compared to the RPD is a more appropriate monitor of precision near the minimum detectable concentration (MDC) and provides a better indicator of precision anomalies that may need to be further evaluated.

Table 18-1. Summary of field duplicate samples for compliance monitoring in 2004

Analysis	Matrix	Number of Samples Reported[a]	Number of Samples Reported above MDC[b]	Average Absolute RPD of those above MDC (%)[c]	Average Absolute RER[d]
Gross Alpha	Air	124	5	98.5	0
Gross Beta	Air	29	29	3.5	0.1
Am-241	Air	125	14	31.7	0
Be-7	Air	125	117	8.6	0
Pu-238	Air	27	0	NA	0
Pu-239/240	Air	27	3	78.1	0.1
Tritium	Air	60	28	8.8	2.5
Am-241	Soil	8	0	NA	0.5
Pu-238	Soil	2	2	60.4	0.7
Pu-239+240	Soil	2	2	3	0.1
Sr-90	Soil	2	0	NA	0.7
Am-241	Water	6	2	104.7	0.3
Gross Alpha	Water	5	5	17.2	0.2
Gross Beta	Water	5	5	6.6	0.6
Pu-238	Water	1	1	0.2	0
Pu-239+240	Water	1	1	10.2	0.6
Ra-226	Water	1	0	NA	0.3
Ra-228	Water	1	0	NA	0.7
Sr-90	Water	1	0	NA	0.7
Tritium	Water	33	16	25.9	0.1
TLDs	Ambient Radiation	424	424	3.0	NA

(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 MDC. The MDC does not apply to TLD measurements. If either the field samples or its duplicate was reported below MDC, the precision was not determined.

(c) Reflects the Average Absolute RPD calculated for sample and field duplicate pairs reported above the detection limit.

The Absolute RPD is calculated as follows:

$$Absolute\ \ RPD = \frac{|FD - FS|}{(FD + FS)/2}\ X\ \ 100\,\%$$

Where: FD = Field Duplicate result
FS = Field Sample result

(d) Relative Error Ratio (RER) determined by the following equation is used to determine whether a sample result and the associated field duplicate result differ significantly when compared to their respective uncertainty (standard deviation). The RER is calculated for all sample and field duplicate pairs reported without regard to the MDC.

$$Absolute\ \ RER = \frac{|FS - FD|}{\sqrt{(TPU_S)^2 + (TPU_D)^2}}$$

Where: S = Sample result
D = Duplicate result
TPU_S = Total Propagated Uncertainty of the Field Sample
TPU_D = Total Propagated Uncertainty of the Field Duplicate

18.6.2 Laboratory Control Samples

Laboratory control samples (LCS) are used to evaluate analytical accuracy by the subcontract laboratory. The analytical accuracy 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 used for the project samples. The results are determined as the measured value divided by the true value, expressed as a percent. To be considered valid, the results must fall within established control limits (or percentage range) for further analyses to be performed. The LCS results obtained for samples analyzed in 2004 are summarized in Table 18-2. The LCS results were satisfactory with no more than one result being out of control for any given analysis or matrix category for the year.

Table 18-2. Summary of laboratory control samples (LCS) for 2004

Analysis	Matrix	Number of LCS Results Reported	Number Within Control Limits[(a)]
$^{239+240}$Pu	Air	22	22
^{241}Am	Air	22	21
^{137}Cs	Air	15	15
^{60}Co	Air	13	13
Gross Alpha	Water	3	3
Gross Beta	Water	3	3
$^{239+240}$Pu	Water	4	4
Tritium	Water	54	54
^{90}Sr	Water	3	3
^{226}Ra	Water	2	2
^{228}Ra	Water	2	2
^{241}Am	Water	7	7
^{137}Cs	Water	6	6
^{60}Co	Water	6	6
^{90}Sr	Soil	6	6
$^{239+240}$Pu	Soil	10	10
^{241}Am	Soil	16	15
^{137}Cs	Soil	8	8

(a) Control limits are 70 to 130 percent for all analyses

18.6.3 Blank Analysis

Blank analysis and control samples are used to evaluate overall laboratory procedures including sample preparation and instrument performance. Laboratory blank sample analyses are essentially the opposite of control samples discussed in Section 18.6.2. 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 detection limit of a specific procedure. The laboratory blank sample results obtained for 2004 are summarized in Table 18-3. The laboratory blank results were satisfactory with no more than one results being out of control for any given analysis/matrix category for the year.

Table 18-3. Summary of laboratory blank samples for 2004

Analysis	Matrix	Number of Blank Results Reported	Number Within Control Limits[(a)]
Gamma	Air	24	24
$^{239+240}$Pu	Air	31	31
Gamma	Water	18	18
Gross Alpha	Water	16	16
Gross Beta	Water	16	16
$^{239+240}$Pu	Water	11	11
Tritium	Water	54	53
^{90}Sr	Water	7	7
^{226}Ra	Water	4	4
^{228}Ra	Water	5	4
Gamma	Soil	14	13
^{90}Sr	Soil	8	8
$^{239+240}$Pu	Soil	12	12

(a) Control limit is less than MDC

18.6.4 *Interlaboratory Comparison Studies*

Table 18-4 shows the summary of 2004 interlaboratory comparison sample results for the subcontract radiochemistry laboratories. The subcontractors participated in the InterLaB RadCheM™ Proficiency Testing Program directed by Environmental Resource Associates (ERA) and the Mixed Analyte Performance Evaluation Program (MAPEP) conducted by the Radiological and Environmental Sciences Laboratory (RESL) of the Idaho National Engineering and Environmental Laboratory (INEEL). The subcontractors performed very well during the year by passing 80 out of 81 parameters analyzed.

Table 18-5 shows the summary of interlaboratory comparison sample results for the BN Radiological Health Dosimetry Group. This internal evaluation was based on National Voluntary Laboratory Accreditation Program (NVLAP) criteria. The Dosimetry Group participated in the Battelle Pacific Northwest National Laboratory performance evaluation study program during the course of the year. The Dosimetry Group performed very well during the year by passing 35 out of 35 TLDs analyzed.

Table 18-4. Summary of interlaboratory comparison samples of the subcontract radiochemistry laboratories for compliance monitoring in 2004

Analysis	Matrix	Number of Results Reported	Number Within Control Limits[(a)]
		ERA Results	
Gross Alpha	Water	9	9
Gross Beta	Water	9	9
Gamma	Water	17	16

Table 18-4. (continued)

Analysis	Matrix	Number of Results Reported	Number Within Control Limits[(a)]
		ERA Results, cont.	
Tritium	Water	5	5
^{89}Sr	Water	8	8
^{90}Sr	Water	8	8
^{226}Ra	Water	12	12
^{228}Ra	Water	10	10
		MAPEP Results	
Gamma	Soil	1	1
$^{239+240}$Pu	Soil	1	1
^{90}Sr	Soil	1	1

(a) Control limits are determined by the individual interlaboratory comparison study

Table 18-5. Summary of interlaboratory comparison TLD samples for the BN Radiological Health Dosimetry Group in 2004

Analysis	Matrix	Number of Results Reported	Number Within Control Limits[(a)]
TLDs	Ambient Radiation	35	35

(a) Based upon NVLAP criteria; absolute value of the bias plus one standard deviation < 0.3.

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19.0 Oversight Quality Assurance Program for CEMP

The Community Environmental Monitoring Program (CEMP) Quality Assurance Program Plan (QAPP) was followed for the collection and analysis of radiological air and water data presented in Section 6.0 of this report. The CEMP QAPP ensures compliance with U.S. Department of Energy (DOE) Order 414.1A *Quality Assurance* which implements a quality management system ensuring the generation and use of quality data. This QAPP addresses the following items previously defined in Section 18.0:

- 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

19.1 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 are further explained in Appendices A through E of DOE (2003b).

19.2 Measurement Quality Objectives (MQOs)

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, 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 18.1 for onsite activities.

19.3 Sampling QA Program

Quality Assurance (QA) in field operations for the CEMP includes sampling assessments, surveillances, and oversight of the following supporting elements:

- The sampling plan, data quality objectives, 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
- Chains-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 station manager Community Environmental Monitor (CEM) (see Section 6.0 for 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 protocol 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 Compact Disk-Read Only Memory by calendar year. Analytical reports and databases are protected and maintained in accordance with Desert Research Institutes (DRI's) Computer Protection Program.

19.4 Laboratory QA Oversight

CEMP ensures that DOE Order 414.1A *Quality Assurance* requirements are met with respect to laboratory services through review of the vendor laboratory policies formalized in a Laboratory Quality Assurance Plan (LQAP). 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.

19.4.1 Procurement

Laboratory services are procured through subcontract. 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 CEMP that includes the following items:

- All procedures pertinent to subcontract scope
- EH&S Plan
- LQAP
- Example deliverables (hard copy and/or electronic)
- Proficiency Testing (PT) results from the previous year from recognized PT programs
- Resumes
- Facility design/description
- Accreditations and certifications
- Licenses
- Audits performed by an acceptable DOE program covering comparable scope
- Past performance surveys
- Pricing

CEMP evaluates the review package in terms of technical capability. Vendor selection is based solely on these capabilities and not biased by pricing.

19.4.2 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 CEMP (usually by the CEMP QA Officer). In no instance shall CEMP 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. Tasks supporting continuing assessment are:

- Tracking schedule compliance
- Review of analytical data deliverables
- Monitoring of the lab's adherence to the LQAP
- Conducting regular audits
- Monitoring for continued successful participation in approved PT programs

19.4.3 Laboratory QA Program

The laboratory policies and approach to the implementation of DOE Order 414.1A must be verified in a LQAP prepared by the laboratory. The elements of a LQAP required for the CEMP are similar to those required by BN for onsite monitoring, and are described in Section 18.3.3.

19.5 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 (OIs). 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:

- 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
- Appling qualifiers to analytical results in the CEMP databases for the purposes of defining the limitations in the use of the reviewed data

OIs/Procedures, applicable project specific work plans, field sampling plans, QAPPs, 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 – Data Quality Assessment (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.

19.6 QA Program Assessments

The overall effectiveness of the QA program is determined through management and independent assessment as defined in the CEMP QAPP. These assessments evaluate the plan execution work-flow (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.

19.7 2004 Sample QA Results

Quality assurance procedures 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 was provided by Severn Trent Laboratories (gross alpha/beta and gamma spectroscopy data), Global Dosimetry Solutions (thermoluminescent dosimeter [TLD] data), and DRI (tritium data). A brief discussion of the 2004 results for field duplicates, laboratory control samples, blank analysis, and interlaboratory comparison studies are provided along with summary tables within this section. The 2004 CEMP radiological air and water monitoring data themselves are presented in Section 6.0.

19.7.1 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 2004 samples and is listed in Table 19-1. An RPD of zero indicates a perfect duplication of results of the duplicate pair, whereas an RPD >100 percent generally indicates that a duplicate pair falls beyond QA requirements and are 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.

19.7.2 Laboratory Control Samples (Accuracy)

Laboratory control samples (a.k.a. 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 percent. To be considered valid, the results must fall within established control limits (or percentage range) for further analyses to be performed. The laboratory control samples (LCS) results obtained for 2004 are summarized in Table 19-2. The LCS results were satisfactory with no samples falling outside of control parameters for gross alpha, gross beta, and gamma spectroscopy analyses for the air sample matrix, and tritium for the water matrix.

Table 19-1. Summary of field duplicate samples for oversight monitoring in 2004

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	116	112	27.7
Gross Beta	Air	116	116	7.8
Gamma - Beryllium-7	Air	9	8	17.1
Tritium	Water	4	1	23.1
TLDs	Ambient Radiation	12	12	6.2

(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. 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

Table 19-2. Summary of laboratory control samples (LCS) for oversight monitoring in 2004

Analysis	Matrix	Number of LCS Results Reported	Number Within Control Limits[(a)]
Gross Alpha	Air	106	106
Gross Beta	Air	106	106
Gamma	Air	8	8
Tritium	Water	4	4

(a) Control limits are as follows: 80 to 134 percent for gross alpha and beta; 80 to 114 percent for gamma (^{137}Cs, ^{60}Co, ^{241}Am); 80 to 120 for tritium.

19.7.3 Blank Analysis

Laboratory blank sample analyses are essentially the opposite of control samples discussed in Section 19.7.2. 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 2004 are summarized in Table 19-3. The laboratory blank results were satisfactory with only one gross alpha sample (<1 percent) sample being outside of control parameters for the air sample matrix.

Table 19-3. Summary of laboratory blank samples for oversight monitoring in 2004

Analysis	Matrix	Number of Blank Results Reported	Number Within Control Limits[a]
Gross Alpha	Air	107	106
Gross Beta	Air	107	107
Gamma	Air	8	8
Tritium	Water	6	6

(a) Control limit is less than the MDC.

19.7.4 Interlaboratory Comparison Studies

Interlaboratory 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 interlaboratory comparison sample results obtained for 2004 are summarized in Tables 19-4 and 19-5. Note: the DRI tritium laboratory did not participate in any of these programs.

Table 19-4 shows the summary of interlaboratory comparison sample results for the Subcontract Radiochemistry Laboratory. The Laboratory participated in the Quality Assurance Program administered by the Environmental Measurements Laboratory (EML) and the Mixed Analyte Performance Evaluation Program (MAPEP) for gross alpha, gross beta, and gamma analyses. The subcontractor performed very well during the year by passing all of the parameters analyzed.

Table 19-5 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 20 out of 20 TLDs analyzed.

Table 19-4. Summary of interlaboratory comparison samples of the subcontract radiochemistry laboratory for oversight monitoring in 2004

Analysis	Matrix	Number of Results Reported	Number Within Control Limits[a]
		MAPEP and EML Results	
Gross Alpha	Air	6	6
Gross Beta	Air	6	6
Gamma	Air	4	4

(a) Control limits are determined by the individual interlaboratory comparison study.

Table 19-5. Summary of interlaboratory comparison TLD samples of the subcontract dosimetry group for compliance monitoring in 2004

Analysis	Matrix	Number of Results Reported	Number Within Control Limits[a]
TLDs	Ambient Radiation	20	20

(a) Based upon NVLAP criteria; absolute value of the bias plus one standard deviation < 0.3.

Appendix A

Nevada Test Site Description

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Appendix A: Nevada Test Site Description

This appendix expands on the general description of the Nevada Test Site (NTS) presented in the Introduction. Included are subsections that summarize the site's geological, hydrological, climatological, and ecological setting. The cultural resources of the NTS are also presented. The subsections are meant to aid the reader in understanding the complex physical and biological environment of the NTS. An adequate knowledge of the site's environment is necessary to assess the environmental impacts of new projects, design and implement environmental monitoring activities for current site operations, and assess the impacts of site operations on the public residing in the vicinity of the NTS. The NTS environment contributes to several key features of the site which afford protection to the inhabitants of adjacent areas from potential exposure to radioactivity or other contaminants resulting from NTS operations. These key features include the general remote location of the NTS, restricted access, extended wind transport times, the great depths to slow-moving groundwater, little or no surface water, and low population density. This appendix complements the annual summary of monitoring program activities and dose assessments presented in the main body of this report.

A.1 Geology

A.1.1 Physiographic/Geologic Setting

The NTS is located in the southern part of the Great Basin, the northern-most sub-province of the Basin and Range Physiographic Province (Figure A-1). The NTS terrain is typical of much of the Basin and Range Physiographic Province, characterized by mostly tilted, fault-bounded blocks that are as much as 80 kilometers (km) (50 miles [mi]) long and 24 km (15 mi) wide. These features are modified locally by the Las Vegas Shear Zone (a component of the Walker Lane regional structural belt) in the southern part of the NTS, and by resurgent calderas of the Southwest Nevada Volcanic Field (SWNVF). The land forms and topography of the NTS area reflect the complex geology and its location in the arid Mojave Desert.

The NTS area is geologically complex, with at least six Tertiary-age calderas nearby, many relatively young basin-and-range-style normal faults, and Mesozoic-age thrust faults and intrusive bodies, all superimposed on a basement complex of highly deformed Proterozoic and Paleozoic-age sedimentary and metasedimentary rocks. Geologic units exposed at the surface in the NTS area can be categorized as approximately 40 percent alluvium-filled basins and 20 percent Paleozoic and uppermost Precambrian sedimentary rocks, the remainder beingTertiary-age volcanic rocks with a few intrusive masses (Orkild, 1983b; Slate et al., 1999). A generalized geologic map of the NTS area is given in Figure A-2.

The NTS area is dominated by Tertiary-age volcanic rocks formed from materials that were erupted from various vents in the SWNVF, located on and adjacent to the northwestern part of the NTS (Figure A-2). At least six major calderas have been identified in this multi-caldera silicic volcanic field (Byers et al., 1976). The calderas formed by the voluminous eruption of zoned ash-flow tuffs between 16 and 7.5 million years ago (Ma) (Sawyer et al., 1994). From oldest to youngest the calderas are: Grouse Canyon, Area 20, Claim Canyon, Rainier Mesa, Ammonia Tanks, and Black Mountain calderas. A comprehensive review of past studies and the evolution of concepts on calderas of the SWNVF during the period from 1960 to 1988 is presented in Byers et al., 1989.

The volcanic rocks are covered in many areas by a variety of late Tertiary and Quaternary surficial deposits. These younger deposits consist of alluvium, colluvium, eolian (wind-blown sand) deposits, spring deposits, basalt lavas, lacustrine (fresh-water lake) deposits, and playa deposits.

The area includes more than 300 described Tertiary-age volcanic units (Warren et al., 2000a; 2003). As a matter of practicality, some units are grouped together, especially those of limited areal extent or thickness. Table A-1 presents most of the Tertiary volcanic units useful in characterizing the subsurface at the NTS.

Figure A-1. Basin and Range Physiographic Province and Great Basin Hydrologic Province

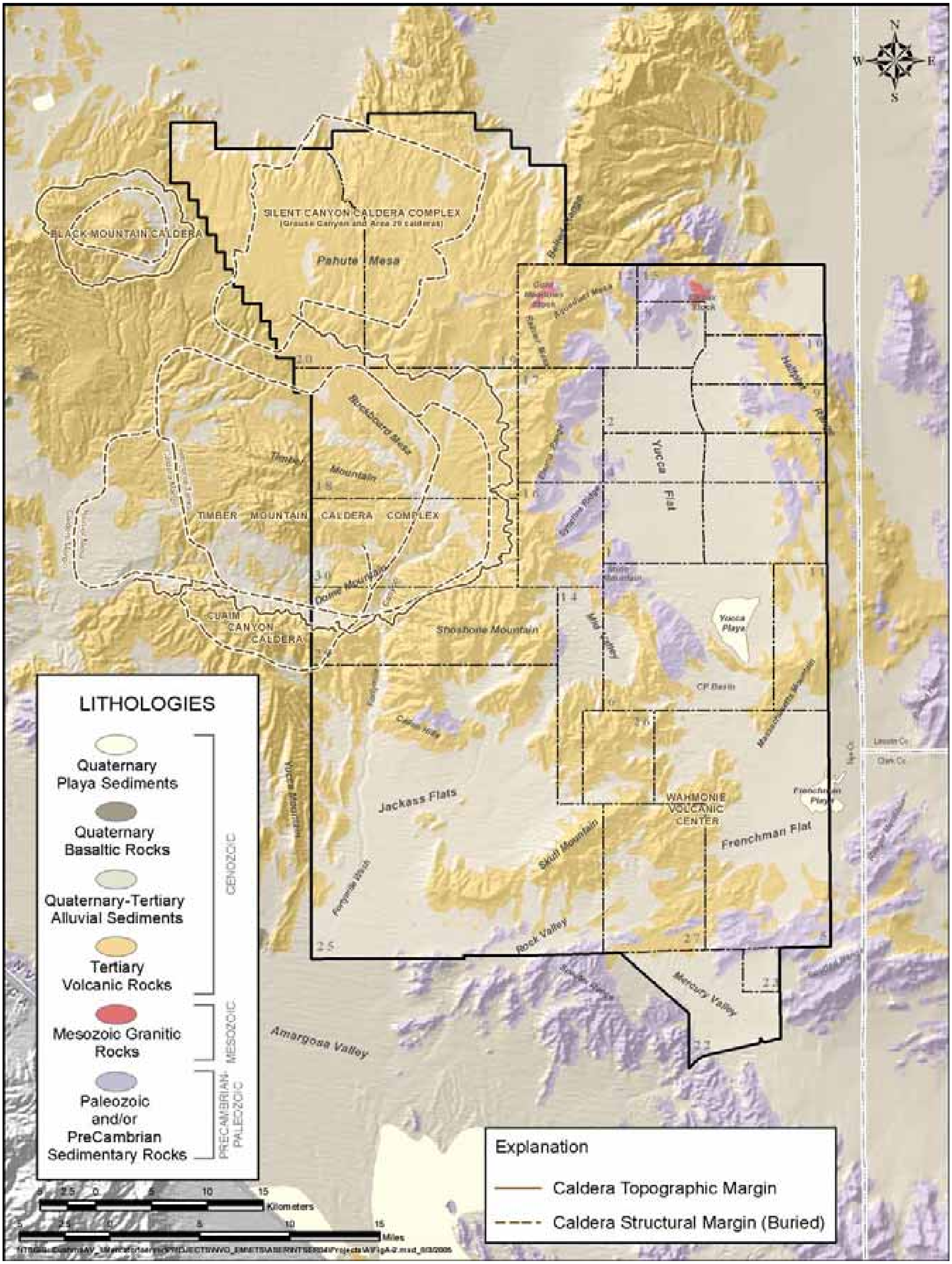

Figure A-2. Generalized geologic map of the NTS and vicinity

Underlying the Tertiary volcanic rocks are Paleozoic and Proterozoic sedimentary rocks including dolomite, limestone, quartzite, and argillite, some of which form the primary regional aquifer and the regional hydrologic "basement" (Table A-2). During Precambrian and Paleozoic time, as much as 10,000 meters (m) (32,800 feet [ft]) of marine sediments were deposited in the NTS region (Cole, 1997). The only surface exposure of Mesozoic-age rocks in the NTS area are granitic intrusive masses, the Gold Meadows Stock north of Rainier Mesa (Snyder, 1977; Gibbons et al.,1963), and the Climax Stock located at the extreme north end of Yucca Flat (Maldonado, 1977; Barnes et al., 1963) (Figure A-2).

Table A-1. Quaternary and Tertiary stratigraphic units of the NTS and vicinity

Stratigraphic Assemblages and Major Units[a, b]	Volcanic Sources[c]
Quaternary or Tertiary Sediments Young alluvium (Qay) Playa (Qp) Quaternary - Tertiary colluvium (QTc) Middle alluvium (Qam) Eolian sand (QTe) Quaternary-Tertiary alluvium (QTa) Quaternary Basalts (Qby) Pliocene Basalts (Typ) Tertiary alluvium (Tgy)	Not applicable
Miocene Basalt and Rhyolite Thirsty Canyon and Younger Basalts (Tyb) Rhyolite of Obsidian Butte (Tyr)	Several discrete sources
Tertiary Sediments Late synvolcanic sedimentary rocks (Tgm) Caldera moat-filling sedimentary deposits (Tgc) Younger landslide and sedimentary breccia (Tgyx)	Not applicable
Thirsty Canyon Group (Tt) Gold Flat Tuff (Ttg) Trachyte of Hidden Cliff (Tth) Trachytic rocks of Pillar Spring and Yellow Cleft (Tts) Trail Ridge Tuff (Ttt) Pahute Mesa and Rocket Wash Tuffs (Ttp) Comendite of Ribbon Cliff (Ttc)	Black Mountain Caldera
Volcanics of Fortymile Canyon (Tf) Rhyolite of Boundary Butte (Tfu) Post-Timber Mountain Basaltic Rocks (Tft) Trachyte of Donovan Mountain (Tfn) Rhyolite of Shoshone Mountain (Tfs) Lavas of Dome Mountain (Tfd) Younger intrusive rocks (Tiy) Rhyolite of Rainbow Mountain (Tfr) Beatty Wash Formation (Tfb) Tuff of Leadfield Road (Tfl) Rhyolite of Fleur-de-lis Ranch (Tff)	Several discrete vent areas in and around the Timber Mountain caldera complex

Table A-1. (continued)

Stratigraphic Assemblages and Major Units$^{(a, b)}$	Volcanic Sources$^{(c)}$
Timber Mountain Group (Tm)	Timber Mountain Caldera Complex
Trachyte of East Cat Canyon (Tmay)	
Tuff of Buttonhook Wash (Tmaw)	
Ammonia Tanks Tuff (Tma)	Ammonia Tanks Caldera
Bedded Ammonia Tanks Tuff (Tmab)	
Timber Mountain landslide breccia (Tmx)	
Rhyolite of Tannenbaum Hill (Tmat)	
Basalt of Tierra (Tmt)	Rainier Mesa Caldera
Rainier Mesa Tuff (Tmr)	
Rhyolite of Fluorspur Canyon (Tmrf)	
Tuff of Holmes Road (Tmrh)	
Landslide or eruptive breccia (Tmrx)	
Rhyolite of Windy Wash (Tmw)	
Transitional Timber Mountain rhyolites (Tmn)	
Paintbrush Group (Tp)	Claim Canyon Caldera
Rhyolite of Benham (Tpb)	
Post-Tiva Canyon rhyolites (Tpu)	
Paintbrush caldera-collapse breccias (Tpx)	
Tiva Canyon Tuff (Tpc)	Claim Canyon Caldera
Yucca Mountain Tuff (Tpy)	Unknown
Rhyolite of Delirium Canyon (Tpd)	
Rhyolite of Echo Peak (Tpe)	
Middle Paintbrush Group rhyolites (Tpm)	
Pah Canyon Tuff (Tpp)	
Rhyolite of Silent Canyon (Tpr)	
Topopah Spring Tuff (Tpt)	Unknown
Calico Hills Formation (Th; formerly Tac)	Unknown
Wahmonie Formation (Tw)	Wahmonie Volcanic Center
Crater Flat Group (Tc)	Silent Canyon Caldera Complex
Rhyolite of Inlet (Tci)	
Prow Pass Tuff (Tcp)	
Rhyolite of Kearsarage (Tcpk)	Area 20 Caldera
Andesite of Grimy Gulch (Tcg)	
Bullfrog Tuff (Tcb)	
Rhyolites in the Crater Flat Group (Tcr)	
Tram Tuff (Tct)	
Belted Range Group (Tb)	Grouse Canyon Caldera
Deadhorse Flat Formation (Tbd)	
Grouse Canyon Tuff (Tbg)	
Comendite of Split Range (Tbgs)	
Comendite of Quartet Dome (Tbq)	

Table A-1. (continued)

Stratigraphic Assemblages and Major Units[a, b]	Volcanic Sources[c]
Tram Ridge Group (Tr) Lithic Ridge Tuff (Trl) Dikes of Tram Ridge (Trd) Rhyolite of Picture Rock (Trr)	Uncertain
Tunnel Formation (Tn) 4 Member (Tn4) 3 Member (Tn3)	Uncertain
Volcanics of Quartz Mountain (Tq) Tuff of Sleeping Butte (Tqs) Hornblende-bearing rhyolite of Quartz Mountain(Tqh) Tuff of Tolicha Peak (Tqt) Early rhyolite of Quartz Mountain (Tqe) Dacite of Mount Helen (Tqm)	Uncertain
Volcanics of Big Dome (Tu) Comendite of Ochre Ridge (Tuo) Tub Spring Tuff (Tub) Comendite of Emigrant Valley (Tue)	Unknown
Volcanics of Oak Spring Butte (To) Tunnel bed 2 (Ton2) Yucca Flat Tuff (Toy) Tunnel bed 1 (Ton1) Redrock Valley Tuff (Tor) Tuff of Twin Peaks (Tot)	Unknown
Older Volcanics (Tqo)	Unknown
Paleocolluvium (Tl)	N/A

(a) Compiled from Wahl et al. (1997) and Ferguson et al. (1994).
(b) Letters in parentheses are stratigraphic unit map symbols.
(c) Sources, where known, from Sawyer et al. (1994).
Refer to Table A-2 for lists of Mesozoic, Paleozoic, and Precambrian sedimentary rock formations.

Table A-2. Pre-Tertiary stratigraphic units of the NTS and vicinity

Map Unit	Stratigraphic Unit Map Symbol	Stratigraphic Thickness		Dominant Lithology
		Feet	Meters	
Gold Meadows Stock	Kgg	N/A	N/A	Quartz monzonite
Climax Stock	Kgc			Granodiorite
Tippipah Limestone (correlative with the Bird Spring Formation)	PPt	3,500	1,070	Limestone
Chainman Shale and Eleana Formation	Mc MDe	4,000	1,220	Shale, argillite, and quartzite
Guilmette Formation	Dg	1,400	430	Limestone
Simonson Dolomite	Ds	1,100	330	Dolomite
Sevy Dolomite	DSs	690	210	Dolomite
Laketown Dolomite	Sl	650	200	Dolomite
Ely Spring Dolomite	Oes	340	105	Dolomite
Eureka Quartzite	Oe	400	125	Quartzite
Antelope Valley Limestone	Oa	1,530	466	Limestone
Ninemile Formation	On	335	102	Limestone
Goodwin Limestone	Og	685	209	Limestone
Nopah Formation	Cn	2,050	620	Limestone
Bonanza King Formation	Cb	4,350	1,330	Limestone/dolomite
Carrara Formation (upper)	Cc	925	280	Limestone
Carrara Formation (lower)	Cc	925	280	Shale/Siltstone
Zabriskie Quartzite	Cz	200	60	Quartzite
Wood Canyon Formation	CZw	2,300	700	Micaceous quartzite
Stirling Quartzite	Zs	2,900	890	Quartzite
Johnnie Formation	Zj	3,000	914	Quartzite/siltstone/limestone

(Stratigraphic units and lithologies adapted from Cole, 1992)

A.1.2 Stratigraphy

In order to confidently characterize the geology at the NTS, geoscientists must start from a well understood stratigraphic system. Refinement of the stratigraphy of the area was a continuous process during the decades in which geoscientists associated with the Weapons Testing Program (WTP) worked to understand the complex volcanic setting (documented by Byers et al., 1989). The need to develop detailed geologic models in support of the Underground Test Area (UGTA) Project (see Section 14) intensified this process, and the recognition of smaller and smaller distinct volcanic units permitted a greater understanding of the three-dimensional configuration of the various types of rocks, which has been incorporated into the geologic framework. Efforts to understand the structure and stratigraphy of the non-volcanic rocks (pre-Tertiary) have also continued to a lesser degree (Cole, 1997; Cole and Cashman, 1999; Cashman and Trexler, 1991; Trexler et al., 2003). The most widespread and significant Quaternary and Tertiary (mainly volcanic) units of the NTS area are listed in Table A-1. Refer to Table A-2 for a list of Mesozoic (granitic), Paleozoic (sedimentary), and Precambrian (sedimentary and metamorphic) stratigraphic units.

A.1.3 Structural Controls

Geologic structures are an important component of the hydrogeology of the area. Structures define the geometric configuration of the area, including the distribution, thickness, and orientation of units. Synvolcanic structures, including caldera faults and some normal faults had strong influence on depositional patterns of many of the units. The juxtaposition of units with different hydrologic properties across faults may have significant hydrogeologic consequences. Also, faults may act as either conduits or barriers of groundwater flow, depending on the difference in permeability between a fault zone and the surrounding rocks. This is partially determined by whether the fault zone is characterized by open fractures, or if it is associated with fine-grained gouge or increased alteration.

Five main types of structural features exist in the area:

- Thrust faults (e.g., Belted Range and CP thrusts)
- Normal faults (e.g., Yucca and West Greeley faults)
- Transverse faults and structural zones (e.g., Rock Valley and Cane Spring faults)
- Calderas (e.g., Timber Mountain and Silent Canyon caldera complexes)
- Detachment faults (e.g., Fluorspar Canyon - Bullfrog Hills detachment fault)

The Belted Range thrust fault is the principle pre-Tertiary structure in the NTS region, and thus, controls the distribution of pre-Tertiary rocks in the area. The fault can be traced or inferred from Bare Mountain just south of the southwest corner of the NTS area to the northern Belted Range, just north of the NTS, a distance of more than 130 km (81 mi). It is an eastward-directed thrust fault that generally places late Proterozoic to early Cambrian rocks over rocks as young as Mississippian. Several imbricate thrust faults occur east of the main thrust fault. Deformation related to the Belted Range thrust fault occurred sometime between 100 and 250 Ma. Lesser thrusts of similar age are mapped in the area (e.g., the CP and Spotted Range thrusts).

Normal faults in the area are related mainly to basin-and-range extension (e.g., Yucca fault in Yucca Flat and West Greeley fault on Pahute Mesa). Most of them likely developed during and after the main phase of volcanic activity of the SWNVF (Sawyer et al., 1994). The majority of these faults are northwest-to northeast-striking, high angle faults. However, the exact locations, amount of offset along the faults, and character of the faults become increasingly uncertain with depth.

Calderas are probably the most hydrogeologically important features in the NTS area. Volcano-tectonic and geomorphic processes related to caldera development, result in abrupt and dramatic lithologic and thickness changes across caldera margins. Consequently, caldera margins (i.e., faults) separate regions with considerably different hydrogeologic character.

A.2 Hydrology

The hydrologic character of the NTS and vicinity reflects the region's arid climatic conditions and complex geology (D'Agnese et al., 1997). The hydrology of the NTS has been extensively studied for over 40 years (DOE, 1996); numerous scientific reports and large databases are available (refer to cited references for more detailed information). The following subsections present an overview of the hydrologic setting of the NTS and vicinity, including summary descriptions of surface water and groundwater, hydrogeologic framework, and brief descriptions of the hydrogeology for each of the idle underground test areas on the NTS. The reader is directed to Section 14 in the main body of this document for a discussion of the hydrogeologic modeling efforts conducted through the Underground Test Area (UGTA) Project.

A.2.1 Surface Water

The NTS is located within the Great Basin, a closed hydrographic province that comprises several closed hydrographic basins (Figure A-3). The closed hydrographic basins of the NTS (most notably Yucca and Frenchman Flats) are subbasins of the Great Basin. Streams in the region are ephemeral, flowing only in response to precipitation events or snowmelt. Runoff is conveyed through normally dry washes toward the lowest areas of the closed hydrographic subbasins, and collects on playas. There are two playas (seasonally dry lakes) on the NTS: Frenchman Lake and Yucca Lake, which lie in Frenchman and Yucca Flats, respectively. While water may stand on the playas for a few weeks before evaporating, the playas are dry most of the year. Surface water may leave the NTS in only a few places, such as Fortymile Canyon in the southwestern NTS.

Springs that emanate from local perched groundwater systems are the only natural sources of perennial surface water in the region. There are 24 known springs or seeps on the NTS (Hansen et al., 1997; BN, 1999) (Figure A-4). Spring discharge rates are low, ranging from 0.014 to 2.2 liters/sec (0.22 to 35 gallons/minute) (IT, 1997). Most water discharged from springs travels only a short distance from the source before evaporating or infiltrating into the ground. The springs are important sources of water for wildlife, but they are too small to be of use as a public water supply source.

Other surface waters on the NTS include man-made impoundments constructed at several locations throughout the NTS to support various operations. These are numerous, and include open industrial reservoirs, containment ponds, and sewage lagoons (DOE, 2003). Surface water is not a source of drinking water on the NTS.

A.2.2 Groundwater

The NTS is located within the Death Valley regional groundwater flow system, one of the major hydrologic subdivisions of the southern Great Basin (Waddell et al., 1984; Laczniak et al., 1996). Groundwater in southern Nevada is conveyed within several flow-system subbasins within the Death Valley regional flow system (a subbasin is defined as the area that contributes water to a major surface discharge area [Laczniak, et al., 1996]). Three principal groundwater subbasins, named for their down-gradient discharge areas, have been identified within the NTS region: the Ash Meadows, Oasis Valley, and Alkali Flat-Furnace Creek Ranch subbasins (Waddell et al., 1984) (Figure A-5).

The groundwater-bearing rocks at the NTS have been classified into several hydrogeologic units (HGUs; see Section A.2.3 below), of which the most important is the lower carbonate aquifer, a thick sequence of Paleozoic carbonate rock. This unit extends throughout the subsurface of central and southeastern Nevada, and is considered to be a regional aquifer (Winograd and Thordarson, 1975; Laczniak, et al., 1996; IT, 1996a). Various volcanic and alluvial aquifers are also locally important as water sources.

The depth to groundwater in wells at the NTS varies from about 210 m (690 ft) below the land surface under the Frenchman Flat playa in the southeastern NTS, to more than 610 m (2,000 ft) below the land surface in the northwestern NTS, beneath Pahute Mesa (Lock et al., 2003; Bright et al., 2000; IT, 1996b; Reiner et al., 1995; O'Hagan and Laczniak, 1996; Robie et al., 1995). Perched groundwater (isolated lenses of water lying above the regional groundwater level) occurs locally throughout the NTS, mainly within the volcanic rocks.

Recharge areas for the Death Valley groundwater system are the higher mountain ranges of central and southern Nevada, where there can be significant precipitation and snowmelt. Groundwater flow is generally from these upland areas to natural discharge areas in the south and southwest. Groundwater at the NTS is also derived from underflow from basins up-gradient of the area (Harrill et al., 1988). The direction of groundwater flow may locally be influenced by structure, rock type, or other geologic conditions. Based on existing water-level data (Reiner et al., 1995; Hale et al., 1995; IT, 1996b; DOE, 2003) and flow models (IT, 1996a; D'Agnese et al., 1997) the general groundwater flow direction within major water-bearing units beneath the NTS is to the south and southwest.

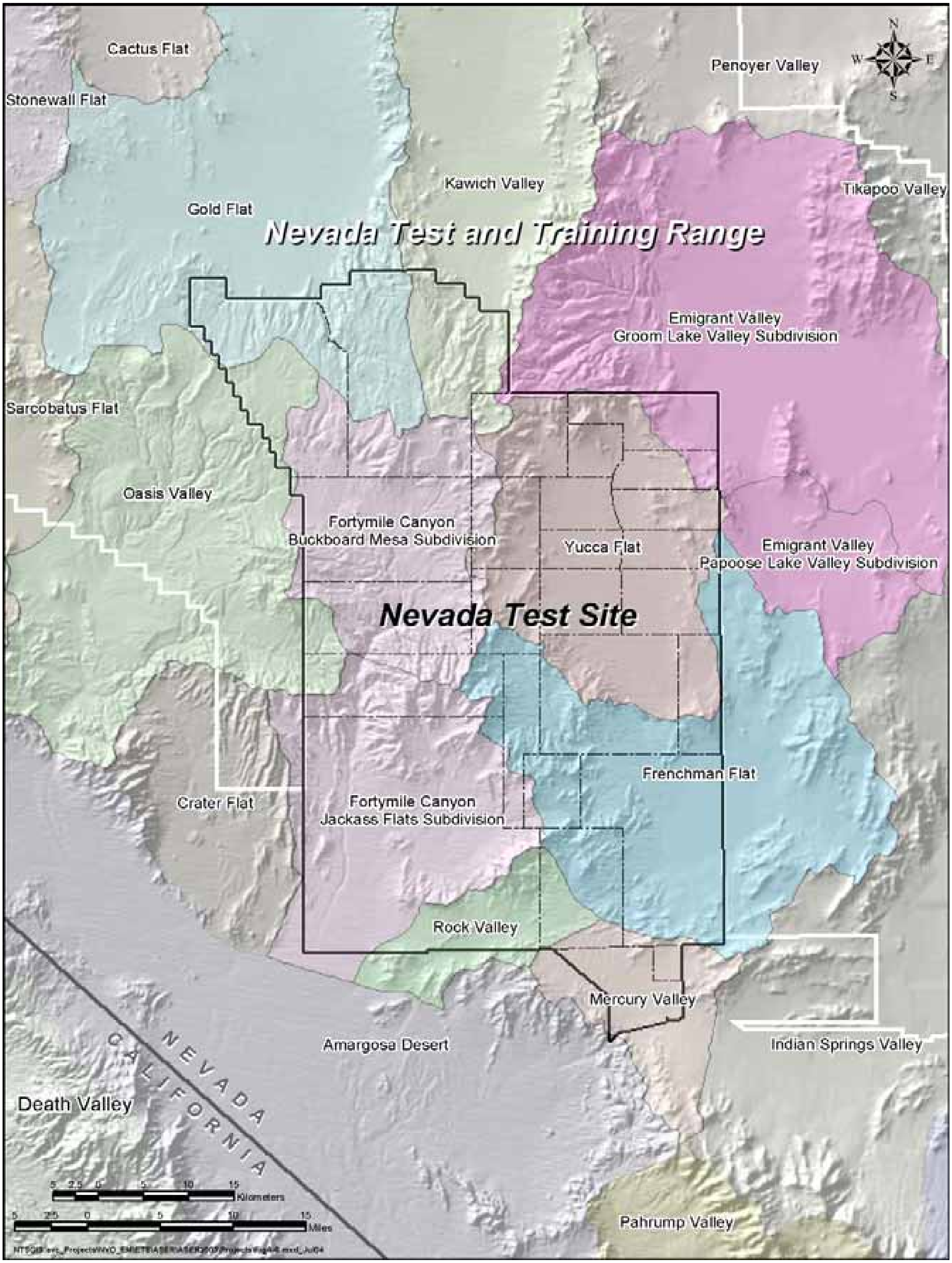

Figure A-3. Closed hydrographic subbasins on the NTS

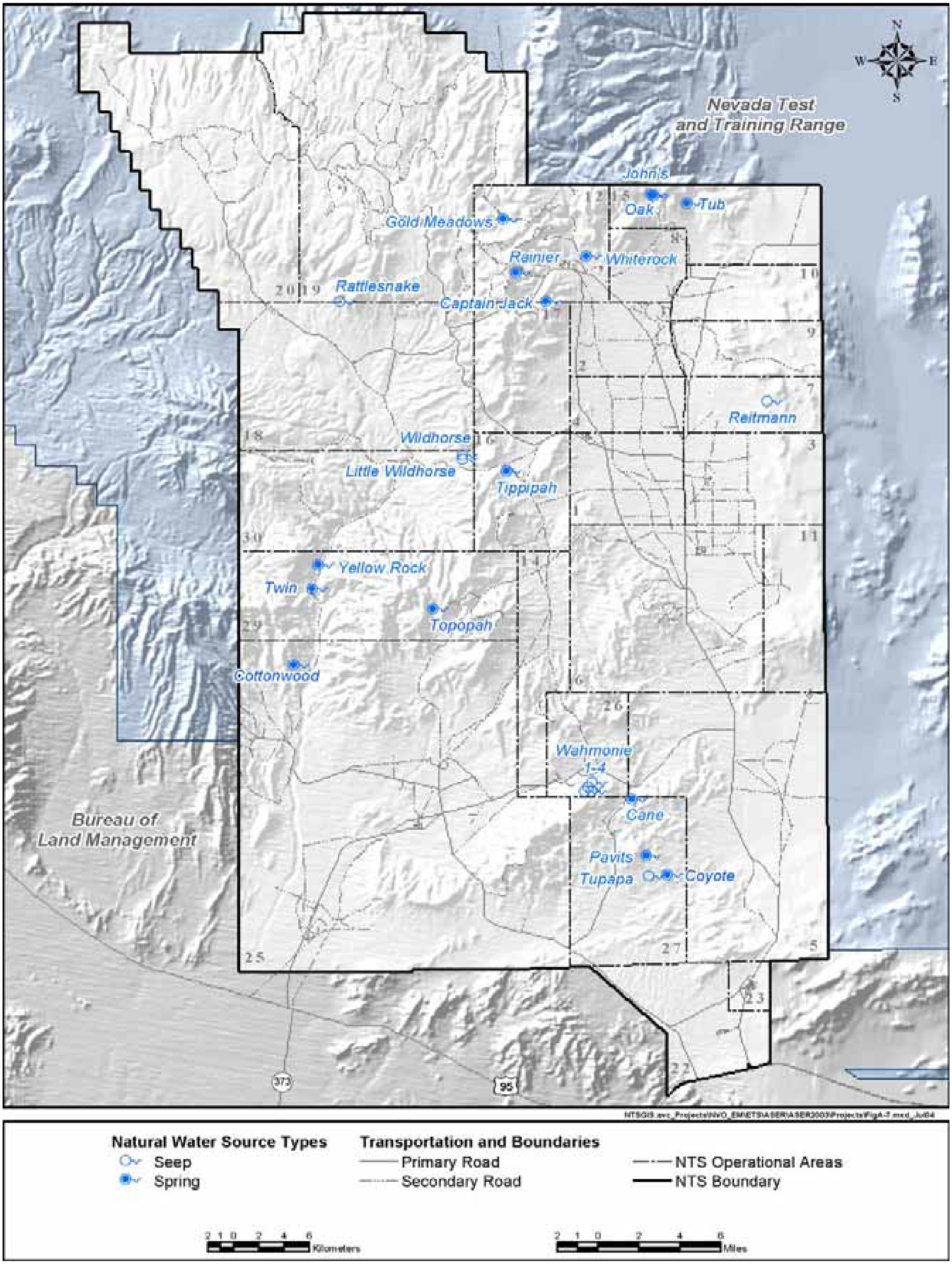

Figure A-4. Natural springs and seeps on the NTS

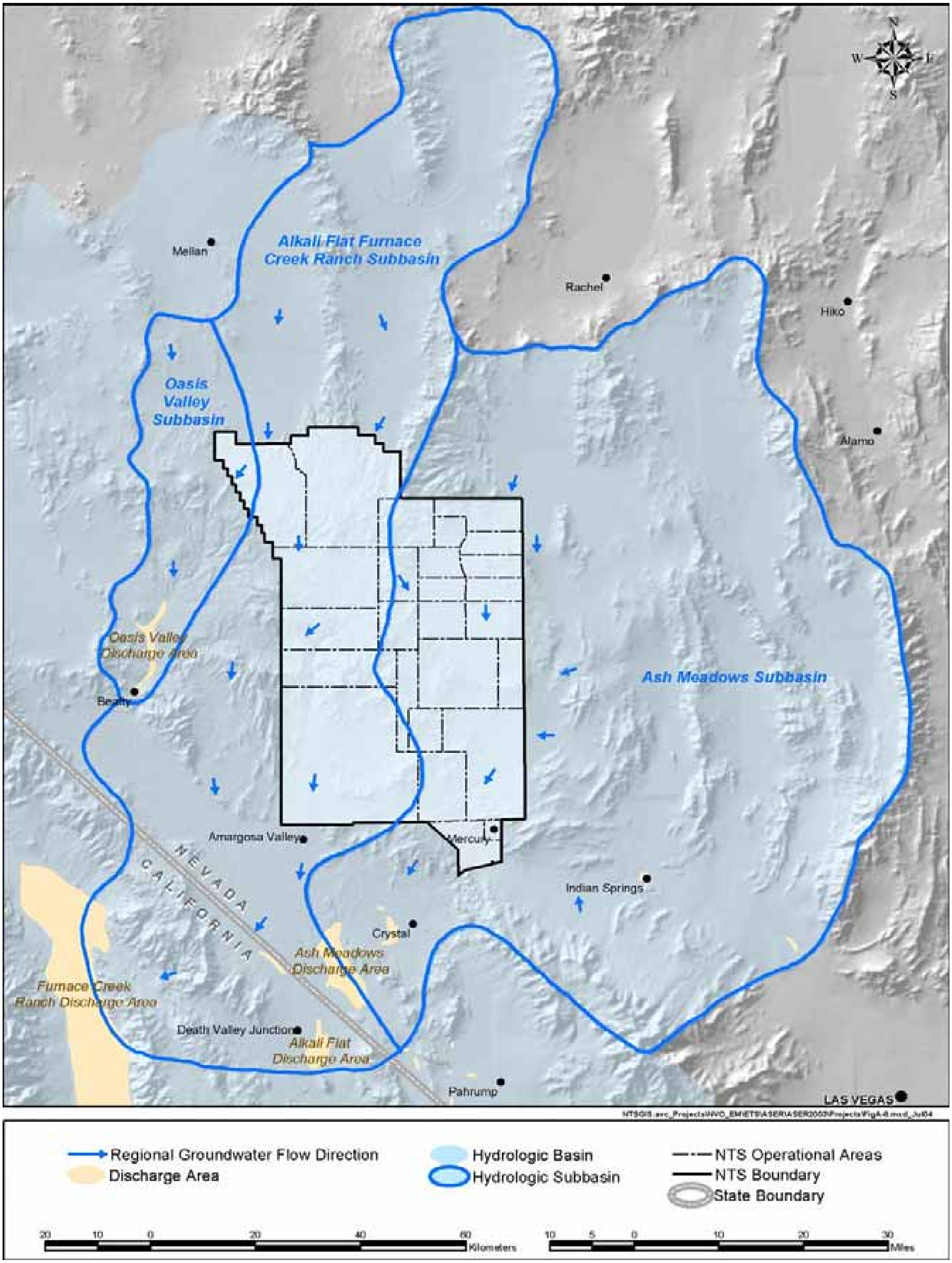

Figure A-5. Groundwater subbasins of the NTS and vicinity

Most of the natural discharge from the Death Valley flow system is via transpiration by plants or evaporation from soil and playas in the Amargosa Desert and Death Valley. Groundwater discharge at the NTS is minor, consisting of small springs which drain perched water lenses and artificial discharge at a limited number of water supply wells.

Groundwater is the only local source of potable water on the NTS. The nine supply wells that make up the NTS water system and the other supply wells for the various water systems in the area (town of Beatty, small mines, and local ranches) produce water for human and industrial use from the carbonate, volcanic, and alluvial aquifers. Water chemistry varies from a sodium-potassium-bicarbonate type to a calcium-magnesium-carbonate type, depending on the mineralogical composition of the aquifer source. Groundwater quality within aquifers of the NTS is generally acceptable for drinking water and industrial and agricultural uses (Chapman, 1994), and meets Safe Drinking Water Act standards (Chapman and Lyles, 1993; Rose et al., 1997; BN, 2003).

A.2.3 Hydrogeologic Framework for the NTS and Vicinity

When the need for testing nuclear devices underground was recognized in the 1950s, among the first concerns was the effect testing would have on the groundwater of the area. One of the earliest nuclear tests conducted below the groundwater table (the BILBY test conducted in 1963) was designed in part to study explosion effects on groundwater and the movement in groundwater of radioactive byproducts from the explosion (Hale et al., 1963; Garber, 1971). Since that time additional studies at various scales have been conducted to aid in the understanding of groundwater flow at the NTS. The current understanding of the regional groundwater flow at the NTS is derived from work by Winograd and Thordarson (1975), which was summarized and updated by Laczniak et al. (1996), and has further been developed by the UGTA Project hydrogeologic modeling team (IT, 1996a, 1998; BN, 2002a). See Section 14 for a description of the UGTA Project.

Winograd and Thordarson (1975) established a hydrogeologic framework, incorporating the work of Blankennagel and Weir (1973) who defined the first hydrogeologic units (HGUs) to address the complex hydraulic properties of volcanic rocks. HGUs are used to categorize lithologic units according to their ability to transmit groundwater, which is mainly a function of their primary lithologic properties, degree of fracturing, and secondary mineral alteration. Hydrostratigraphic units (HSUs) for the NTS volcanic rocks were first defined during the UGTA modeling initiative (IT, 1996a). HSUs are groupings of contiguous stratigraphic units that have a particular hydrogeologic character, such as aquifer (unit through which water moves readily) or confining unit (unit that generally is impermeable to water movement). The concept of HSUs is very useful in volcanic terrains where stratigraphic units can vary greatly in hydrologic character both laterally and vertically.

The rocks of the NTS have been classified for hydrologic modeling using this two-level classification scheme in which HGUs are grouped to form HSUs (IT, 1996a). An HSU may consist of several HGUs but is defined so that a single general type of HGU dominates (for example, mostly welded-tuff and vitric-tuff aquifers or mostly tuff confining units).

A.2.3.1 Hydrogeologic Units

All the rocks of the NTS and vicinity can be classified as one of ten HGUs, which include the alluvial aquifer, a playa confining unit, four volcanic HGUs, two intrusive units, and two HGUs that represent the pre-Tertiary rocks (Table A-3).

The deposits of alluvium (alluvial aquifer) fill the main basins of the NTS, and generally consist of a loosely consolidated mixture of boulders, gravel, and sand derived from volcanic and Paleozoic sedimentary rocks (Slate et al., 1999). The finest sediments can be deposited as playa deposits (or dry lake beds) in some closed basins (e.g., Yucca and Frenchman Flats). Because of their silty/clayey nature these fine-grained units tend to behave hydrologically as confining units (restrictive of groundwater flow).

Table A-3. Hydrogeologic units of the NTS area

Hydrogeologic Unit	Typical Lithologies	Hydrologic Significance
Alluvial Aquifer (AA)	Unconsolidated to partially consolidated gravelly sand, eolian sand, and colluvium; thin, basalt flows of limited extent	Has characteristics of a highly conductive aquifer, but less so where lenses of clay-rich paleocolluvium or playa deposits are present.
Welded-Tuff Aquifer (WTA)	Welded ash-flow tuff; vitric to devitrified	Degree of welding greatly affects interstitial porosity (less porosity as degree of welding increases) and permeability (greater fracture permeability as degree of welding increases).
Vitric-Tuff Aquifer (VTA)	Bedded tuff; ash-fall and reworked tuff; vitric	Constitutes a volumetrically minor hydrogeologic unit. Generally does not extend far below the static water level due to tendency to become zeolitized (which drastically reduces permeability) under saturated conditions. Significant interstitial porosity (20 to 40 percent). Generally insignificant fracture permeability.
Lava-Flow Aquifer (LFA)	Rhyolite lava flows; includes flow breccias (commonly at base) and pumiceous zones (commonly at top)	Generally a caldera-filling unit. Hydrologically complex; wide range of transmissivities; fracture density and interstitial porosity differ with lithologic variations.
Tuff Confining Unit (TCU)	Zeolitized bedded tuff with interbedded, but less significant, zeolitized, nonwelded to partially welded ash-flow tuff	May be saturated but measured transmissivities are very low. May cause accumulation of perched and/or semi-perched water in overlying units.
Intracaldera Intrusive Confining Unit (IICU)	Highly altered, highly injected/intruded country rock and granitic material	Assumed to be impermeable. Conceptually underlies each of the SWNVF calderas and Calico Hills.
Granite Confining Unit (GCU)	Granodiorite, quartz monzonite	Relatively impermeable; forms local bulbous stocks, north of Rainier Mesa and Yucca Flat; may contain perched water.
Clastic Confining Unit (CCU)	Argillite, siltstone, quartzite	Clay-rich rocks are relatively impermeable; more siliceous rocks are fractured, but with fracture porosity generally sealed due to secondary mineralization.
Carbonate Aquifer (CA)	Dolomite, limestone	Transmissivity values differ greatly and are directly dependent on fracture frequency.

Note: Adapted from BN (2002a).

The volcanic rocks of the NTS and vicinity can be categorized into four HGUs based on primary lithologic properties, degree of fracturing, and secondary mineral alteration. In general, the altered (typically zeolitized, but hydrothermally altered near caldera margins) volcanic rocks act as confining units (tuff confining unit), and the unaltered rocks form aquifers. The volcanic aquifer units can be further divided into welded-tuff aquifers or vitric-tuff aquifers (depending upon the degree of welding) and lava-flow aquifers. The denser rocks (welded ash-flow tuffs and lava flows) tend to fracture more readily, and therefore have relatively high permeability (Blankennagel and Weir, 1973; Winograd and Thordarson, 1975; Laczniak et al., 1996; IT, 1997, 1996c; Prothro and Drellack, 1997).

The pre-Tertiary sedimentary rocks at the NTS and vicinity are also categorized as aquifer or confining unit HGUs based on lithology. The silicic clastic rocks (quartzite, siltstone, shale) tend to be aquitards or confining units, while the carbonates (limestone and dolomite) tend to be aquifers (Winograd and Thordarson, 1975; Laczniak et al., 1996). The granite confining unit is considered to behave as a confining unit due to low primary porosity and low permeability, and because most fractures are probably filled with secondary minerals (Walker, 1962).

A.2.3.2 Hydrostratigraphic Units

The rocks at the NTS and vicinity are grouped into roughly 60 HSUs. The more important and widespread HSUs in the area are discussed separately below, from oldest to youngest. Additional information regarding other HSUs is summarized in tables introduced in Section A.2.5 below where the hydrogeology of Yucca and Frenchman Flats, and Pahute and Rainier Mesas UGTAs at the NTS is addressed. Additional information can be found in the documentation packages for the UGTA CAU-scale hydrogeologic models (IT, 1996a; 1998; Gonzales and Drellack, 1999; and BN, 2002a).

Lower Clastic Confining Unit (LCCU) – The Proterozoic to Middle-Cambrian-age rocks are largely quartzite and silica-cemented siltstone. Although these rocks are brittle and commonly fractured, secondary mineralization seems to have greatly reduced formation permeability (Winograd and Thordarson, 1975). These units make up the LCCU, which is considered to be the regional hydrologic basement (IT, 1996a). The LCCU is interpreted to underlie the entire region, except at the calderas. Where it is in a structurally high position, the LCCU may act as a barrier to deep regional groundwater flow.

Lower Carbonate Aquifer (LCA) – The LCA consists of thick sequences of Middle Cambrian through Upper Devonian carbonate rocks. This HSU serves as the regional aquifer for most of southern Nevada and locally may be as thick as 5,000 m (16,400 ft) (Cole, 1997; Cole and Cashman, 1999). The LCA is present under most of the area, except where the LCCU is structurally high and at the calderas. Transmissivities of these rocks differ from place to place, apparently reflecting the observed differences in fracture and fault densities and characteristics (Winograd and Thordarson, 1975).

Upper Clastic Confining Unit (UCCU) – Upper Devonian and Mississippian silicic clastic rocks in the NTS vicinity are assigned to the Eleana Formation and the Chainman Shale (Trexler et al., 2003; Cashman and Trexler, 1991; Trexler et al., 1996). Both formations are grouped into the UCCU. At the NTS this HSU is found mainly within a north-south band along the western portion of Yucca Flat. It is a significant confining unit and in many places forms the footwall of the Belted Range and Control Point (CP) thrust faults.

Lower Carbonate Aquifer, Upper Thrust Plate (LCA3) – Cambrian through Devonian, mostly carbonate rocks that occur in the hanging wall of the Belted Range and CP thrust faults are designated as LCA3. These rocks are equivalent stratigraphically to the LCA, but are structurally separated from the LCA by the Belted Range thrust fault. The LCA3 is patchily distributed as remnant thrust blocks, particularly along the western and southern sides of Yucca Flat (at Mine Mountain and the CP Hills), at Calico Hills, and at Bare Mountain.

Mesozoic Granite Confining Unit (MGCU) – The Mesozoic era is represented at the NTS only by intrusive igneous rocks. Cretaceous-age granitic rocks are exposed at two locations: in northern Yucca Flat, at the Climax Stock; and the Gold Meadows Stock, which lies 12.9 km (8 mi) west of the Climax Stock, just north of Rainier Mesa (Snyder, 1977; Bath et al., 1983) (Figure A-5). The two are probably related in both source and time and are believed to be connected at depth (Jachens, 1999). Because of its low intergranular porosity and permeability, and the lack of inter-connecting fractures (Walker, 1962), the MGCU is considered a confining unit. The Climax and Gold Meadows intrusives are grouped into the MGCU HSU.

Tertiary and Quaternary Hydrostratigraphic Units – Tertiary-and Quaternary-age strata at the NTS are organized into dozens of HSUs. Nearly all are of volcanic origin, except the alluvial aquifer, which is the uppermost HSU. These rocks are important because (1) most of the underground nuclear tests at the NTS were conducted in these units, (2) they constitute a large percentage of the rocks in the area, and (3) they are inherently complex and heterogeneous. As pointed out in Section A.2.3.1, the volcanic rocks are divided into aquifer or confining units according to lithology and secondary alteration. More detailed information can be found in the documentation packages for the UGTA CAU-scale hydrogeologic models (IT, 1996a, 1998; Gonzales and Drellack, 1999; BN, 2002a).

Alluvial Aquifer (AA) – The alluvium throughout most of the NTS is a loosely consolidated mixture of detritus derived from silicic volcanic and Paleozoic-age sedimentary rocks, ranging in particle size from clay to boulders. Sediment deposition is largely in the form of alluvial fans (debris flows, sheet wash, and braided streams) which coalesce to form discontinuous, gradational, and poorly sorted deposits. Eolian sand, playa deposits, and rare basalt flows are also present within the alluvial section of some valleys. The alluvium thickness in major valleys (e.g., Frenchman Flat and Yucca Flat) generally ranges from about 30 m (100 ft) to more than 1,128 m (3700 ft) in the deepest subbasins. The AA HSU is restricted primarily to the basins of the NTS. However, because the water table in the vicinity is moderately deep, the alluvium is generally unsaturated, except in the deep subbasins of some valleys. These sediments are porous and thus, have high storage coefficients. Hydraulic conductivity may also be high, particularly in the coarser, gravelly beds.

A.2.4 General Hydraulic Characteristics of NTS Rocks

Volcanic rocks typically are extremely variable in lithologic character both laterally and vertically. The characteristics of rocks that control the density and character of fractures are the primary determinants of their hydraulic properties, and most hydraulic heterogeneity ultimately is related to fracture characteristics such as fracture density, openness, orientation, and other properties. Secondary fracture-filling minerals can drastically obstruct the flow through or effectively seal an otherwise transmissive formation (Drellack et al., 1997; IT, 1996c). Fracture density typically increases with proximity to faults, potentially increasing the hydraulic conductivity of the formation; however, the hydrologic properties of faults, per se, are not well known. Limited data suggest that the full spectrum of hydraulic properties, from barrier to conduit, may be possible (Blankennagel and Weir, 1973; Faunt, 1998).

Table A-4 includes a brief summary of the hydrologic properties of NTS HGUs. The lowest transmissivity values in volcanic rocks at the NTS are typically associated with non-welded ash-flow tuff and bedded tuff (air-fall and reworked tuffs). Although interstitial porosity may be high, the interconnectivity of the pore space is poor, and these relatively incompetent rocks tend not to support open fractures. Secondary alteration of these tuffs (most commonly, zeolitization) ultimately yields a very impermeable unit. As described in Section A.2.3.1, these zeolitized tuffs are considered to be confining units. The equivalent unaltered bedded and non-welded tuffs are considered to be vitric-tuff aquifers, and have intermediate transmissivities.

In general, the most transmissive rocks tend to be moderately to densely welded ash-flow tuffs (welded-tuff aquifer), rhyolite lava flows (lava-flow aquifer), and carbonate rocks (limestone and dolomite). Although their interstitial porosity is low, these competent lithologies tend to be highly fractured, and groundwater flow through these rocks is largely through an interconnected network of fractures (Blankennagel and Weir, 1973; GeoTrans, 1995).

Underground nuclear explosions affect hydraulic properties of the geologic medium, creating both long-term and short-term effects. Effects include enhanced permeability from shock-induced fractures, the formation of vertical conduits (e.g., collapse chimneys), and elevated water levels (mounding and over-pressurization of saturated low-permeability units). However, these effects tend to be localized (Borg, et al., 1976; Brikowski, 1991; Allen et al., 1997).

Table A-4. Summary of hydrologic properties for hydrogeologic units at the NTS

Hydrogeologic Unit(a)			Fracture Density(b, c)	Relative Hydraulic Conductivity(c)
Alluvial Aquifer			Very low	Moderate to very high
Vitric-Tuff Aquifer			Low	Low to moderate
Welded-Tuff Aquifer			Moderate to high	Moderate to very high
Lava-Flow Aquifer (d)	Pumiceous Lava	Vitric	Low	Low to moderate
		Zeolitic	Low	Very low
	Stony Lava and Vitrophyre		Moderate to high	Moderate to very high
	Flow Breccia		Low to moderate	Low to moderate
Tuff Confining Unit			Low	Very low
Intrusive Confining Unit			Low to moderate	Very low
Granite Confining Unit			Low to moderate	Very low
Carbonate Aquifer			Low to high (variable)	Low to very high
Clastic Confining Unit			Moderate	Very low to low (e)

(a) Refer to Table A-3 for hydrogeologic nomenclature.

(b) Including primary (cooling joints in tuffs) and secondary (tectonic) fractures.

(c) The values presented are the authors' qualitative estimates based on data from published (IT [1996c] and Blankennagel and Weir [1973], Winograd and Thordarson [1975]) and unpublished sources (i.e., numerous Los Alamos and Lawrence Livermore National Laboratory drill-hole characterization reports).

(d) Abstracted from Prothro and Drellack (1997).

(e) Fractures tend to be sealed by the presence of secondary minerals.

Note: Adapted from BN (2002c).

A.2.5 Hydrogeology of the NTS Underground Test Areas

Most NTS underground nuclear detonations were conducted in three main UGTAs: (1) Yucca Flat, (2) Pahute Mesa, and (3) Rainier Mesa (including Aqueduct Mesa). Underground tests in Yucca Flat and Pahute Mesa typically were conducted in vertical drill holes, whereas almost all tests conducted in Rainier Mesa were tunnel emplacements. A total of 85 underground tests (85 detonations) were conducted on Pahute Mesa, including 18 high-yield detonations (200 kilotons [kt] or more). Rainier Mesa hosted 61 underground tests (62 detonations), almost all of which were relatively low-yield (generally less than 20 kt) tunnel-based weapons-effects tests. Yucca Flat was the most extensively used UGTA, hosting 659 underground tests (747 detonations), four of which were high-yield detonations (200 kilotons or more) (Allen et al., 1997).

In addition to the three main UGTAs, underground nuclear tests were conducted in Frenchman Flat (ten tests), Shoshone Mountain (six tests), the Oak Spring Butte/Climax Mine area (three tests), the Buckboard Mesa area (three tests), and Dome Mountain (one test with five detonations) (Allen et al., 1997). It should be noted that these totals include nine cratering tests (13 total detonations) conducted in various areas of the NTS. Table A-5 is a synopsis of information about each UGTA at the NTS, and Figure A-6 shows the aerial distribution of underground nuclear tests conducted at the NTS.

Table A-5. Information summary of NTS underground nuclear tests

Physiographic Area	NTS Area(s)	Total Underground(a)		Test Dates(a)	Depth of Burial Range	Overburden Media	Comments
		Tests	Detonations				
Yucca Flat	1, 2, 3, 4, 6, 7, 8, 9, 10	659	747	1951 - 1992	27 - 1219 m (89 - 3999 ft)	Alluvium/playa, Volcanic tuff, Paleozoic rocks	Various test types and yields; almost all were vertical emplacements above and below static water level; includes 4 high-yield(b) detonations.
Pahute Mesa	19, 20	85	85	1965 - 1992	31 - 1452 m (100 - 4765 ft)	Alluvium, (thin) volcanic tuffs and lavas	Almost all were large-diameter vertical emplacements above and below static water level; includes 18 high-yield detonations.
Rainier/Aqueduct Mesa	12	61	62	1957 - 1992	61 - 640 m (200 - 2100 ft)	Tuffs with welded tuff caprock (little or no alluvium)	Two vertical emplacements; all others were horizontal tunnel emplacements above static water level; mostly low-yield(c) U.S. Department of Defense weapons effects tests.
Frenchman Flat	5, 11	10	10	1965 - 1971	179 - 296 m (587 - 971 ft)	Mostly alluvium, minor volcanic tuff	Various emplacement configurations, both above and below static water level.
Shoshone Mtn.	16	6	6	1962 - 1971	244 - 640 m (800 - 2100 ft)	Bedded tuff	Tunnel-based low-yield weapons effects and Vela Uniform tests.
Oak Spring Butte (Climax Area)	15	3	3	1962 - 1966	229 - 351 m (750 - 1150 ft)	Granite	Three tests above static water level. (HARD HAT, TINY TOT, and PILE DRIVER).
Buckboard Mesa	18	3	3	1962 - 1964	≤ 27 m (90 ft)	Basaltic lavas	Shallow, low-yield experiments (SULKY, JOHNNIE BOY(d) and DANNY BOY); all were above static water level.
Dome Mountain	30	1	5	03/12/1968	50 m (165 ft)	Mafic lava	BUGGY (A, B, C, D, and E); Plowshare cratering test of five-detonation horizontal salvo; all above static water level.

(a) Source: U.S. Department of Energy (2000b).

(b) High-yield detonations – detonations more than 200 kilotons, or detonations described with an upper yield range of at least 200 kilotons.

(c) Low-yield detonations – detonations less than 20 kilotons.

(d) JOHNNIE BOY was detonated at a depth of 1.75 ft (essentially a surface burst) approximately one mile east of Buckboard Mesa.

Source: Allen, et al., 1997.

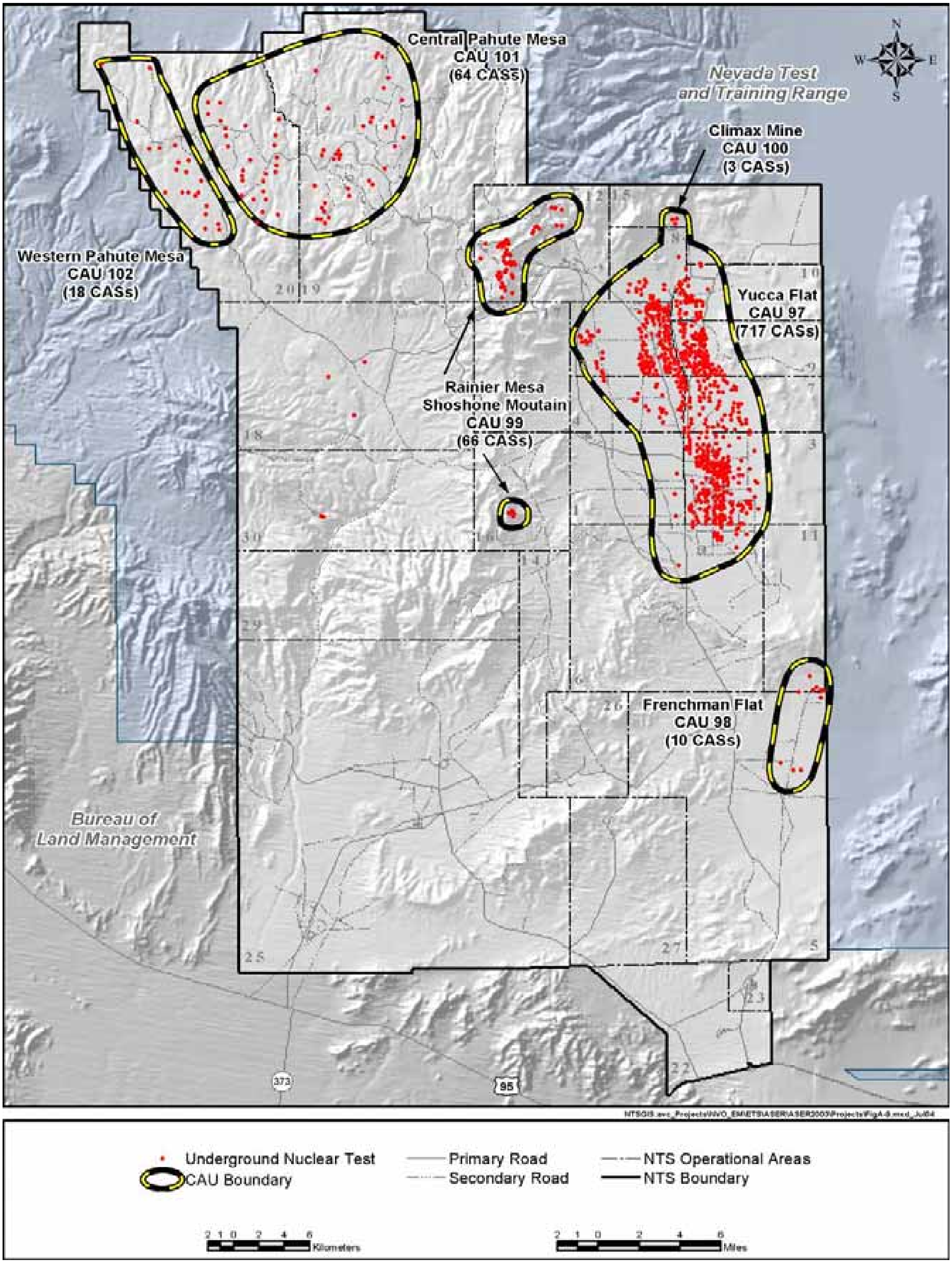

Figure A-6. Location of Corrective Action Units and Corrective Action Sites on the NTS

The location of each underground nuclear test is classified as a Corrective Action Site (CAS). These in turn have been grouped into six Corrective Action Units (CAUs), according to the Federal Facilities Agreement and Consent Order (FFACO, 1996) between the DOE and the state of Nevada. In general, the CAUs relate to the geographical UGTAs on the NTS (see Figure A-6).

The hydrogeology of the four main NTS UGTAs is summarized in the following subsections. For detailed stratigraphic descriptions of geologic units at the NTS (including each of the UGTAs) see Sawyer et al. (1994) and Slate et al. (1999).

A.2.5.1 Frenchman Flat Underground Test Area

The Frenchman Flat CAU consists of ten CASs located in the northern part of NTS Area 5 and southern part of Area 11 (see Figure A-6). The detonations were conducted in vertical emplacement holes and two mined shafts. Nearly all the tests were conducted in alluvium above the water table.

Physiography – Frenchman Flat is a closed intermontane basin located in the southeastern portion of the NTS. It is bounded on the north by Massachusetts Mountain and the Halfpint Range, on the east by the Buried Hills, on the south by the Spotted Range, and on the west by the Wahmonie volcanic center (see Figure A-5). The sparsely vegetated valley floor slopes gently toward a central playa lakebed. Ground-level elevations range from 938 m (3,078 ft) above sea level at the playa, to over 1,463 m (4,800 ft) in the nearby surrounding mountains.

Geology Overview – The stratigraphic section for Frenchman Flat consists of (from oldest to youngest) Proterozoic and Paleozoic clastic and carbonate rocks, Tertiary sedimentary and tuffaceous sedimentary rocks, Tertiary volcanic rocks, and Quaternary and Tertiary alluvium (Slate et al., 1999). In the northernmost portion of Frenchman Flat, the middle to upper Miocene volcanic rocks that erupted from calderas located to the northwest of Frenchman Flat unconformably overlie Ordovician-age carbonate and clastic rocks. To the south, these volcanic units, including the Ammonia Tanks Tuff, Rainier Mesa Tuff, Topopah Spring Formation, and Crater Flat Group, either thin considerably, interfinger with coeval sedimentary rocks, or pinch out together (IT, 1998b). Upper-middle Miocene tuffs, lavas, and debris flows from the Wahmonie volcanic center located just west of Frenchman Flat dominate the volcanic section beneath the western portion of the valley. To the south and southeast, most of the volcanic units are absent and Oligocene to middle Miocene sedimentary and tuffaceous sedimentary rocks, which unconformably overlie the Paleozoic rocks in the southern portion of Frenchman Flat, dominate the Tertiary section (Prothro and Drellack, 1997). In most of the Frenchman Flat area, upper Miocene to Holocene alluvium covers the older sedimentary and volcanic rocks (Slate et al., 1999). Alluvium thicknesses range from a thin veneer along the valley edges to perhaps as much as 1,158 m (3,800 ft) in north central Frenchman Flat.

Structural Setting – The structural geology of Frenchman Flat is complex. During the late Mesozoic era, the region was subjected to compressional deformation, which resulted in folding, thrusting, uplift, and erosion of the pre-Tertiary rocks (Barnes et al., 1982). Approximately 16 Ma, the region underwent extensional deformation, during which the present basin-and-range topography was developed, and the Frenchman Flat basin was formed (Ekren et al., 1968). In the immediate vicinity of Frenchman Flat, extensional deformation has produced northeast-trending, left-lateral strike-slip faults and generally north-trending normal faults that displace the Tertiary and pre-Tertiary rocks. Beneath Frenchman Flat, major west-dipping normal faults merge and are probably contemporaneous with strike-slip faults beneath the southern portion of the basin (Grauch and Hudson, 1995). Movement along the faults has created a relatively deep, east-dipping, half-graben basin elongated in a northeasterly direction (Figure A-7).

Hydrogeology Overview – The hydrogeology of Frenchman Flat is fairly complex, but is typical of the NTS area. Many of the HGU-and HSU-building blocks developed for the NTS vicinity are applicable to the Frenchman Flat basin. The strata in the Frenchman Flat area have been subdivided into five Tertiary-age HSUs (including the Quaternary/Tertiary alluvium) and three pre-Tertiary HSUs to serve as layers for the UGTA Frenchman Flat CAU groundwater model (IT, 1998b). In descending order these units are: the AA, the Timber Mountain aquifer (TMA), the Wahmonie confining unit (WCU), the tuff confining unit (TCU), the volcaniclastic confining unit (VCU), the LCA, and the LCCU (Table A-6).

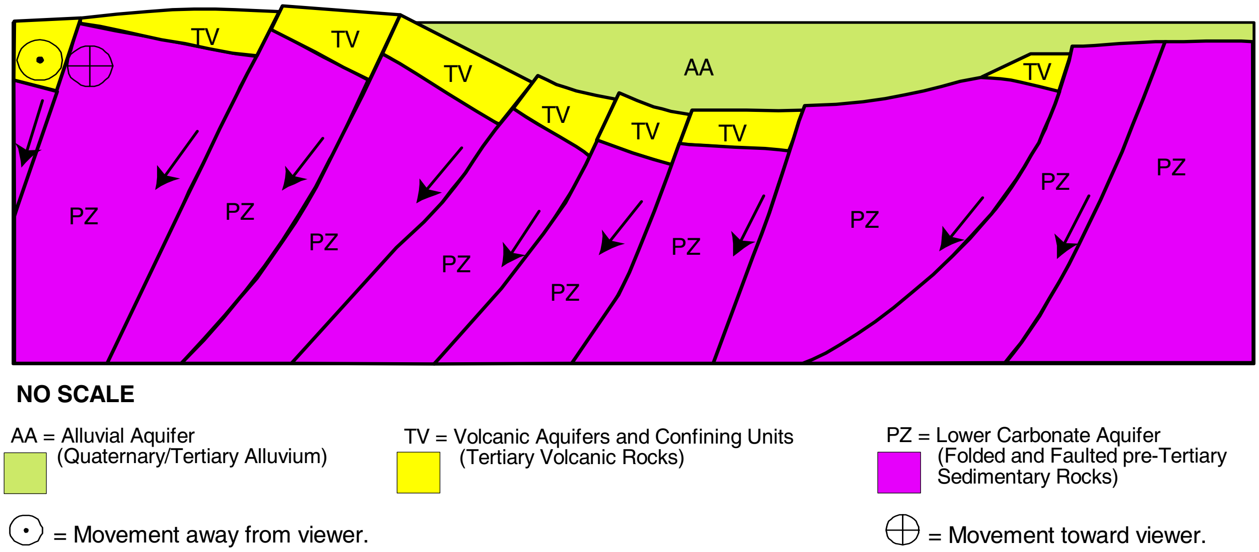

Figure A-7. Conceptual east-west cross section through Frenchman Flat

Table A-6. Hydrostratigraphic units of the Frenchman Flat underground test area

Hydrostratigraphic Unit (Symbol)	Dominant Hydrogeologic Unit[(a)]	Typical Lithologies
Alluvial Aquifer (AA)	AA, minor LFA	Alluvium (gravelly sand); also includes relatively thin basalt flow in northern Frenchman Flat and playa deposits in south-central part of basin
Timber Mountain Aquifer (TMA)	WTA, VTA	Welded ash-flow tuff and related nonwelded and air-fall tuffs; vitric to devitrified
Wahmonie Volcanic Confining Unit (WVCU)	TCU, minor LFA	Air-fall and reworked tuffs; debris and breccia flows; minor intercalated lava flows. Typically altered: zeolitic to argillic
Tuff Confining Unit (TCU)	TCU	Zeolitic bedded tuffs, with interbedded but less significant zeolitic, nonwelded to partially welded ash-flow tuffs
Volcaniclastic Confining Unit (VCU)	TCU, minor AA	Diverse assemblage of interbedded volcanic and sedimentary rocks including tuffs, shale, tuffaceous and argillaceous sandstones, conglomerates, minor limestones
Upper Clastic Confining Unit (UCCU)	CCU	Argillite, quartzite; present only in northwest portion of model in the CP Basin
Lower Carbonate Aquifer (LCA)	CA	Dolomite and limestone; the "regional aquifer"
Lower Clastic Confining Unit (LCCU)	CCU	Quartzites and siltstones; the "hydrologic basement"

(a) See Table A-3 for descriptions of hydrogeologic units.

Note: Adapted from IT, 1998b.

Water–level Elevation and Groundwater Flow Direction – The depth to the static water level (SWL) in Frenchman Flat ranges from 210 m (690 ft) near the central playa to more than 350 m (1,150 ft) at the northern end of the valley. The SWL is generally located within the AA, TMA, WVCU, or TCU. In the deeper, central portions of the basin, more than half of the alluvium section is saturated. Water-level elevation data in the AA indicate a very flat water table (Blout et al., 1994; IT, 1998b).

Water-level data for the LCA in the southern part of the NTS are limited, but indicate a fairly low gradient in the Yucca Flat, Frenchman Flat, and Jackass Flats areas. This gentle gradient implies a high degree of hydraulic continuity within the aquifer, presumably due to high fracture permeability (Laczniak et al., 1996). Furthermore, the similarity of the water levels measured in Paleozoic rocks (LCA) in Yucca Flat and Frenchman Flat implies that, at least for deep interbasin flow, there is no groundwater barrier between the two basins. Inferred regional groundwater flow through Frenchman Flat is to the south-southwest toward discharge areas in Ash Meadows (see Figure A-5). An increasing westward flow vector in southern NTS may be due to preferential flow paths subparallel to the northeast-trending Rock Valley fault (Grauch and Hudson, 1995) and/or a northward gradient from the Spring Mountain recharge area (IT, 1996a; b).

Groundwater elevation measurements for wells completed in the AA and TMA are higher than those in the underlying LCA (IT, 1996b; 1998b). This implies a downward gradient. This apparent semi-perched condition is believed to be due to the presence of intervening TCU and VCU units.

A.2.5.2 Yucca Flat/Climax Mine Underground Test Area

The Yucca Flat/Climax Mine CAU consists of several hundreds of CASs located in NTS Areas 1, 2, 3, 4, 6, 7, 8, 9, 10, and three CASs located in Area 15 (see Figure A-6). These tests were typically conducted in vertical emplacement holes and a few related tunnels (see Table A-5).

The Yucca Flat and Climax Mine UGTAs were originally defined as two separate CAUs (CAU 97 and CAU 100) in the FFACO (1996) because the geologic frameworks of the two areas are distinctly different. The Yucca Flat underground nuclear tests were conducted in alluvial, volcanic, and carbonate rocks, whereas the Climax Mine tests were conducted in an igneous intrusion in northern Yucca Flat. However, particle-tracking simulations performed during the regional evaluation (IT, 1997) indicated that the local Climax Mine groundwater flow system merges into the much larger Yucca Flat groundwater flow system during the 1,000-year time period of interest, so the two areas were combined into the single CAU 97.

Yucca Flat was the most heavily used UGTA on the NTS (see Figure A-6). The alluvium and tuff formations provide many characteristics advantageous to the containment of nuclear explosions. They are easily mined or drilled. The high-porosity overburden (alluvium and vitric tuffs) will accept and depressurize any gas which might escape the blast cavity. The deeper tuffs are zeolitized, which creates a nearly impermeable confining unit. The zeolites also have absorptive and "molecular sieve" attributes which severely restrict or prevent the migration of radionuclides. The deep water table (greater than 503 m [1,650 ft] depth) provides additional operational and environmental benefits.

This section provides brief descriptions of the geologic and hydrogeologic setting of the Yucca Flat/Climax Mine UGTA, as well as a discussion of the hydrostratigraphic framework. This summary was compiled from various sources, including BN (2001a), Gonzales and Drellack (1999), Winograd and Thordarson (1975), Laczniak et al., (1996), Byers et al., (1989), and Cole (1997) where additional information can be found.

Physiography – Yucca Flat is a topographically closed basin with a playa at its southern end. The geomorphology of Yucca Flat is typical of the arid, inter-mountain basins found throughout the Basin and Range province of Nevada and adjoining states. Faulted and tilted blocks of Tertiary-age volcanic rocks and underlying Precambrian and Paleozoic sedimentary rocks form low ranges around the basin (see Figure A-5). These rocks also compose the "basement" of the basin, which is now covered by alluvium.

Ground elevation in the Yucca Flat area ranges from about 1,195 m (3,920 ft) above mean sea level at Yucca Lake (playa) in the southern portion to about 1,463 m (4,800 ft) in the northern portion of the valley. The highest portions of the surrounding mountains and hills range from less than 1,500 m (5,000 ft) in the south to over 2,316 m (7,600 ft) at Rainier Mesa in the northwest corner of the area. Yucca Flat is bounded by the Halfpint Range to the east; by Rainier Mesa and the Belted Range to the north; by the Eleana Range and Mine Mountain to the west; and by the CP Hills, CP Hogback, and Massachusetts Mountain to the south.

Geology Overview – The Precambrian and Paleozoic rocks of the NTS area consist of approximately 11,300 m (37,000 ft) of carbonate and silicic clastic rocks (Cole, 1997). These rocks were severely deformed by compressional movements during Mesozoic time, which resulted in the formation of folds and thrust faults (e.g., Belted Range and CP thrust faults). During the middle Late Cretaceous, granitic bodies (such as the Climax stock in northern Yucca Flat) intruded these deformed rocks (Maldonado, 1977; Houser and Poole, 1960).

A total of 22 pre-Tertiary formations (including the Mesozoic granitic intrusives) have been recognized in the Yucca Flat region (see Table A-2). These rocks range in age from Precambrian to Cretaceous and represent primarily carbonate and silicic shallow-to deep-water sedimentation near a continental margin. Some of these units are widespread throughout southern Nevada and California, though complex structural deformation has created many uncertainties in determining the geometric relationships of these units around Yucca Flat.

During Cenozoic time, the sedimentary and intrusive rocks were buried by thick sections of volcanic material deposited in several eruptive cycles from source areas in the SWNVF. The Cenozoic stratigraphy of the Yucca Flat area, though not structurally complicated, is very complex. Most of the volcanic rocks of the Yucca Flat area were deposited during many eruptive cycles of the SWNVF (see Section A.4.1). The source areas of most units (Volcanics of Oak Spring Butte, Tunnel Formation, Belted Range Group, Crater Flat Group, Calico Hills Formation, Paintbrush Group, and Timber Mountain Group) are located to the west and northwest of Yucca Flat; the Wahmonie source area is located southwest of Yucca Flat. Table A-1 lists the Tertiary stratigraphic units common to the Yucca Flat basin.

The volcanic rocks include primarily ash-flow tuffs, ash-fall tuffs, and reworked tuffs, whose thicknesses and extents vary partly due to the irregularity of the underlying depositional surface, and partly due to the presence of topographic barriers and windows between Yucca Flat and the source areas to the north and west.

Over the last several million years, gradual erosion of the highlands that surround Yucca Flat has deposited a thick blanket of alluvium on the tuff section. The alluvium in Yucca Flat and throughout most of the NTS is a loosely consolidated mixture of detritus derived from silicic volcanic and Paleozoic sedimentary rocks, ranging in particle size from clay to boulders. Sediment deposition is largely in the form of alluvial fans (debris flows, sheet wash, and braided streams) which coalesce to form discontinuous, gradational, and poorly sorted deposits. Eolian sand, playa deposits, and rare basalt flows are also present within the alluvium section of Yucca Flat. The alluvium thickness in Yucca Flat generally ranges from about 30 m (100 ft) to over 914 m (3,000 ft) (Drellack and Thompson, 1990).

Structural Setting – The structure of the pre-Tertiary rocks in Yucca Flat is complex and poorly known (Cole, 1997), but it is important because the pre-Tertiary section is very thick and extensive and includes units which form regional aquifers. The main pre-Tertiary structures in the Yucca Flat area are related to the east-vergent Belted Range thrust fault which has placed Late Proterozoic to Cambrian-age rocks over rocks as young as Late Mississippian (Cole, 1997; Cole and Cashman, 1999). In several places along the western and southern portions of Yucca Flat, east-vergent structures related to the Belted Range thrust were deformed by younger west-vergent structural activity (Cole and Cashman, 1999). This west-vergent deformation is related to the CP thrust fault which also placed Cambrian and Ordovician rocks over Mississippian and Pennsylvanian-age rocks beneath western Yucca Flat (Caskey and Schweickert, 1992).

Large-scale normal faulting began in Yucca Flat in response to regional extensional movements near the end of this period of volcanism. This faulting formed the Yucca Flat basin. A fault movement continued, blocks between faults were down-dropped and tilted, creating subbasins within the Yucca Flat basin.

Over the last several million years, gradual erosion of the highlands that surround Yucca Flat has deposited a thick blanket of alluvium on the tuff section. The thickness of the alluvium in the Yucca Flat basin varies as a function of the topography of the underlying deposits and due to continuing movements along faults during alluvium deposition.

The major basin-forming faults generally strike in a northerly direction, and relative offset is typically down to the east (e.g., Yucca, Topgallant, and Carpetbag faults). Movement along the Yucca fault in central Yucca Flat indicates deformation in the area has continued into the Holocene (Hudson, 1992). Specific details regarding these faults are lacking because of the propensity to avoid inferred and known faults during drilling of emplacement holes for underground nuclear tests.

The configuration of the Yucca Flat basin is illustrated on the generalized west-east cross section shown in Figure A-8. The cross section is simplified to show the positions of only the primary lithostratigraphic units in the region. This cross section provides a conceptual illustration of the irregular Precambrian and Paleozoic rocks overlain by the Tertiary volcanic units, and the basin-filling alluvium at the surface. The main Tertiary-age, basin-forming large-scale normal faults are also shown.

Hydrogeologic Overview – All the rocks of the Yucca Flat underground test area can be classified as one of eight HGUs (see Table A-3), which include the AA, four volcanic HGUs, an intrusive unit, and two HGUs that represent the pre-Tertiary rocks.

The strata in Yucca Flat have been subdivided into eleven Tertiary-age HSUs (including the Tertiary/Quaternary alluvium), one Mesozoic intrusive HSU, and six Paleozoic HSUs (Gonzales and Drellack, 1999). These units are listed in Table A-7, and several of the more important HSUs are discussed in the following paragraphs. The alluvium and pre-Tertiary HSUs in Yucca Flat are as defined in Section A.2.3.2.

The hydrostratigraphy for the Tertiary-age volcanic rocks in Yucca Flat can be simplified into two categories: zeolitic tuff confining units and (non-zeolitic) volcanic aquifers.

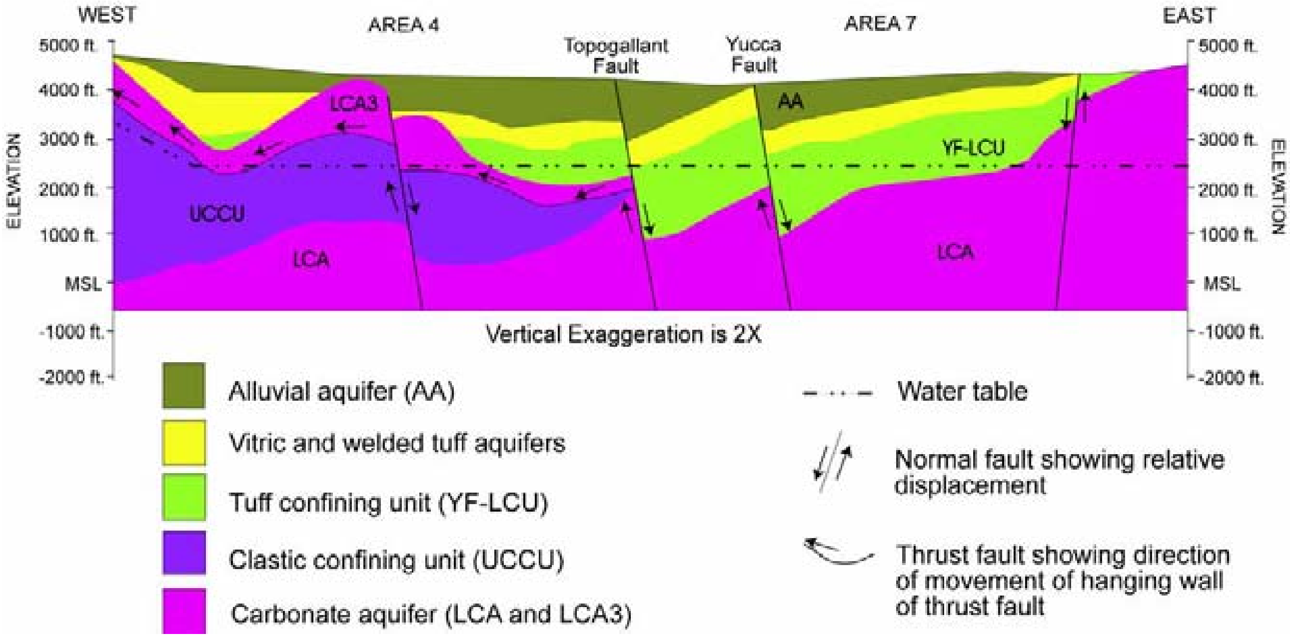

Figure A-8. Generalized west-east hydrogeologic cross section through central Yucca Flat

Table A-7. Hydrostratigraphic units of the Yucca Flat underground test area

Hydrostratigraphic Unit (Symbol)	Dominant Hydrogeologic Units[a]	Typical Lithologies
Alluvial Aquifer (AA)	AA, minor LFA	Alluvium (gravelly sand); also includes one or more thin basalt flows, playa deposits and eolian sands
Timber Mountain Upper Vitric-Tuff Aquifer (TM-UVTA)	WTA, VTA	Includes vitric nonwelded ash-flow and bedded tuff
Timber Mountain Welded-Tuff Aquifer (TM-WTA)	WTA	Partially to densely welded ash-flow tuff; vitric to devitrified
Timber Mountain Lower Vitric-Tuff Aquifer (TM-LVTA)	VTA	Nonwelded ash-flow and bedded tuff; vitric
Yucca Flat Upper Confining Unit (YF-UCU)	TCU	Zeolitic bedded tuff
Topopah Spring Aquifer (TSA)	WTA	Welded ash-flow tuff; present only in extreme southern Yucca Flat
Belted Range Aquifer (BRA)	WTA	Welded ash-flow tuff
Belted Range Confining Unit (BRCU)	TCU	Zeolitic bedded tuffs
Pre-Grouse Canyon Tuff Lava-Flow Aquifer (Pre-Tbg-LFA)	LFA	Lava flow
Tub Spring Aquifer (TUBA)	WTA	Welded ash-flow tuff
Yucca Flat Lower Confining Unit (YF-LCU)	TCU	Zeolitic bedded tuffs with interbedded but less significant zeolitic, nonwelded to partially welded ash-flow tuffs
Mesozoic Granite Confining Unit (MGCU)	GCU	Granodiorite and quartz monzonite
Upper Carbonate Aquifer (UCA)	CA	Limestone
Lower Carbonate Aquifer - Yucca Flat Upper Plate (LCA3)	CA	Limestone and dolomite
Lower Clastic Confining Unit - Yucca Flat Upper Plate (LCCU1)	CCU	Quartzite and siltstone
Upper Clastic Confining Unit (UCCU)	CCU	Argillite and quartzite
Lower Carbonate Aquifer (LCA)	CA	Dolomite and limestone; "regional aquifer"
Lower Clastic Confining Unit (LCCU)	CCU	Quartzite and siltstone; "hydrologic basement"

(a) See Table A-3 for description of hydrogeologic units.

Note: Adapted from Gonzales and Drellack, 1999.

The Yucca Flat lower confining unit (YF-LCU) is an important HSU in the Yucca Flat region (stratigraphically similar to the TCU in Frenchman Flat) because it separates the volcanic aquifer units from the underlying regional LCA. Almost all zeolitized tuff units in Yucca Flat are grouped within the YF-LCU, which comprises mainly zeolitized bedded tuff (air-fall tuff, with minor reworked tuff). The YF-LCU is saturated in much of Yucca Flat; however, measured transmissivities are very low.

The YF-LCU is generally present in the eastern two-thirds of Yucca Flat. It is absent over the major structural highs, where the volcanic rocks have been removed by erosion. Areas where the YF-LCU is absent include the "Paleozoic bench" in the western portion of the basin. In northern Yucca Flat the YF-LCU tends to be confined to the structural subbasins. Outside the subbasins and around the edges of Yucca Flat the volcanic rocks are thinner and are not zeolitized.

The unaltered volcanic rocks of Yucca Flat are divided into three Timber Mountain HSUs. The hydrogeology of this part of the geologic section is complicated by the presence of one or more ash-flow tuff units that are quite variable in properties both vertically and laterally.

The Timber Mountain Group includes ash-flow tuffs that might be either welded-tuff aquifers or vitric-tuff aquifers, depending on the degree of welding (refer to Sections A.2.3.1 and A.2.3.2). In Yucca Flat these units are generally present in the central portions of the basin. They can be saturated in the deepest structural subbasins.

The AA is confined primarily to the basins of the NTS. However, because the water table in the vicinity is moderately deep, the alluvium is generally unsaturated, except in the deep sub-basins of some valleys. These sediments are porous, and thus, have high storage coefficients. Transmissivities may also be high, particularly in the coarser, gravelly beds.

The more recent large-scale extensional faulting in the Yucca Flat area is significant from both hydrologic and containment perspectives because the faults have profoundly affected the hydrogeology of the Tertiary volcanic units by controlling to a large extent their alteration potential and final geometry. In addition, the faults themselves may facilitate flow of high-pressure gases from nearby explosion cavities and of potentially contaminated groundwater from sources in the younger rocks into the underlying regional aquifers. Final geometry of formations may be such that rocks of very different properties are now juxtaposed (i.e., a Paleozoic carbonate scarp).

Water-level Elevation and Groundwater Flow Direction – Water-level data are abundant for Yucca Flat, as a result of more than 30 years of drilling in the area in support of the weapons testing program. However, water-level data for the surrounding areas are scarce. These data are listed in the potentiometric data package prepared for the UGTA regional-scale groundwater model (IT, 1996b; Hale et al., 1995).

The SWL in the Yucca Flat basin is relatively deep, ranging in depth from about 183 m (600 ft) in extreme western Yucca Flat to more than 580 m (1,900 ft) in north-central Yucca Flat (Laczniak et al., 1996; Hale et al., 1995). Elevation of the water table in Yucca Flat varies from 1,340 m (4,400 ft) in the north (western Emigrant Valley) to 730 m (2,400 ft) at the southern end of Yucca Flat (Laczniak et al., 1996; Hale et al., 1995). Throughout much of the Yucca Flat area, the SWL typically is located within the lower portion of the volcanic section, in the YF-LCU. Beneath the hills surrounding Yucca Flat, the SWL can be within the Paleozoic-age units, while in the deeper structural subbasins of Yucca Flat, the Timber Mountain Tuff and the lower portion of the alluvium are also saturated.

Water levels measured in wells completed in the AA and volcanic units in the eastern two-thirds of Yucca Flat are typically about 20 m (70 ft) higher than in wells completed in the LCA (Winograd and Thordarson, 1975; IT, 1996b). The hydrogeology of these units suggests that the higher elevation of the water table in the overlying Tertiary rocks is related to the presence of low permeability zeolitized tuffs of the YF-LCU (aquitard) between the Paleozoic and Tertiary aquifers. Detailed water-level data indicate the existence of a groundwater trough along the axis of the valley. The semi-perched water within the alluvial aquifer and volcanic aquifers eventually moves downward to the carbonate aquifer in the central portion of the valley.

Water-level elevations in western Yucca Flat are also well above the regional water level. The hydrology of western Yucca Flat is influenced by the presence of the Mississippian clastic rocks, which directly underlie the carbonate aquifer of the upper plate of the CP thrust (locally present), AA, and volcanic rocks west of the Topgallant fault. This geometry is a contributing factor in the development of higher (semi-perched) water levels in this area. The Climax Stock also bears perched water (Walker, 1962; Laczniak et al., 1996) well above the regional water level.

The present structural interpretation for Yucca Flat depicts the LCCU at great depth, except in the northeast corner of the study area. The Zabriskie Quartzite and Wood Canyon Formation, which are both classified as clastic confining units, are exposed in the northern portion of the Halfpint Range. The high structural position of the LCCU there (and in combination with the Climax Stock) may be responsible for the steep hydrologic gradient observed between western Emigrant Valley and Yucca Flat.

Based on the existing data and as interpreted from the UGTA regional-scale groundwater flow model (DOE, 1997c), the overall groundwater flow direction in Yucca Flat is to the south and southwest (see Figure A-5). Groundwater ultimately discharges at Franklin Lake Playa to the south and Death Valley to the southwest.

A.2.5.3 Pahute Mesa Underground Test Area

This section provides descriptions of the geologic and hydrologic settings of the Pahute Mesa UGTA. This summary was compiled from various sources, including BN (2002a and b), Winograd and Thordarson (1975), Laczniak et al., (1996), Byers et al. (1976; 1989), and Cole (1997). Additional information can be found in these documents. For detailed stratigraphic descriptions see Sawyer et al., (1994) and Slate et al., (1999).

The Western and Central Pahute Mesa CAUs, encompassing Areas 19 and 20 of the NTS, were the site of 85 underground nuclear tests (DOE, 2000a) (see Figure A-6). These detonations were all conducted in vertical emplacement holes (see Table A-5). The Western Pahute Mesa CAU is separated from the Central Pahute Mesa by the Boxcar fault and is distinguished by a relative abundance of tritium (IT, 1999b). For hydrogeologic studies and modeling purposes, these two CAUs are treated together.

Hydrogeologically, these CAUs are considered to be part of a larger region that includes areas both within and outside the boundaries of the NTS, designated as the Pahute Mesa-Oasis Valley (PM-OV) study area. Because most of the underground nuclear tests at Pahute Mesa were conducted near or below the SWL, test-related contaminants are available for transport via a groundwater flow system that may extend to discharge areas in Oasis Valley. So, like the UGTAs of Frenchman Flat and Yucca Flat, a CAU-scale hydrostratigraphic framework model has been developed for the PM-OV study area to support modeling of groundwater flow and contaminant transport for the UGTA Project (BN, 2002c).

Physiography – Pahute Mesa is a structurally high volcanic plateau in the northwest corner of the NTS (see Figure A-5). Ground-level elevations in the area range from below 1,650 m (5,400 ft) off the mesa to the north and south, to over 2,135 m (7,000 ft) in eastern Pahute Mesa. Pahute Mesa proper is composed of flat-topped buttes and mesas separated by deep canyons. This physiographic feature covers most of NTS Areas 19 and 20, which are the second most utilized testing real estate at the NTS. Consequently, there are numerous drill holes which provide a substantial amount of subsurface geologic and hydrologic information (BN, 2002a; Warren et al., 2000a and b).

Geology Overview – Borehole and geophysical data from Pahute Mesa indicate the presence of several nested calderas which produced thick sequences of rhyolite tuffs and lavas. The older calderas are buried by ash-flow units produced from younger calderas. Most of eastern Pahute Mesa is capped by the voluminous Ammonia Tanks and Rainier Mesa ash-flow tuff units which erupted from the Timber Mountain Caldera, located immediately to the south of Pahute Mesa (Byers et al., 1976). The western portion is capped by ash-flows of the Thirsty Canyon Group from the Black Mountain caldera. A typical geologic cross section for Pahute Mesa is presented in Figure A-9. For a more detailed geologic summary, see Ferguson, et al., (1994), Sawyer, et al., (1994), Warren, et al., (2000b), and BN (2002a).

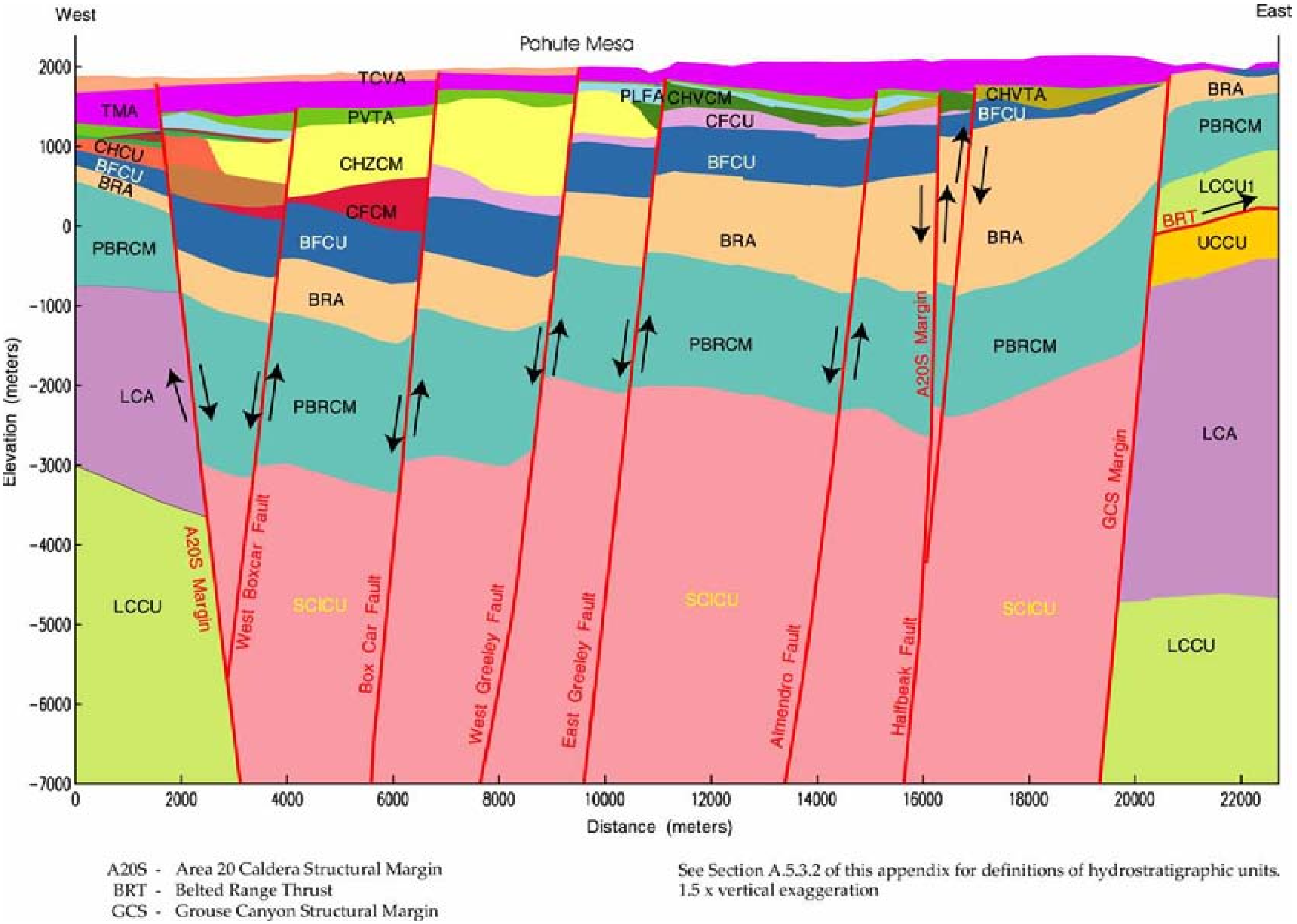

Figure A-9. Generalized hydrostratigraphic cross section through the Silent Canyon complex, Pahute Mesa

The most widespread and significant Quaternary and Tertiary (mainly volcanic) units of the Pahute Mesa area are listed in Table A-1. Refer to Table A-2 for a list of Mesozoic (granitic), Paleozoic (sedimentary), and Precambrian (sedimentary and metamorphic) stratigraphic units.

Underlying the Tertiary-age volcanic rocks (exclusive of the caldera complexes) are Paleozoic and Proterozoic sedimentary rocks consisting of dolomite, limestone, quartzite, and argillite. During Precambrian and Paleozoic time, as much as 10,000 m (32,800 ft) of these marine sediments were deposited in the NTS region (Cole, 1997). For detailed stratigraphic descriptions of these rocks see Slate et al. (1999). The only occurrence of Mesozoic age rocks in the Pahute Mesa area is the Gold Meadows Stock, a granitic intrusive mass located at the eastern edge of Pahute Mesa, north of Rainier Mesa (Snyder, 1977; Gibbons et al., 1963).

The Silent Canyon caldera complex (SCCC) lies beneath Pahute Mesa. This complex contains the oldest known calderas within the SWNVF, and is completely buried by volcanic rocks erupted from younger nearby calderas. It was first identified from gravity observations that indicated a deep basin below the topographically high Pahute Mesa. Subsequent drilling on Pahute Mesa indicated that the complex consists of at least two nested calderas, the Grouse Canyon caldera and younger Area 20 caldera (13.7 and 13.25 Ma, respectively; Sawyer et al., 1994). For more information on the SCCC, see Ferguson et al., (1994), which is a comprehensive study of the caldera complex based on analysis of gravity, seismic refraction, drill hole, and surface geologic data.

Like the SCCC, the Timber Mountain caldera complex (TMCC) consists of two nested calderas, the Rainier Mesa caldera and younger Ammonia Tanks caldera, 11.6 and 11.45 Ma, respectively (Sawyer et al., 1994). However, unlike the SCCC, the TMCC has exceptional topographic expression, consisting of an exposed topographic margin for more than half its circumference and a well exposed central resurgent dome (Timber Mountain, the most conspicuous geologic feature in the western part of the NTS). The complex truncates the older Claim Canyon caldera (12.7 Ma; Sawyer et al., 1994) which is further to the south. The calderas of the TMCC are the sources for the Rainier Mesa and Ammonia Tanks Tuffs which form important and extensive stratigraphic units at the NTS and vicinity.

The Black Mountain caldera is a relatively small caldera in the northwest portion of the Pahute Mesa area. It is the youngest caldera in the area, formed as a result of the eruption, 9.4 Ma, of tuffs assigned to the Thirsty Canyon Group (Sawyer et al., 1994).

Deep gravity lows and the demonstrated great thickness of tuffs in the Pahute Mesa area suggest the presence of older buried calderas. These calderas would pre-date the Grouse Canyon caldera and thus, could be the source of some of the pre-Belted Range units.

Structural Setting – The structural setting of the Pahute Mesa area is dominated by the calderas described in the previous paragraphs. Several other structural features are considered to be significant factors in the hydrology, including the Belted Range thrust fault (see Section A.1.3), numerous normal faults related mainly to basin-and-range extension, and transverse faults and structural zones. However, many of these features are buried, and their presence is inferred from drilling and geophysical data. A typical geologic cross section for Pahute Mesa is presented in Figure A-9. For a more detailed geologic summary, see Ferguson et al., (1994); Sawyer et al., (1994); and BN (2002c).

Hydrogeology Overview – The hydrogeology of Pahute Mesa is complex. The thick section of volcanic rocks comprises a wide variety of lithologies that range in hydraulic character from aquifer to aquitard. The presence of several calderas and tectonic faulting further complicate the area, placing the various lithologic units in juxtaposition and blocking or enhancing the flow of groundwater in a variety of ways.

The general hydrogeologic framework for Pahute Mesa and vicinity was established in the early 1970s by USGS geoscientists (Blankennagel and Weir, 1973; Winograd and Thordarson, 1975). As described in Section A.2.3, their work has provided the foundation for most subsequent hydrogeologic studies at the NTS (IT, 1996a; BN, 2002c).

All the rocks in the PM-OV study area can be classified as one of nine HGUs, which include the AA, three volcanic HGUs, two intrusive units, and two HGUs that represent the pre-Tertiary rocks (see Table A-3).

The rocks within the PM-OV study area are grouped into 44 HSUs for the UGTA CAU-scale hydrogeology framework model (Table A-8). The volcanic units are organized into 37 HSUs that include 13 aquifers, 13 confining units, and 11 composite units (comprising a mixture of hydraulically variable units). The underlying pre-Tertiary rocks are divided into 6 HSUs, including 2 aquifers and 4 confining units. HSUs that are common to several CAUs at the NTS are briefly discussed in Section A.2.3.2.

Table A-8. Hydrostratigraphic units of the Pahute Mesa-Oasis Valley area

Hydrostratigraphic Unit (Symbol)	Dominant Hydrogeologic Unit(s)[(a)]	Typical Lithologies
Alluvial Aquifer (AA)	AA	Alluvium (gravelly sand); also includes eolian sand
Younger Volcanic Composite Unit (YVCM)	LFA, WTA, VTA	Basalt, welded and nonwelded ash-flow tuff
Thirsty Canyon Volcanic Aquifer (TCVA)	WTA, LFA, lesser VTA	Partially to densely welded ash-flow tuff; vitric to devitrified
Detached Volcanics Composite Unit (DVCM)	WTA, LFA, TCU	Complex distribution of welded ash-flow tuff, lava, and zeolitic bedded tuff
Fortymile Canyon Composite Unit (FCCM)	LFA, TCU, lesser WTA	Lava flows and associated tuffs
Timber Mountain Composite Unit (TMCM)	TCU (altered tuffs, lavas) and unaltered WTA and lesser LFA	Densely welded ash-flow tuff; includes lava flows, and minor debris flows.
Tannenbaum Hill Lava-Flow Aquifer (THLFA)	LFA	Rhyolitic lava
Tannenbaum Hill Composite Unit (THCM)	Mostly TCU lesser WTA	Zeolitic tuff and vitric, nonwelded to welded ash-flow tuffs
Timber Mountain Aquifer (TMA)	Mostly WTA, minor VTA	Partially to densely welded ash-flow tuff; vitric to devitrified
Subcaldera Volcanic Confining Unit (SCVCU)	TCU	Probably highly altered volcanic rocks and intruded sedimentary rocks beneath each caldera
Fluorspar Canyon Confining Unit (FCCU)	TCU	Zeolitic bedded tuff
Windy Wash Aquifer (WWA)	LFA	Rhyolitic lava
Paintbrush Composite Unit (PCM)	WTA, LFA, TCU	Welded ash-flow tuffs, rhyolitic lava and minor associated bedded tuffs
Paintbrush Vitric-tuff Aquifer (PVTA)	VTA	Vitric, nonwelded and bedded tuff
Benham Aquifer (BA)	LFA	Rhyolitic lava
Upper Paintbrush Confining Unit (UPCU)	TCU	Zeolitic, nonwelded and bedded tuff

Table A-8. (continued)

Hydrostratigraphic Unit (Symbol)	Dominant Hydrogeologic Unit(s)[(a)]	Typical Lithologies
Tiva Canyon Aquifer (TCA)	WTA	Welded ash-flow tuff
Paintbrush Lava-Flow Aquifer (PLFA)	LFA	Lava; moderately to densely welded ash-flow tuff
Lower Paintbrush Confining Unit (LPCU)	TCU	Zeolitic nonwelded and bedded tuff
Topopah Spring Aquifer (TSA)	WTA	Welded ash-flow tuff
Yucca Mountain Crater Flat Composite Unit (YMCFCM)	LFA, WTA, TCU	Lava; welded ash-flow tuff; zeolitic, bedded tuff
Calico Hills Vitric-tuff Aquifer (CHVTA)	VTA	Vitric, nonwelded tuff
Calico Hills Vitric Composite Unit (CHVCM)	VTA, LFA	Partially to densely welded ash-flow tuff; vitric to devitrified
Calico Hills Zeolitized Composite Unit (CHZCM)	LFA, TCU	Rhyolitic lava and zeolitic nonwelded tuff
Calico Hills Confining Unit (CHCU)	Mostly TCU, minor LFA	Zeolitic nonwelded tuff; minor lava
Inlet Aquifer (IA)	LFA	Lava
Crater Flat Composite Unit (CFCM)	Mostly LFA, intercalated with TCU	Lava and welded ash-flow tuff
Crater Flat Confining Unit (CFCU)	TCU	Zeolitic nonwelded and bedded tuff
Kearsarge Aquifer (KA)	LFA	Lava
Bullfrog Confining Unit (BCU)	TCU	Zeolitic, nonwelded tuff
Belted Range Aquifer (BRA)	LFA and WTA, with lesser TCU	Lava and welded ash-flow tuff
Pre-Belted Range Composite Unit (PBRCM)	TCU, WTA , LFA	Zeolitic bedded tuffs with interbedded but less significant zeolitic, nonwelded to partially welded ash-flow tuffs

Table A-8. (continued)

Hydrostratigraphic Unit (Symbol)	Dominant Hydrogeologic Unit(s)(a)	Typical Lithologies
Black Mountain Intrusive Confining Unit (BMICU)	IICU	These units are presumed to be present beneath the calderas of the SWNVF. Their actual character is unknown, but they may be igneous intrusive rocks or older volcanic and pre-Tertiary sedimentary rocks intruded to varying degrees by igneous rocks.
Ammonia Tanks Intrusive Confining Unit (ATICU)	IICU	
Rainier Mesa Intrusive Confining Unit (RMICU)	IICU	
Claim Canyon Intrusive Confining Unit (CCICU)	IICU	
Calico Hills Intrusive Confining Unit (CHICU)	IICU	
Silent Canyon Intrusive Confining Unit (SCICU)	IICU	
Mesozoic Granite Confining Unit (MGCU)	GCU	Granodiorite and quartz monzonite; Gold Meadows Stock
Lower Carbonate Aquifer-Thrust Plate (LCA3)	CA	Limestone and dolomite
Lower Clastic Confining Unit Thrust Plate (LCCU1)	CCU	Quartzite and siltstone
Upper Clastic Confining Unit (UCCU)	CCU	Argillite and quartzite
Lower Carbonate Aquifer (LCA)	CA	Dolomite and limestone; "regional aquifer"
Lower Clastic Confining Unit (LCCU)	CCU	Quartzite and siltstone; "hydrologic basement"

(a) See Table A-3 for definitions of hydrogeologic units.
Note: Adapted from BN, 2002c.

Water–level Elevation and Groundwater Flow Direction – Water-level data are relatively abundant for the Pahute Mesa UGTA as a result of more than 30 years of drilling in the area in support of the weapons testing program. However, water-level data for the outlying areas to the west and south are sparse. These data are listed in the potentiometric data package prepared for the UGTA regional-scale groundwater flow model (IT, 1996b) and the Pahute Mesa water table map (O'Hagan and Laczniak, 1996).

The SWL at Pahute Mesa is relatively deep, at about 640 m (2,100 ft) below the ground surface. Groundwater flow at Pahute Mesa is driven by recharge in the east and subsurface inflow from the north. Local groundwater flow is influenced by the discontinuous nature of the volcanic aquifers and the resultant geometry created by overlapping caldera complexes and high angle basin and range faults (Laczniak et al., 1996). Potentiometric data indicate that groundwater flow direction is to the southwest toward discharge areas in Oasis Valley and ultimately Death Valley (see Figure A-5).

A.2.5.4 Rainier Mesa/Shoshone Mountain

The Rainier Mesa/Shoshone Mountain CAU consists of 61 CASs on Rainier Mesa and 6 on Shoshone Mountain, which are located in NTS Areas 12 and 16 respectively (see Figure A-6). Together, these two mesas constitute the third major area utilized for underground testing of nuclear weapons at the NTS between 1957 and 1992. Underground nuclear tests were conducted in horizontal, mined tunnels within these mesas, and two tests were conducted in vertical drill holes. All tests were conducted above the regional water table. Underground geologic mapping data from the numerous tunnel complexes, and lithologic and geophysical data from dozens of exploratory drill holes, provide a wealth of geologic and hydrologic information for this relatively small underground test area.

Physiography – The Rainier Mesa underground test area includes Rainier Mesa proper and the contiguous Aqueduct Mesa. Rainier Mesa and Aqueduct Mesa form the southern extension of the northeast trending Belted Range (see Figure A-5). This high volcanic plateau cuts diagonally across Area 12 in the north-central portion of the NTS. Ground-level elevations on Rainier Mesa are generally over 2,225 m (7,300 ft). The highest point on the NTS, 2,341 m (7,679 ft), is on Rainier Mesa. Aqueduct Mesa has slightly rougher and lower terrain, generally above 1,920 m (6,300 ft) in elevation. The edge of the mesas drop off quite spectacularly on the west, south and east sides.

Shoshone Mountain is located about 20 km (12 mi) south of Rainier Mesa. It is located in the middle of the NTS, at the west end of Syncline Ridge (see Figure A-5). Ground-level elevations range from 1,707 to 2,012 m (5,600 to 6,600 ft), but are generally above 1,830 m (6,000 ft). Tippipah Point, above the old Area 16 tunnels, has an elevation of 2,015 m (6,612 ft).

Geology Overview – Both Rainer Mesa and Aqueduct Mesa are composed of Miocene age air-fall and ash-flow tuffs, which erupted from nearby calderas to the west and southwest. As in Yucca Flat, these silicic volcanic tuffs were deposited unconformably on an irregular pre-Tertiary (upper Precambrian and Paleozoic) surface of sedimentary rocks (Gibbons et al., 1963; Orkild, 1963) and Mesozoic granitic rocks (at Rainier Mesa only). The stratigraphic units and lithologies are similar to those present in the subsurface of Yucca Flat (see Section A.2.5.2). Most of Rainier Mesa and Shoshone Mountain consist of zeolitized bedded tuff, though the upper part of this section is unaltered (vitric) in some areas. At both locations, the bedded tuffs are capped by a thick layer of welded ash-flow tuff. The Tertiary stratigraphic units and lithologies are similar to those present in the subsurface of Yucca Flat (see Section A.2.5.2).

Structural Setting – The geologic structure of the volcanic rocks of the Rainier Mesa is well documented. Several high-angle, normal faults have been mapped in the volcanic rocks. Faults with greater than about 30 m (100 ft) of displacement are notably absent in the volcanic rocks of Rainier Mesa. At Shoshone Mountain several faults have been mapped, but in general the structure is less well known there than at Rainier Mesa. The structure of the pre-Tertiary section at both locations is poorly known, though some workers speculate that the trace of the Belted Range thrust fault is present in the pre-Tertiary rocks beneath Rainier Mesa. A broad synclinal feature mapped at the surface and in the tuffs of Rainier Mesa/Aqueduct Mesa may reflect a paleo-topographic low beneath the tuffs (Figure A-10), but the exact character of this feature is unknown.

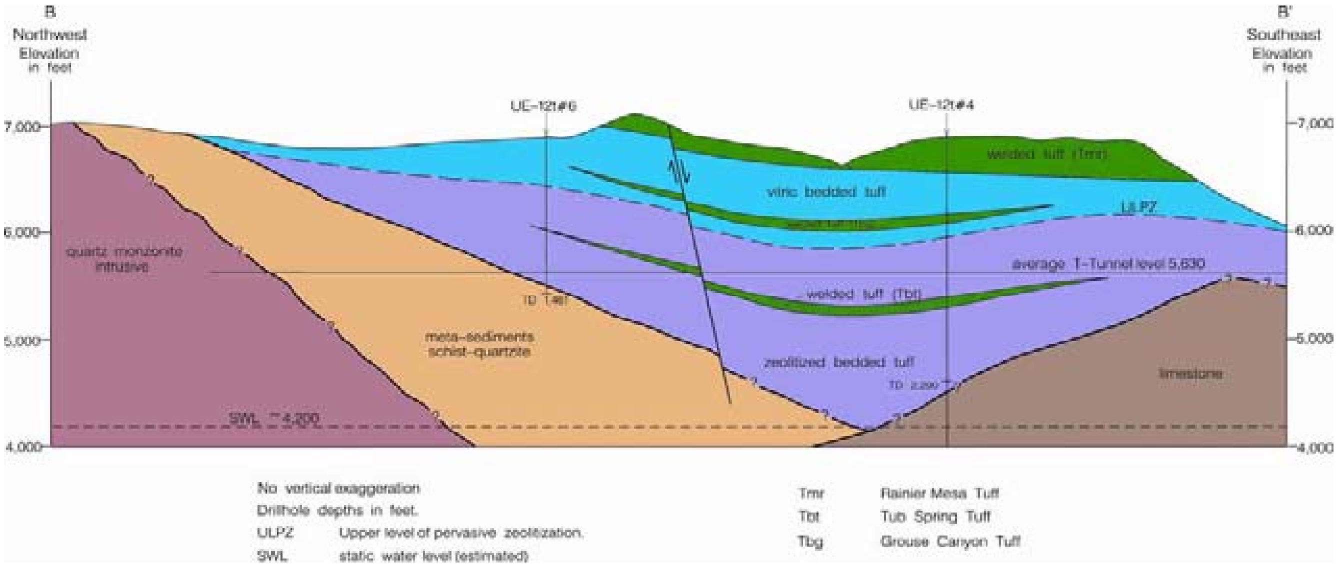

Figure A-10. Generalized hydrostratigraphic cross section through Aqueduct Mesa

Hydrogeology Overview – Construction of UGTA CAU-scale hydrogeology models for the Rainier Mesa and Shoshone Mountain UGTAs is scheduled to begin in fiscal year 2006. However, HGUs and HSUs in the Rainier Mesa and Shoshone Mountain area are expected to be similar to those defined for the Yucca Flat area (see Table A-7).

The hydrostratigraphy of the pre-Tertiary section is unknown at Shoshone Mountain, and is poorly known at Rainier Mesa. At Rainier Mesa, granitic rocks (related to the nearby Gold Meadows Stock), carbonate rocks, silicic sedimentary rocks such as siltstone, and metamorphic rocks such as quartzite and schist have been encountered beneath the tuff section in the few existing drill holes that penetrate through the tuff section. This variability is indicative of the complex geology of the pre-Tertiary section.

Most of the tests in Shoshone Mountain and Rainier Mesa tunnels were conducted in the tuff confining unit, though a few were conducted in vitric bedded tuff higher in the stratigraphic section.

Water-level Elevation and Groundwater Flow Direction – The regional water level at Rainier Mesa is not well known, but is estimated to be at an elevation of approximately 1,280 m (4,200 ft) in the pre-Tertiary carbonate rocks that underlie the volcanic section. This is approximately 300 m (1,000 ft) below the average elevation of test locations in Rainier Mesa. The SWL, where measured in a few drill holes at Rainier Mesa, is at an elevation of about 1,847 m (6,060 ft). This anomalously high water level relative to the regional water level reflects the presence of water perched above the regional aquifer within the tuff confining unit (Walker 1962; Laczniak et al., 1996). Abundant water is present in the fracture systems of some of the tunnel complexes at Rainier Mesa. This water currently is permitted to flow from U12e Tunnel (also known as E Tunnel); however, water has filled the open drifts behind barriers built near the portals of U12n and U12t Tunnels.

The water level elevation at Shoshone Mountain is not known. No water was encountered during mining at Shoshone Mountain.

Regional groundwater flow from Rainier Mesa may be directed either toward Yucca Flat or, because of the intervening UCCU, to the south toward the Alkali Flat discharge area (see Figure A-5). The groundwater flow direction beneath Shoshone Mountain is probably southward.

A.2.6 Conclusion

The hydrogeology of the NTS and vicinity is complex and varied. Yet, the remote location, alluvial and volcanic geology, and deep water table of the NTS provided a favorable setting for conducting and containing underground nuclear tests. Its arid climate and its setting in a region of closed hydrographic basins also are factors in stabilizing residual surficial contamination from atmospheric testing, and are considered positive environmental attributes for existing radioactive waste management sites.

Average groundwater flow velocities at the NTS are generally slow, and flow paths to discharge areas or potential receptors (domestic and public water supply wells) are long. The water table for local aquifers in the valleys and the underlying regional carbonate aquifer are relatively flat. The zeolitic volcanic formation (TCU) separating the shallower alluvial and volcanic aquifers and the regional carbonate aquifer (LCA) appears to be a viable aquitard. Consequently, both vertical and horizontal flow velocities are low. Additionally, carbon-14 dates for water from NTS aquifers are on the order of 10,000 to 40,000 years old (Rose et al., 1997). Thus, there is considerable residence time in the aquifers, allowing contaminant attenuating processes such as matrix diffusion, sorption, and natural decay, to operate.

A.3 Climatology

The NTS is located in the extreme southwestern corner of the Great Basin. Consequently, the climate is arid with limited precipitation, low humidity, intense sunlight, and large daily temperature ranges. Meteorological and climatological data are collected on the NTS by the Air Resources Laboratory, Special Operations and Research Division (ARL/SORD). Data are collected through the Meteorological Data Acquisition (MEDA) system, a network of approximately 30 mobile meteorological towers which have been located on and near the NTS for many years (see Figure 16-2). The climatological data presented below were developed from the MEDA system.

A.3.1 Precipitation

Two fundamental physical processes drive precipitation events on the NTS: those resulting from cool-season, mid-tropospheric cyclones and those resulting from summertime convection. Cool-season precipitation is usually light and can consist of rain or snow. Although light, winter precipitation events can last for several days and result in significant precipitation totals per winter storm; especially in January and February. Summer is thunderstorm season. Precipitation from thunderstorms is usually light; however, some storms are associated with very heavy rain, flash floods, intense cloud-to-ground lightning (CG), and strong surface winds. Thunderstorms generally occur in July and August when moist tropical air can flow from the south-eastern North Pacific Ocean and spread over the desert southwest. This seasonal event is referred to as the south-western monsoon. The winter-summer precipitation mechanisms produce a bi-modal monthly precipitation cycle. Figure A -11 shows these patterns of mean monthly precipitation recorded from six of the 16 climatological stations on the NTS over the past 40+ years. Mean annual precipitation totals on the NTS range from nearly 33 centimeters (cm) (13 inches [in]) over the high terrain in the north-western part of the NTS to less than 12.7 cm (5 in) in Frenchman Flat. However, inter-annual variations can be great. For example, 24.6 cm (9.67 in) occurred in Frenchman Flat in 1998 and 68 cm (26.79 in) fell on Rainier Mesa in 1978. Annual totals of less than 2.54 cm (1.0 in) have occurred on the lower elevations of the NTS. Daily precipitation totals can also be large and can range from 5 cm to just over 9 cm (2.0 to over 3.5 in). The greatest daily precipitation event on the NTS was 9.32 cm (3.67 in), which was measured in Mid-Valley on October 19-20, 2004. A storm-total precipitation amount of 8.9 cm (3.5 in) is a 100-year, 24-hour, extreme precipitation event. Daily totals of 5.1 to-7.6 cm (2-3 in) have been measured at several sites on the NTS (Randerson, 1997).

Snow can fall on the NTS anytime between October and May. In Yucca Flat, the greatest daily snow depth measured is 25.4 cm (10 in) in January 1974. The greatest daily depth measured at Desert Rock is 15.2 cm (6 in) in February 1987. Maximum daily totals of 38 to 50 cm (15 to 20 in) or more can occur on Pahute and Rainier Mesas.

Hail, sleet, freezing rain, and fog are rare on the NTS. Only 24 hailstorms were observed in Yucca Flat between 1957 and 1978. Hail and sleet can cover the ground briefly following intense thunderstorms.

A.3.2 Temperature

As is typical of an arid climate; the NTS experiences large daily, as well as annual, ranges in temperature. Moreover, temperatures vary with elevation. Sites 1,524 m (5,000 ft) above mean sea level can be quite cold in the winter and fairly mild during the summer months. At lower elevations, summertime temperatures frequently exceed 37.7 degrees Centigrade (°C) (100 degrees Fahrenheit [°F]). In the dry lakebeds, daily temperature ranges can be 22.2 to 33.3 °C (40 to 60 °F) with very cold morning temperatures in the winter and very hot temperatures in the summer. These temperature characteristics are clearly shown in Figure A-12. These annual temperature plots describe the temperature extremes and normal maximums and minimums throughout the year at different locations on the NTS.

In Frenchman Flat, the average daily temperature minimum and maximum for January is -4.4 to 13.3 °C (24 to 56 °F), while in July it is 16.7 to 38.9 °C (62 to 102 °F). By contrast, on Pahute Mesa the minimum and maximum temperature for January is -3.9 to 5 °C (25 to 41 °F) and for July, 16.1 to 28.9 °C (61 to 84 °F.) The highest maximum temperature measured on the NTS is 46.1 °C (115 °F) in Frenchman Flat near Well 5B in July 1998 and in Jackass Flats near Lathrop Gate in July 2002. The coldest minimum temperature measured on the NTS is -28.9 °C (-20 °F) in Area 19 in January 1970. The temperature extremes at Mercury are -11.7 to 45 °C (11 to 113 °F).

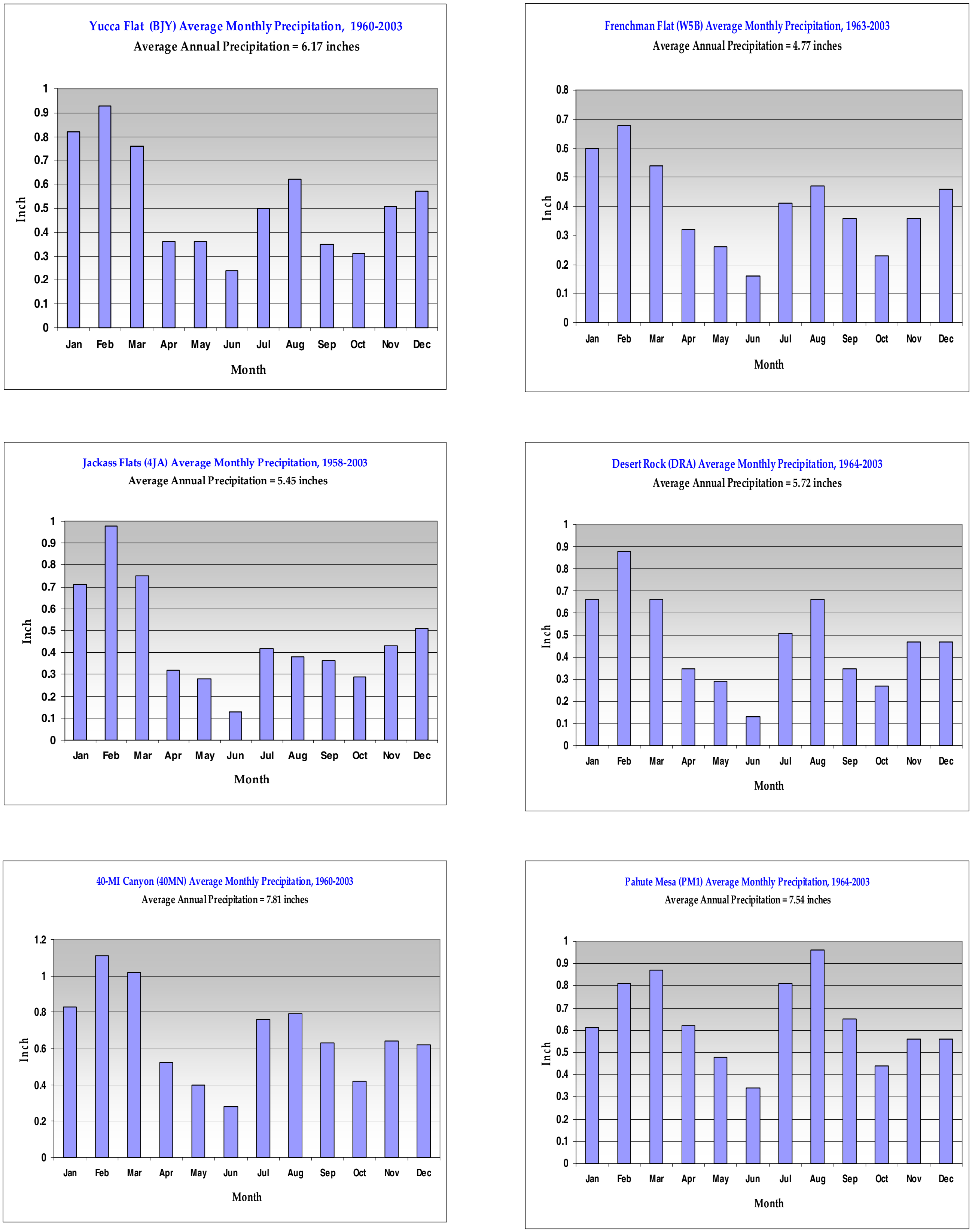

Figure A-11. Mean monthly precipitation at six NTS MEDA stations

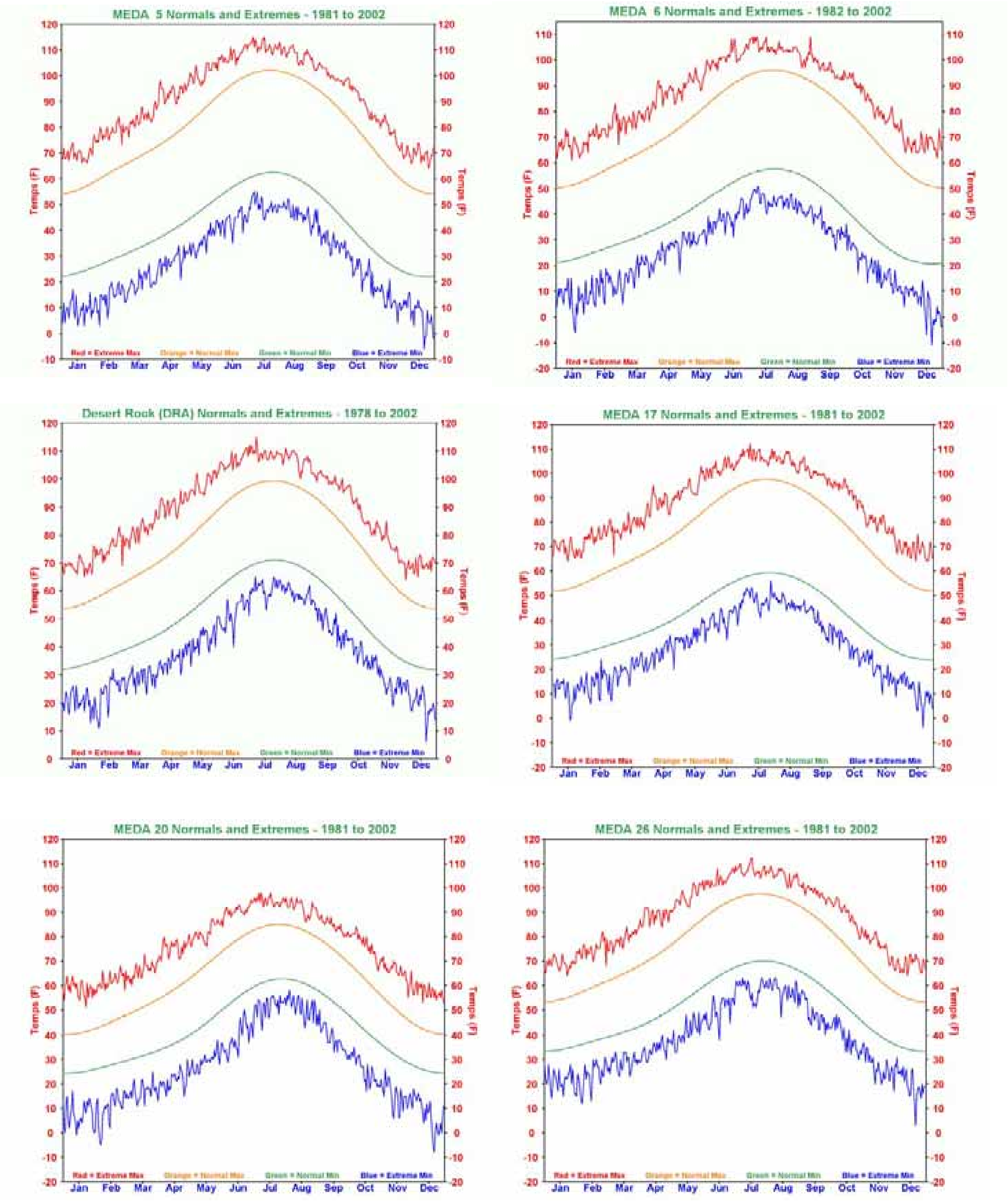

Figure A-12. Temperature extremes and normal maximums and minimum at six NTS MEDA stations

A.3.3 Wind

Complex topography, such as that on the NTS, can influence wind speeds and directions. Furthermore, there is a seasonal as well as strong daily periodicity to local wind conditions. For example, in Yucca Flat, during the summer months, the wind direction is usually northerly (from the north) from 10 p.m. Pacific Daylight Time (PDT) to 8 a.m. PDT and southerly from 10 a.m. PDT to 8 p.m. PDT. However, in January the winds are generally from the north from 6 p.m. Pacific Standard Time (PST) to 11 a.m. PST with some southerly winds developing between 1100 a.m. PST and 5 p.m. PST. March through June tend to experience the fastest average wind speeds 13 to 19 kilometers per hour (kmh) (8 to 12 miles per hour [mph]) with the faster speeds occurring at the higher elevations. Peak wind gusts of 80 to 113 kmh (50 to 70 mph) have occurred throughout the NTS. Peak winds at Mercury have been as high as 84 mph during a spring wind storm. Frenchman Flat experienced wind gusts to 113 kmh (70 mph) during the same windstorm. The peak wind speeds measured on the NTS are above 145 kmh (90 mph) on the high terrain with maximums of 146 kmh (91 mph) at Yucca Mountain Ridge-top, 148 kmh (92 mph) at the Monastery (MEDS station 10) in Area-6, and 151 (94 mph) in Area-12 on Radio Hill.

Wind speed and direction data has been summarized for all the meteorological towers (MEDAs) on the NTS. These climatological summaries are referred to as wind roses. Annual wind roses for six stations on the NTS are shown in Figure A-13. This figure describes the strong seasonal and diurnal effects on the surface air flow pattern across the NTS. In general, winter and pre-sunrise winds tend to be northerly while summer and afternoon flow tends to be southerly. Terrain also contributes to determining wind direction.

A.3.4 Relative Humidity

The air over the NTS tends to be dry. On average, June is the driest month with humidity ranging from 10 percent to 35 percent. Humidity readings of 35 percent to 70 percent are common in the winter. The reason for this variability is that relative humidity is temperature dependent. The relative humidity tends to be higher with cold temperatures and lower with hot temperatures. Consequently there is not only a seasonal variation but also a marked diurnal rhythm with this parameter. Early in the morning the humidity ranges from 25 percent to 70 percent and in mid-afternoon it is in the 10 percent to 40 percent range, with the larger readings occurring in winter. Humidity readings of more than 75 percent are not common on the NTS.

A.3.5 Atmospheric Pressure

On the NTS, atmospheric pressure is measured at many of the sites shown in Figure 16-2. These measurements show that atmospheric pressure has marked annual and diurnal cycles. In addition, pressure decreases with elevation. Consequently, stations at high elevations have lower atmospheric pressures than do those stations at lower elevations. Moreover, since pressure depends on temperature, the larger pressure readings occur during the winter months and the smaller readings in the summer months. The diurnal cycle is bimodal and is driven by the diurnal tide of the entire atmosphere and by the diurnal heating/cooling cycle. In general, maximum daily surface pressure on the NTS occurs between 8 a.m. and 10 a.m. PST (later in winter, earlier in summer) and minimum pressure tends to occur between 2 p.m. and 6 p.m. PST (earlier in winter, later in summer). Weaker secondary maxima occur at approximately midnight PST and minima near 3 a.m. PST. In Yucca Flat (elevation 1195 m) the atmospheric pressure varies from 857 millibars (mb) to 908 mb, annually; however, the daily range is only approximately 3.4 mb in summer and 2.7 mb in winter.

A phenomena referred to as atmospheric or barometric pumping can occur as atmospheric pressure decreases. When this happens, gases trapped below ground can “vent” or seep upward through the soil and enter the atmosphere. Barometric pumping was observed on the NTS following some underground nuclear tests, and small concentrations of noble gases from the tests were detected for several months afterwards. Barometric pumping also contributes to the release of naturally-occurring radionuclides (e.g., radon) from terrestrial sources.

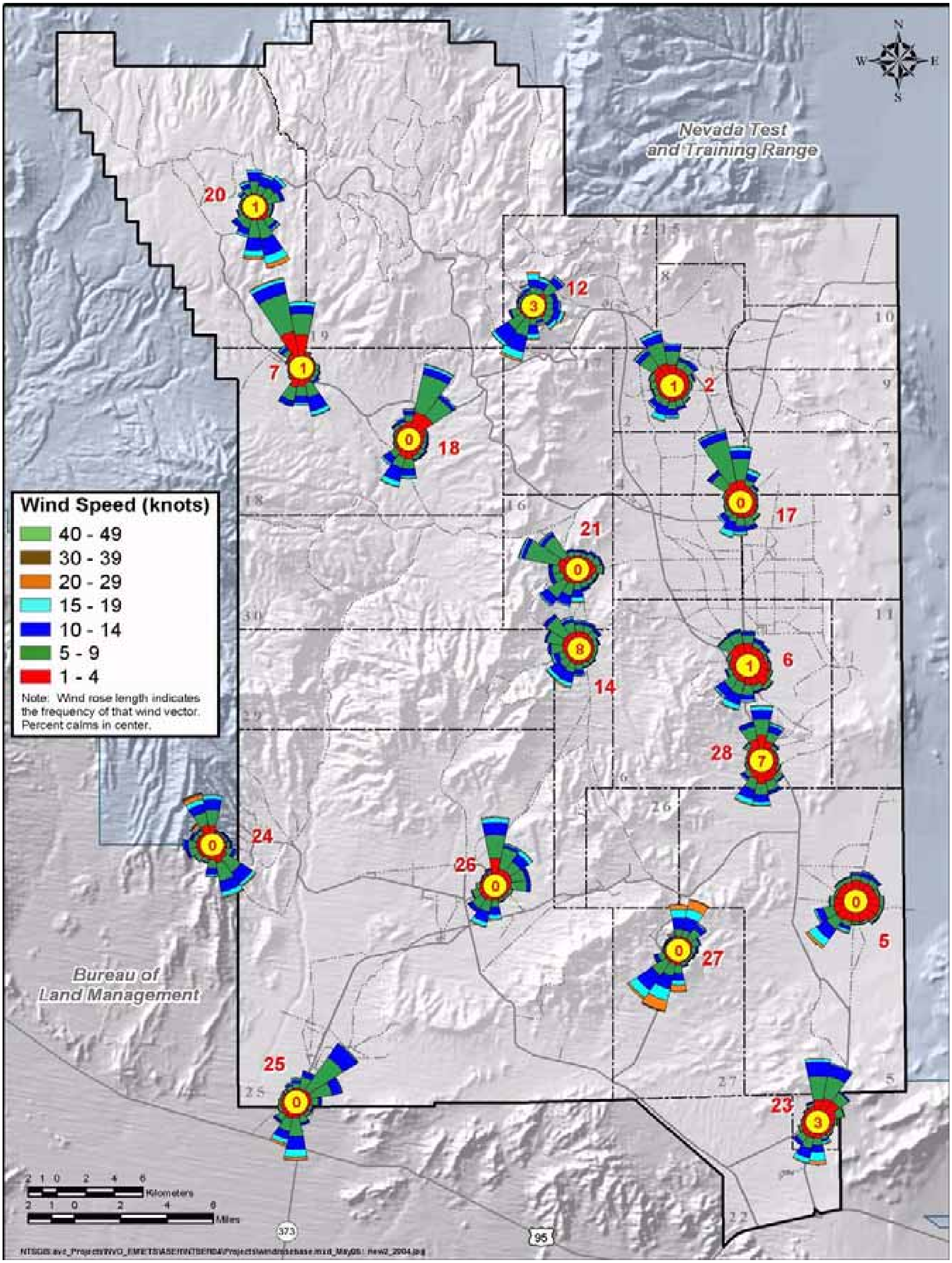

Figure A-13. Annual climatological wind rose patterns at 11 NTS MEDA stations from wind data gathered 1984 to 2004

A.3.6 Dispersion Stability Categories

Determination of the stability of the atmosphere near the ground is a key input requirement for atmospheric dispersion models. Such models are used to estimate the impacts of hazardous materials that might be accidentally released into the atmosphere or become airborne from radioactively contaminated soil sites on the NTS. The dispersion models commonly used for this purpose are Gaussian plume models that require the specification of stability categories to account for effects of atmospheric turbulence on the dispersion process. The mountain-valley topography on the NTS makes it impossible to calculate a single set of values that characterizes atmospheric turbulent mixing on the NTS. Consequently, the stability categories for the NTS are calculated from the average hourly wind speeds for each MEDA station, the solar angle, and the hourly cloud-cover observations reported at the Desert Rock Meteorological Observatory. This procedure follows regulatory guidance provided by the U.S. Environmental Protection Agency (EPA) (2000) and the American Nuclear Society (2000). The stability category concept makes use of the letters "A" through "F" to define different turbulence regimes. Category "A" specifies free convection in statistically unstable air, "D" represents neutral stability, and "F" is very stable (dispersion suppressed) with little turbulent mixing. In Yucca and Frenchman Flats, in winter, F-stability tends to persist from 4 p.m. PST until 8 a.m. PST the next morning with an abrupt transition to C- or B-stability near 9 a.m. PST, followed by C- or B-stability during the afternoon. In summer, E- or F-stabilities occur between 7 p.m. PST and 6 a.m. the next morning with a rapid change to B-stability at 7 a.m. PST and generally C- or B-stabilities and some D-stability in late afternoon.

A.3.7 Other Natural Phenomena

Wind speeds in excess of 97 kmh (60 mph) occur annually. Additional severe weather in the region includes occasional severe thunderstorms, lightning, hail, and dust storms. Severe thunderstorms may produce high precipitation rates that may create localized flash flooding. Few tornadoes have been observed in the region and are not considered a significant threat.

Cloud-to-ground lightning can occur throughout the year but occurs primarily between June and September. Maximum clouod-to-ground lightning activity on the NTS occurs between 1 p.m. and 4 p.m. PDT while minimum activity occurs between 8 a.m. and 9 a.m. PDT. For safety analyses, the mean annual flash density on the NTS is 0.4 flashes per square kilometer. Randerson and Sanders (2002) have characterized CG lightning activity on the NTS.

A.4 Ecology

The NTS lies on the transition between the Mojave and Great Basin deserts. As a result, elements of both deserts are found in a diverse and complex flora and fauna (Ostler et al., 2000; Wills and Ostler 2001).

A.4.1 Flora

A total of 752 taxa of vascular plants have been collected in 10 major vegetation alliances (Figure A-14). A total of 20 vegetation associations from among the alliances have been identified and mapped. Distributions of the Mojave Desert, transition zone, and Great Basin Desert ecoregion vegetation alliances and associations are linked to temperature extremes, precipitation, and soil conditions.

Vegetation associations characteristic of the Mojave Desert occur over the southern third of the NTS, on hillsides and mountain ranges at elevations below about 1,219 m (4,000 ft) (Figure A-14). Creosote bush (*Larrea tridentata*) is the dominant shrub within these associations. Creosote bush associations are absent from habitats where the mean minimum air temperature is below -1.9°C (28.5° F) or the extreme minimum is less than -17.2°C (1° F). It is also limited to zones with an average rainfall of 18.3 cm (7.2 in) or less (Beatley, 1974). Between elevations of 1,219 to 1,524 m (4,000 to 5,000 ft), transitional vegetation associations exist. The largest and most important is the Blackbrush – Nevada Jointfir (*Coleogyne ramosissima-Ephedra nevadensis*) Shrubland Association which covers 21.6 percent of the total area of the NTS (Ostler et al., 2000). Above 1,524 m (5,000 ft,) the vegetation mosaic is characteristic of the Great Basin Desert. Throughout the central and northwestern mountains of the NTS, the dominant shrub species are basin big sagebrush (*Artemisia tridentata*) and black sagebrush (*Artemisia nova*). The distribution of Great Basin Desert associations appears to be limited by mean maximum temperature and by minimum rainfall tolerances of the cold desert species (Beatley, 1975).

Above 1,828 m (6,000 ft), singleleaf pinyon (*Pinus monophylla*) and Utah juniper (*Juniperus osteosperma*) mix with the sagebrush association where there is suitable moisture for these trees. Tree densities on the NTS are often not high enough to create closed canopies, but rather, an open woodland type with a mix of shrub and tree cover.

There are no plants on the NTS which are listed as threatened or endangered under the Endangered Species Act. However, there are 18 plant species and 1 moss species on the NTS considered to be sensitive by the Nevada Natural Heritage Program (see Table 13-2). Sensitive species are those whose long-term viability has been identified as a concern by natural resource experts. Through past field survey efforts over multiple years, population locations of 14 sensitive species have been mapped on the NTS (Figure A-15), and many of these species as well as new species (see Table 13-2) continue to be monitored under the Ecological Monitoring and Compliance Program (see Section 13).

A.4.2 Fauna

At least 1,163 taxa of invertebrates within the phylum Arthropoda have been identified on the NTS. Of the known arthropods, 78 percent are insects. Ants, termites, and ground-dwelling beetles are probably the most important groups of insects as regards distribution, abundance, and functional roles. No native fish species occur on the NTS, although non-native goldfish, golden shiners, and bluegills have been unofficially introduced into a few man-made ponds. The non-native bullfrog is the only amphibian that is known to occur on the NTS.

Among reptiles, the desert tortoise, 16 lizard species, and 17 snake species are known to occur on the NTS (Wills and Ostler, 2001). The rich reptile fauna is partly due to the overlapping ranges of plant species characteristic of the Mojave and Great Basin Deserts. The most abundant, widely distributed lizards include the side-blotched lizard (*Uta stansburiana*), western whiptail (*Cnemidophorus tigris*), desert horned lizard (*Phrynosoma platyrhinos*), and desert spiny lizard (*Sceloporus graciosus*). The western shovel-nosed snake (*Chionactis occipitalis*) is the most common snake on the NTS. There are four species of poisonous snakes: the Mohave Desert sidewinder (*Crotalus cerastes*), Panamint rattlesnake (*Crotalus mitchellii*), night snake (*Hypsiglena torquata*), and Sonoran lyre snake (*Trimorphodon biscutatus*).

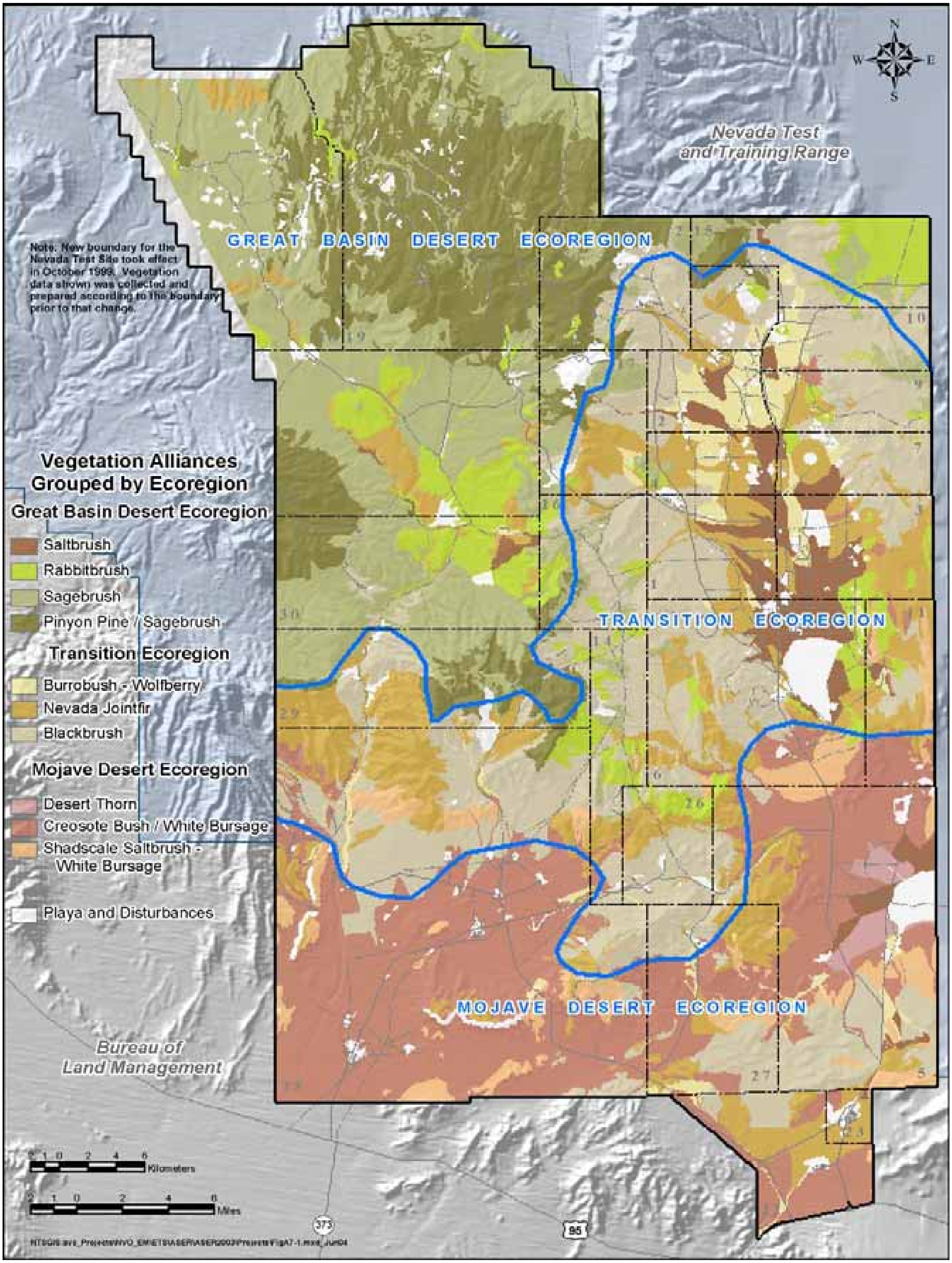

Figure A-14. Distribution of plant alliances on the NTS

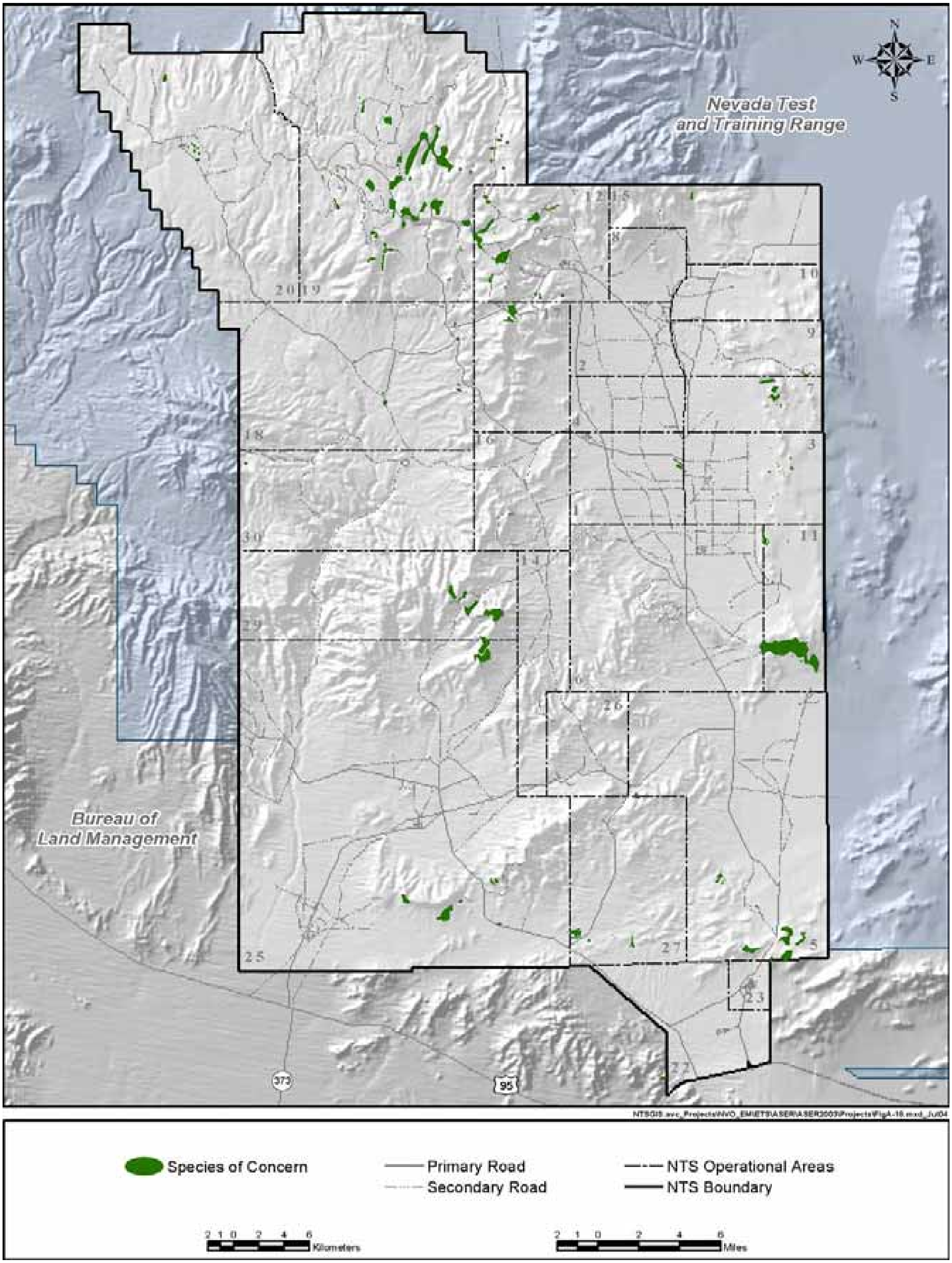

Figure A-15. Known locations of plant species of sensitive plant species on the NTS

There are records of 239 species of birds observed on the NTS (Wills and Ostler, 2001). Approximately 80 percent of the bird species are migrants or seasonal residents. To date, 26 species, including 9 raptor species (birds of prey) are known to breed on the NTS. The raptors which breed on the NTS include the golden eagle (*Aquila chrysaetos*), long-eared owl (*Asia otus*), red-tailed hawk (*Buteo jamaicensis*), Swainson's hawk (*Buteo swainsoni*), prairie falcon (*Falco mexicanus*), American kestrel (*Falco sparverius*), western burrowing owl (*Athene cunicularia hypugaea*), the barn owl (*Tyto alba*), and the great-horned owl (*Bubo virginianus*) (BN, 2002b).

There are 44 terrestrial mammals and 15 bat species that are known to occur on the NTS. Rodents account for about 40 percent of the known mammals, and in terms of distribution and relative abundance, are the most important group of mammals on the NTS (Wills and Ostler, 2001). There is an apparent correlation between production by winter annual plants and reproduction in desert rodents on the NTS. Larger mammals on the site include black-tailed jackrabbit, desert and Nuttall's cottontail rabbits, feral horses, mule deer, pronghorn antelope, coyote, kit fox, badger, bobcat, and mountain lion. Mule deer herds occur mainly on the high mesas and surrounding bajadas. Small numbers of wild horses and pronghorn antelope range over small areas of the NTS. Bighorn sheep and burros are thought to be rare visitors.

The desert tortoise (*Gopherus agassizii*) is the only resident species found on the NTS which is listed as threatened under the Endangered Species Act. Habitat of the desert tortoise is in the southern third of the NTS (see Figure 13-1). The bald eagle is a threatened bird which is a rare migrant on the site. No other threatened or endangered animal is known to occur on the NTS. All but five birds on the NTS are protected by federal legislation under the Migratory Bird Treaty Act and/or by the state of Nevada. Most non-rodent mammals of the NTS are protected by the state of Nevada and managed as either game or furbearing mammals, and 12 bats on the NTS are considered sensitive species (see Tables 13-2 and 13-3).

A.4.3 Natural Water Sources

Important biological communities on the NTS are those associated with springs or other natural sources of water. They are rare, localized habitats that are important to regional wildlife and to isolated populations of water-loving plants and aquatic organisms. There are 30 natural water sources on the NTS which include 15 springs, 9 seeps, 4 tank sites (natural rock depressions that catch and hold surface runoff), and 2 ephemeral ponds (Hansen et al., 1997; BN, 1998; 1999) (Figure A-16).

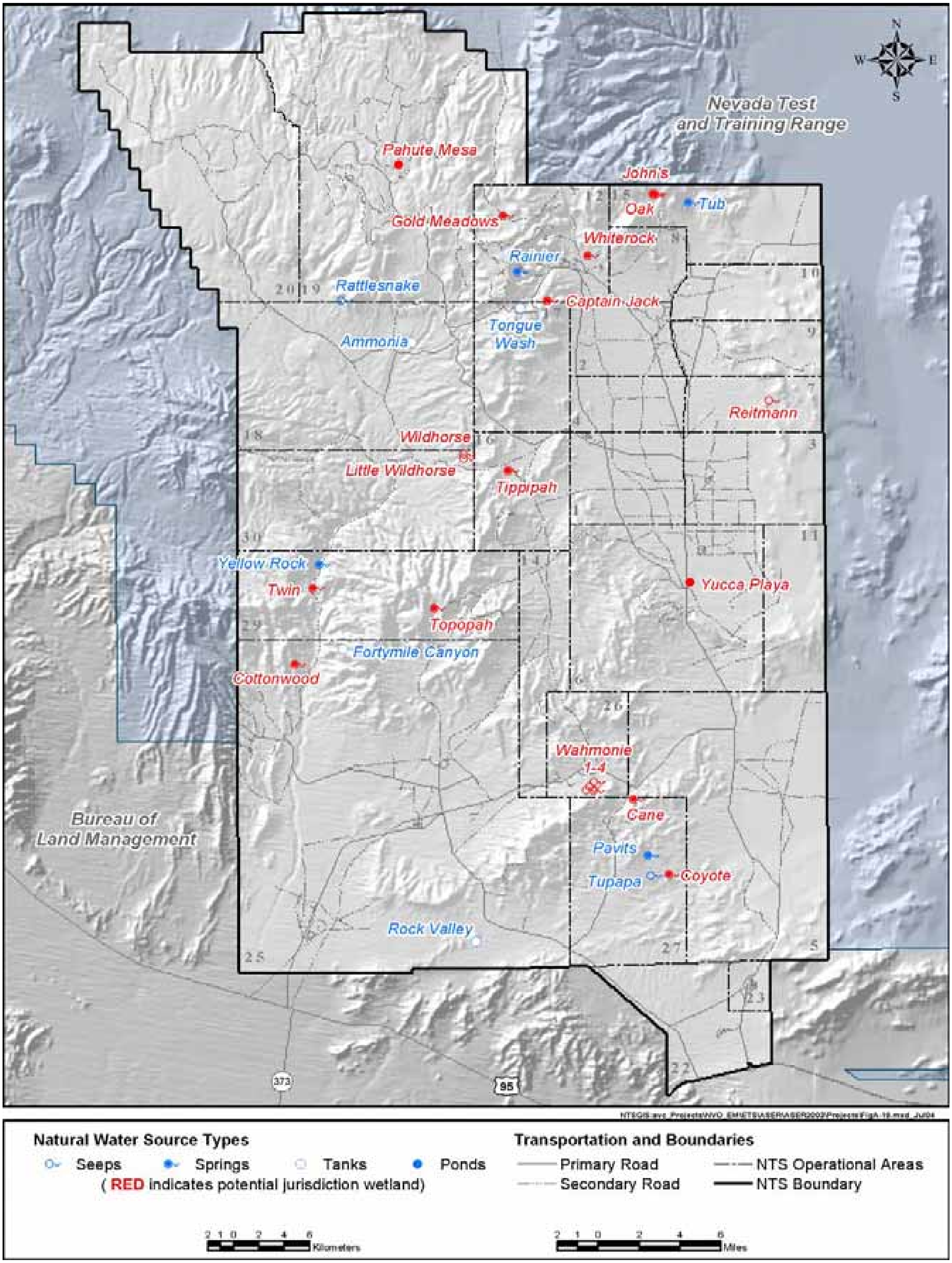

Figure A-16. Natural water sources on the NTS

A.5 Cultural Resources

A.5.1 Cultural Resources Investigations on the NTS

Few cultural resources investigations were performed from the 1940s to the 1960s on what is now the NTS. Earlier explorers did visit the area, such as O.S. Lodwick in the 1900s and Mark R. Harrington of the Heye Museum of the American Indian in the 1920s, but the visits were brief, and no in-depth studies were attempted. The work conducted by S.M. Wheeler in 1940 is the first serious investigation, resulting in some prominent sites being recorded (Winslow, 1996). Wheeler and a small party, including his wife, supported by the Nevada State Parks Commission, were guided by Roscoe J. Wright, a.k.a. "Death Valley Curley," a local miner, into the Fortymile Canyon region with the specific purpose of investigating archaeological sites (Figure A-17). The party spent only a few days in the area, however, and only briefly described the cultural resources they found. In 1955, Richard Shutler (1961), seeking evidence of pueblo ruins, was the next archaeologist to visit and record sites in the same general area of Fortymile Canyon as well as on Timber Mountain. He was guided by Bill Martin, a Shoshone from Beatty. Frederick C.V. Worman (1965, 1966, 1967, 1969), a zoologist and a vocational archaeologist employed by Los Alamos National Laboratory, and Donald Tuohy (1965), an archaeologist from the Nevada State Museum, conducted limited surveys and excavations during the 1960s. These investigations were typically salvage archaeology in response to an Atomic Energy Commission (AEC) directive regarding the preservation and protection of antiquities on AEC lands. It was not until the late 1970s with stronger federal laws and regulations concerning cultural resources that systematic archaeological investigations on the NTS were carried out on a regular basis. Desert Research Institute (DRI) became the cultural resources support contractor at this time and ever since has performed numerous surveys and data recovery efforts (Figure A-18), as well as records keeping and curation of artifacts. Lately, historical evaluations of NTS structures and buildings have become part of the program in documenting a significant period in the local and national history regarding nuclear testing and the Cold War era (Figure A-19).

Figure A-17. Example of prehistoric petroglyphs found on the NTS. This rock art site is in Fortymile Canyon (photo by DRI, 1996).

Figure A-18. DRI archaeologist at an archaeological excavation of a prehistoric site on Pahute Mesa. The site is probably from the middle to late Holocene period (photo by DRI, 1992).

Figure A-19. Building 400, a camera station for photographing atmospheric tests, at Area 6 Control Point, built in 1951. One of the first buildings constructed on the NTS to support weapons testing activities (photo by DRI, 2003).

A.5.2 Paleo-Indian Period

The oldest cultural remains discovered on the NTS are Clovis style projectile point fragments dating to the Paleo-Indian period, ca. 12,000 to 10,000 years before present (BP). One was found along an alluvial terrace of Fortymile Wash near Yucca Mountain (Reno, 1985) and a second at the upper reaches of the Fortymile drainage system near Rattlesnake Ridge at the west base of Rainier Mesa (Jones and Edwards, 1994). The basic economic strategy for the Paleo-Indian was hunting of big game and a predominant use of lacustrine-marsh areas around late Pleistocene and early Holocene pluvial lakes (Madsen, 1982; Warren and Crabtree, 1986). Pluvial lakes were a result of cooler temperatures and higher annual precipitation characteristic of this time (Grayson, 1993). No evidence is available, however, to indicate that the basins on the NTS supported pluvial lakes as in other nearby valleys, such as Groom Lake east of the NTS and the Kawich, Gold Flat, and Mud lakes to the north (Grayson, 1993: Table 5-2; Mifflin and Wheat, 1979). The Fortymile Canyon drainage, where the Clovis points were found, may have been used as a travel route between highland and lowland areas or, as proposed by Pippin (1998a), part of a hunting territory where certain animals such as deer and elk could be found.

A.5.3 Early Holocene Period

A general broadening in the types of resources being exploited from a variety of environments occurs during the early Holocene, ca. 10,000 to 7,500 BP, and includes aquatic and small animals as well as plants (Grayson, 1993). Initially, lakes and marshes still abounded overall, but the climate began to change to one more dry and by 8,000 BP most of the standing bodies of water were gone (Grayson, 1993). Consequently, the woodlands began to move upslope to be replaced by sagebrush or bursage and creosote bush (Grayson, 1993).

Most cultural activities still appear to be restricted to the lower elevations, however (cf. Haynes, 1996; cf. Reno, et al., 1989); and Pippin (1998a) indicates that only short term hunting forays, originating from the lower elevations, occurred in the higher elevations of the NTS. This is similar to the pattern described for the eastern Great Basin (Madsen, 1982).

A.5.4 Middle Holocene Period

The period from ca. 7,500 to 4,500 BP is marked by increased aridity, and a hotter and dryer climate compared to the previous episode and to that of today (Antevs, 1948; Miller and Wigand, 1994). Some evidence suggests that entire areas were abandoned. For example, Warren and Crabtree (1986) contend that the people living in the Mojave Desert at this time were ill-adapted to the arid conditions because so few sites have been found, and of those sites, they appear to represent short-term activities with low artifact densities indicative of a highly mobile lifestyle. They suggest that the people may have aggregated at the margins of the desert near springs and other dependable water sources and only briefly entered the more arid localities during times of greater effective moisture. Few sites have been found in the Great Basin dating to this period as well. Grayson (1993) indicates the higher elevation zones are becoming an important part of the subsistence base and coincides with the upward movement in elevation of the woodlands. Pippin (1998a) also notes this change on the NTS, but he sees the cultural response as an intensification and expansion of the areas previously exploited and not in the relocation of residential bases to the uplands.

A.5.5 Late Holocene Period

The period from ca. 4,500 to 1,900 BP is generally known for cooler and wetter conditions. Subsequent periods fluctuated between dry and wet episodes, with the most notable arid periods from 1,900 to 1,000 BP and 700 to 500 BP (Miller and Wigand, 1994). A pattern of heavy winter precipitation began after 500 BP, but average temperatures have gradually increased since the end of the Little Ice Age about 150 years ago. Culturally, there is an increase in the number of sites and a broadening of the subsistence base (Grayson, 1993; Lyneis, 1982). A shift in the settlement pattern is made in some areas of the southern Great Basin to comparatively large, semi-sedentary communities on valley floors accompanied by a more frequent use of the highlands. An increase in the frequency of milling implements indicates a greater reliance on seeds than previously practiced (Warren and Crabtree, 1986). Evidence at higher elevations on the NTS supports the contention that highland resources were an important part of the subsistence base, and quite likely, logistical seasonal movements between resource zones were being practiced (Pippin, 1998a:). Rock features interpreted as food caches begin to appear within the woodlands (Pippin, 1998a:). Examples of projectile points from this period found by DRI archaeologists on the NTS are shown in Figure A-20. One of the most conspicuous technological changes is the introduction of the bow and arrow, ca. 1,500 BP. Madsen (1986a:) suggests that the advent of this implement may have led to increased efficiency in hunting to where the animal populations were significantly reduced, resulting in a greater dependence by the people on plant resources, such as pinyon and other seed plants. Another introduction was brownware pottery (Figure A-21), ca. 700 to 1,000 BP (Lockett and Pippin, 1990; Madsen, 1986b; Pippin, 1986; Rhode, 1994), indicating a more sedentary lifestyle and a change in the way food was prepared and stored.

Figure A-20. Prehistoric projectile points from the NTS (photo by DRI, 1992)

Figure A-21. Brownware bowl recovered from archaeological excavations on Pahute Mesa (photo by DRI, 1992)

A.5.6 Ethnohistoric American Indian

Early explorers and immigrants in the southern Great Basin during the nineteenth century encountered widely scattered groups of Numic-speaking hunters and gatherers currently known as Southern Paiute (see Kelly and Fowler, 1986) and Western Shoshone (see Thomas et al., 1986). The areas traditionally claimed by these tribal entities encompassed a large region and were bound in territories of ethnic or political groups (Stoffle et al., 1990). Subsistence strategies revolved around movements between environmental zones within their territories (e.g., highlands and lowlands), according to the seasonal availability of food resources (Steward, 1938; cf. Wheat, 1967). The normal range was within 32 km (20 mi) of the primary residential base, but most resources could be found within a short distance of the main camp. Criteria for the location of the primary residential base was nearness to stored or cached foods, the availability of water, wood for fuel and house construction, and relatively warm winter temperatures like that found in canyon mouths or in the woodlands (Steward, 1938).

The communal group around Rainier Mesa and the southern end of the Belted Range ca. 1875-1880 was known as *Eso* (little hill) and had an estimated population of 42. This locale is at the boundaries of the traditional tribal lands for the Southern Paiute and Western Shoshone, and the *Eso* consisted of members from both tribes. The *Eso* were closely linked linguistically with people to the east, but maintained close relationships with groups all around them, particularly to the north and west. They established winter residential camps at Cane Spring, Captain Jack Spring, Oak Springs, Tippipah Springs (Figure A-22), Topopah Spring, White Rock Springs, and on Pahute and Rainier mesas. Another camp, though not located at a spring, was Ammonia Tanks.

One of the better known spring sites, Captain Jack Spring, is named after One-eyed Captain Jack, a Paiute who resided there at various times with his wife(s) during the late 1800s and early 1900s (Steward, 1938; Stoffle et al., 1990). He died in 1928 (Stoffle et al., 1990). At White Rock Springs lived Wandagwana, headman for the Eso. He directed the annual fall rabbit drive in Yucca Flat which was a time of regional interaction between the various camps and with more distant people. A fandango was usually held at *Wungiakuda* off the southeast edge of Pahute Mesa (see Johnson et al., 1999) lasting about five days, and provided opportunity for the exchange of goods and information. Sweat houses, also serving as places of integration for the local group, were located at White Rock Springs and at Oak Springs. They were used by both women and men for smoking, gambling, sweating, and as a dormitory.

Figure A-22. Overview of the Tippipah Spring Area (photo by DRI, 2004)

A.5.7 Historic Mining on and near the NTS

Around the beginning of the twentieth century, when substantial gold and silver deposits were discovered, the Euro American culture began to dominate this particular region of Nevada, with strikes at Tonopah, Goldfield, and Rhyolite (Elliott, 1966, 1973; McCracken, 1992; Zanjani, 1992). The overall population of Nevada doubled (Elliott, 1966; McCracken, 1992). The great mining boom was short-lived, however, and quickly entered the bust phase. By 1908, only four years after it began, mining in the Bullfrog district collapsed and the town of Rhyolite became one of the many ghost towns in the region. For Goldfield, production fell rapidly after 1911 (Zanjani, 1992), but the town still survives today, principally because it is the seat for Esmeralda County (Elliott, 1966). The decline for the Tonopah mining district was more gradual and had time to transform its primary economic base from mining to a supply center, albeit relatively small and limited, for the surrounding ranches, remaining mining districts, and military installations. The Las Vegas and Tonopah rail line lasted until 1918; the rails were removed in 1919 (Myrick, 1963). Still evident on the NTS today are some of the abandoned ties reused for the construction of corrals and other structures at a number of the springs. Around the Beatty area the ties were used in some of the later mining operations for shoring (McCracken, 1992).

As mining explorations continued in the region, fanning out from the earlier strikes, small mining districts were founded, such as Tolicha in 1917 at the west end of Pahute Mesa (Lincoln, 1923) and the Bare Mountain district just west of the NTS (Cornwall, 1972; Lincoln, 1923, Tingley, 1984). Recorded as an archaeological site by Jones et al. (1996), the mining town of Wahmonie in the southern part of the NTS around Mine and Skull mountains was founded in 1928. The history of Wahmonie spans only a few years and was typical of the boom-and-bust cycle of the mining industry. The historic mining camp of Wahmonie is located about 10 km (6 mi) west of Cane Spring (McLane, 1995; Quade and Tingley, 1984). It grew to a small town with boarding houses, tent stores, and cafes. The Silver Dollar Saloon and the Northern Club were but two of the enterprises (Long, 1950). Most of the miners lived in small tents. George Wingfield, a well-known mine owner and banker in Nevada, became interested and incorporated the Wahmonie Mining Company. Soon, however, the strike was apparently not as rich as had first been thought and by early 1929 optimism faded and people began leaving Wahmonie. Small amounts of prospecting in the Wahmonie district continued into the 1930s and 1940s, but few ore deposits were ever discovered.

The earliest record of prospecting on what is now the NTS is the Oak Spring mining district centered around the northern edge of Oak Butte (Drollinger, 2002). Documents at the Recorder's Office in Tonopah indicate it was established by the late 1880s. The main objectives of these early mining activities were gold, silver, and chrysocolla, a green to blue mineral resembling turquoise. Lincoln (1923) indicates copper ore containing some silver was shipped in 1917 from the Horseshoe claim in the Oak Spring mining district, and that minor amounts of tungsten were also mined in the district. The Oak Spring district, although having relatively abundant water and wood sources, did not prove to be very productive overall.

B.M. Bower (a.k.a. Bertha Muzzy Sinclair), a noted author, with husband (Bud Cowan) and family, moved to Nevada from Los Angeles, California in 1920 and took up residence (Figure A-23) at a mining camp near Oak Spring (McLane, 1996) (see Figure A-16). An accomplished and prolific writer, B.M. Bower published a number of short stories and novels over a 40 year career, with some of them becoming the basis for early western-themed movies in Hollywood. She also served as a screenwriter on a couple of them. While living at the camp, Bower wrote 11 novels, incorporating some of the surrounding geographic features, such as Oak Butte and the camp itself, into a few of the stories. (Copies of several of her books have been made electronically available to the public by Project Gutenberg as Etext and can be downloaded at: <http://www.thalasson.com/gtn/gtnletB.htm#bowerbm>). The family also formed the El Picacho Mining Company, with B.M. Bower serving as the president, and filed assessment work for the claims from 1922 to 1928. The family moved to Las Vegas around 1926, but still worked the mining claims sporadically over the next couple years.

They eventually returned to California. Fittingly, in keeping with the theme for some of the novels, the abandoned camp was used in the early 1930s by outlaws from Utah and Arizona whose escapades were later featured in a Death Valley Days radio episode narrated by Ronald Reagan. B.M. Bower died in 1940 and was inducted into the Western Writers of America Hall of Fame in 1994.

Historically, demand of tungsten for use in weaponry was high during times of war (World Wars I, II, the Korean War) and fell during times of peace (Stager and Tingley, 1988). Correspondingly, so did the mining of tungsten in Nevada. Tungsten was discovered in the Oak Spring district and located as the Climax group in 1937 by V.A. Tamney (Kral, 1951; Stager and Tingley, 1988). Most operations ended when the area was closed with the founding of the bombing and gunnery range by the Federal government (Kral, 1951; Quade and Tingley, 1984; Stager and Tingley, 1988). Production was never fully established for these claims, however, and only samples totaling some 15 tons were processed in a nearby dry concentrating mill serving the Oak Spring district. The last known mining. operation at the Climax claims was from December 1956 to May 1957 involving a co-use agreement between George Tamney, W.A. Kinney, A.J. Wright, owners of the Climax Tungsten Corporation, and the AEC (McLane, 1996; Quade and Tingley, 1984). The agreement was terminated and no legal mining has since been conducted on the NTS.

Figure A-23. Bower cabin on the NTS (photo by DRI, 2001)

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Appendix B

Nevada Test Site Satellite Facilities

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Appendix B: Nevada Test Site Satellite Facilities

This appendix provides a general description of the three Nevada Test Site (NTS) satellite facilities in Nevada which support work on the NTS and of all environmental monitoring and compliance activities conducted in 2003 related to these facilities. The NTS and these facilities are managed by the U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office (NNSA/NSO). They include the North Las Vegas Facility (NLVF), Cheyenne Las Vegas Facility (CLVF), and Remote Sensing Laboratory (RSL)-Nellis. They are all located in Clark County (Figure B-1).

B.1 North Las Vegas Facility

The NLVF is a fenced complex comprised of 31 buildings which houses much of the NTS project management, diagnostic development and testing, design, engineering, and procurement. The 80-acre facility is located along Losee Road a short distance west of Interstate 15 (Figure B-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 include the maintenance of four wastewater permits, five air quality operating permits for a variety of equipment, one hazardous materials permit (Table B-1), and the monitoring of tritium in air and ambient gamma-emissions to comply with radiation protection regulations.

Table B-1. Environmental permits for NLVF

Permit Number	Description	Expiration Date	Reporting
Wastewater Discharge			
VEH-112	NLVF Wastewater Contribution Permit	December 31, 2006	Annually
TNEV2003461	NLVF Temporary Well Test/Discharge Permit	May 21, 2004	Monthly
TNEV2004348	NLVF Temporary Well Test/Discharge Permit	November 21, 2004	Monthly
TNEV2004364	NLVF Temporary Well Test/Discharge Permit	May 21, 2005	Monthly
Air Quality			
A38701	A-16 Spray Paint Booth	None	Annually
A38703	A-5/B-5 Emergency Generators	None	Annually
A06503	Emergency Generator	None	Annually
A06505	B-1 Aluminum Sander	None	Annually
A06507	Tinco Dry Blaster	None	Annually
Hazardous Materials			
2287-5144	NLVF Hazardous Materials Permit	February 28, 2005	Annually

B.1.1 Compliance with Water Permits

Wastewater permits for NLVF include: (1) a Class II Wastewater Contribution Permit with the City of North Las Vegas (CNLV) for sewer discharges and (2) three temporary discharge permits to support groundwater characterization and dewatering issued by the Nevada Division of Environmental Protection (NDEP).

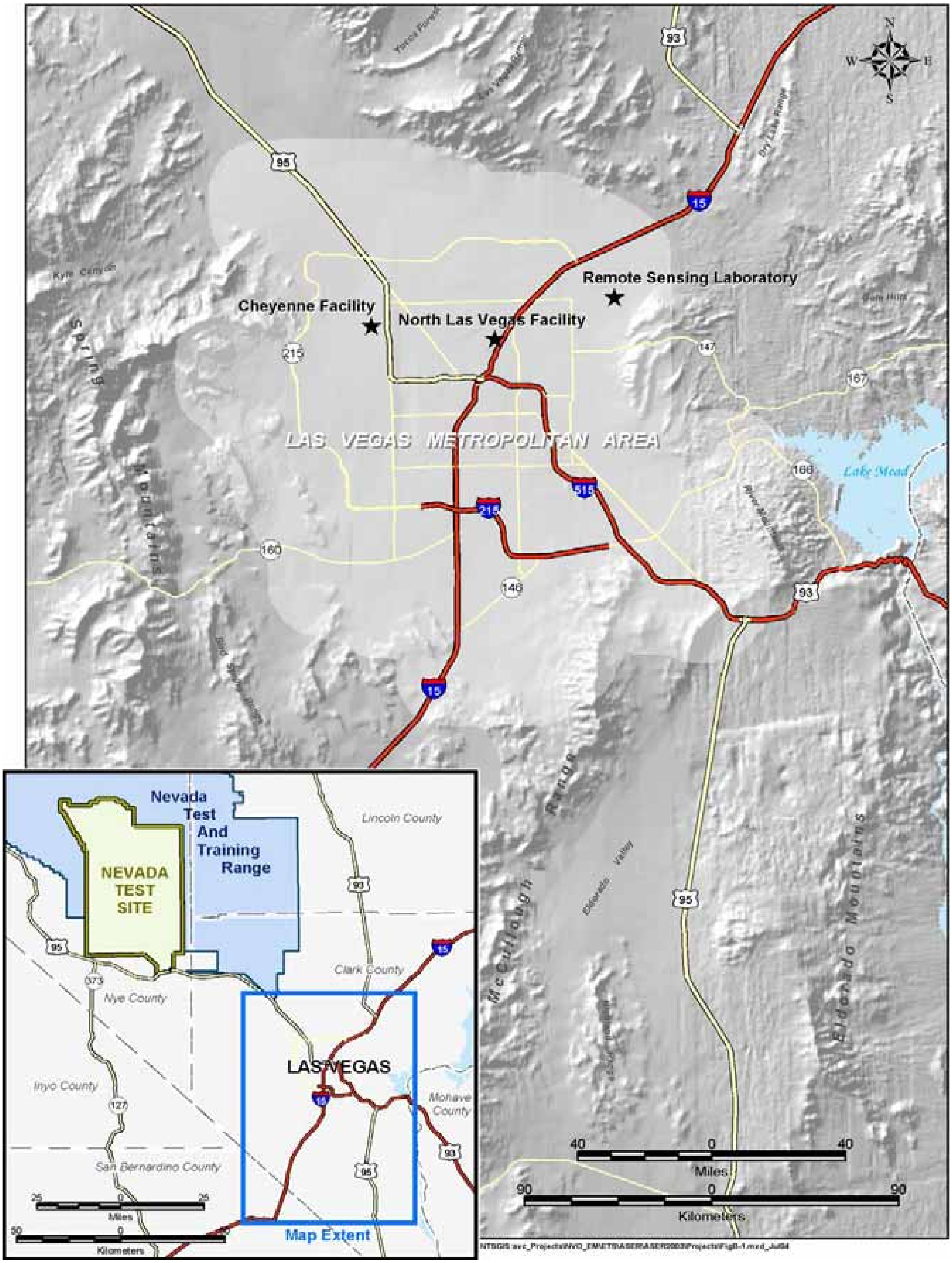


Figure B-1. Location of NTS satellite facilities

Discharges of sewage and industrial wastewater from NLVF are required to meet permit limits set by the CNLV. These limits support the permit limits for the Publicly Owned Treatment Works (POTW) operated by the City of Las Vegas. Regulations for wastewater discharges are codified in the municipal codes for both cities. Groundwater discharges are state regulated by the NDEP, and are discharged through the CNLV stormwater collection system.

These discharges enter waters of the United States (Las Vegas Wash) under a National Pollutant Discharge Elimination System (NPDES) permit. In 2004, the NDEP issued two new temporary permits (six-month duration) to NNSA/NSO. Sediment is the primary pollutant related to these discharges.

B.1.1.1 Wastewater Contribution Permit VEH-112

This permit specifies concentration limits for contaminants in domestic and industrial wastewater discharges. Self-monitoring and reporting of the levels of non-radiological contaminants in sewage and industrial outfalls is conducted. In 2004, contaminant measurements were below established permit limits (Table B-2) in all water samples from NLVF outfalls and all sludge and liquid samples from NLVF sand/oil interceptor. CNLV conducted an annual inspection on September 14, 2004, that resulted in no findings or corrective actions. In compliance with this permit, the following report summarizing wastewater monitoring was generated for NLVF operations and submitted October 25, 2004 to CNLV: *Self-Monitoring Report for the National Nuclear Security Administration's North Las Vegas Facility: Permit VEH-112*.

Table B-2. Results of 2004 monitoring at NLVF for Wastewater Contribution Permit VEH-112

Contaminant	Permit Limit (mg/L)	Outfall A (mg/L)	Outfall B (mg/L)	Outfall C2 (mg/L)
Ammonia	61	8.9	1.9	11
Barium	13.1	0.152	0.100	0.200
BOD	600	110	380	170
Cadmium	0.15	0.0023	0.0182	<0.0003
Chromium (hexavalent)	0.10	< 0.19[(a)]	< 0.19[(a)]	< 0.19[(a)]
Chromium (total)	5.60	0.0022	0.0072	0.0014
Copper	0.60	0.207	0.171	0.262
Cyanide (total)	19.9	< 0.005	< 0.005	< 0.005
Lead	0.20	0.0026	0.0145	<0.0019
Nickel	1.10	0.007	0.0096	0.005
Oil & Grease (animal or vegetable)	250	20	< 17	11
pH (Standard Units)	5.0 – 11.0	8.17	6.90	8.26
Phenols	33.6	0.05	0.77	0.045
Phosphorus (total)	14.0	4.3	1.8	4.7
Silver	2.70	< 0.0009	< 0.0009	< 0.0009
TDS (total dissolved solids)	1200	832	470	1120
TRPH (total recoverable petroleum hydrocarbons)	100	5.5	270[(b)]	11
TSS (total suspended solids)	750	44.5	14.8	81
Zinc	8.20	0.378	0.277	0.318

Yellow shaded results are any which are equal to or greater than the permit limit

(a) The normal detection limit for hexavalent chromium is 0.01. Due to a sample dilution factor of 19, the resultant detection limit was elevated. No further action was required.

(b) Data was qualified as suspect due to poor surrogate recovery caused by matrix interference. No further action was required.

B.1.1.2 Unauthorized Discharge from Building A-1

On August 19, 2004, during a pre-inspection and safety walkthrough, the Facility Owner and Experimentation Support Department Safety Professional observed an unmarked and nearly full 5-gallon bucket of water under the drainpipe of the air-handling unit in Building A-1, Room 4520. The bucket was located approximately 1 foot from a floor drain. Upon investigation, it was determined that the bucket had been placed there to collect potentially tritiated condensate from the air handler. Parts of Building A-1, including Room 4520, were contaminated with tritium by a previous contractor in 1995. The 5-gallon bucket was replaced with a 40-gallon drum and the water was sampled. The sample results indicated a tritium concentration of 23,000 ± 4,000 picocuries per liter (pCi/L). Further investigation identified that at least three times since work was resumed in Room 4520 in May 2004, tritiated water from the bucket had been emptied into the floor drain constituting an unauthorized discharge to the city of North Las Vegas sewer system. NNSA/NSO reported the unauthorized discharge to the CNLV on September 10, 2004. This event was determined to meet occurrence reporting criteria and Occurrence Report Number NVOO--BN-NLV-2004-0003, was submitted on September 13, 2004. The following actions were required by the CNLV to close out this unauthorized discharge, all of which have been completed:

- Fix the condensate tubing in Room 4520 so the hose flows directly into the containment barrel.
- Supply secondary containment for the barrel in Room 4520.
- Install a permanent sign in Room 4520. The sign must state “Do not discharge air conditioner condensate from this room into any building drain”.
- Remove the portion of pipe teeing off the source range wastewater pipe and leading to the floor drain located in Room 4540.
- Institute weekly checks of the condensate barrels.
- Send information to the inspector demonstrating the tritium concentration at the outfall was not detectable following each of the incidents.
- Explain why incident was reported so long after occurrence.

B.1.1.3 NPDES Permits TNEV2003461, TNEV2004348, and TNEV2004364

Temporary National Pollutant Discharge Elimination System/State Pollutant Discharge Elimination System (NPDES) permits covered the groundwater characterization study and remedial dewatering operation which was conducted at NLVF in 2004. Each permit is valid for a period of six months; these are renewed each May and November as long as the study and groundwater pumping is performed. Each renewal involves the issuance of a uniquely numbered permit. Each permit specifies that the total flow volumes from both of the wells being pumped during the study be monitored and that there be sediment controls as necessary on the discharge stream which enters the storm water drains at the facility. Because the groundwater discharges are “clean” (i.e., not wastewater or discharges from an industrial process), no other water parameters are required to be monitored. Water pumped from both wells flow into one storm water outfall; there have been no need for sediment controls. Monthly reports of discharge volumes were submitted to NDEP as required. All permit specifications were met in 2004 (Table B-3).

Table B-3. NPDES/SPDES Non-Compliances

Permit Type	Outfall	Parameter	Number of Permit Exceedances	Number of Samples Taken	Number of Compliant Samples	Percent Compliance	Date(s) Exceeded	Description /Solution
TNEV2 003461/ 004348/ 004364	001	Discharge volume	NA	12 (1/month)	12	100	NA	NA

Note: This table and its specific format are requested by DOE Headquarters for ease in collecting NPDES/SPDES data across multiple DOE and NNSA facilities. NA = Not applicable.

In 2005, during preparation of this report, the U.S. Environmental Protection Agency (EPA) informed the State that they were in direct violation of the Clean Water Act by issuing the temporary NPDES discharge permits for NLVF that allowed discharge of pumped groundwater to the CNLV storm water drainage system. Bechtel Nevada (BN) will implement one of several corrective action options which the State presented so as to comply with the EPA ruling and resolve this issue in 2005.

B.1.2 Groundwater Control Study

Rising groundwater below Building A-1 at NLVF intruded into the elevator pit in 1999. Between November 1999 and January 2001, the water level in a well installed in the basement of Building A-1 rose at the rate of 0.6 meters (m) (2 feet [ft]) per year (BN, 2001). Data collected during 2002 and 2003 show the rate of rise decreasing to less than 0.3 m (1 ft) per year (BN, 2003c). Sealing of the elevator pit and interim pumping at the nearby basement sump slowed the encroaching water. However, if the water level is not lowered, it could jeopardize the integrity of deep-footed infrastructure (e.g., elevator pits, utility trenches, etc.).

In 2002 and 2003, BN conducted a groundwater control study. This comprehensive investigation included the installation of 25 wells (Figure B-2), soil and water sampling, hydrologic testing, and rudimentary modeling (BN, 2003c). The goals of the study were to discover why the water table beneath Building A-1 was rising and to determine what remedial actions could be taken to protect the building. Prior to this investigation, details regarding the subsurface structure, geology, and hydrology at the site were not well known.

The 25 new wells were typically constructed in well pairs. Each site consists of a shallow well (designated with an “s”) drilled to about 12.2 m (40 ft), and a deep well (designated with a “d”) drilled to about 41.1 m (135 ft) depth. The four wells closest to Building A-1 are NLVF-12s and 12d and NLVF-13s and -13d, which were constructed with larger diameter completion casing to accommodate a submersible pump employed during hydraulic testing. Hydraulic properties for the two alluvial aquifers were derived from step draw-down tests, constant-rate pumping, slug tests, and the physical properties measurements. The estimated pumping rate for the silty-sandy aquifer was determined to be only 3.8 liters per minute (lpm) (1 gallons per minute [gpm]) per well.

B.1.2.1 Study Results

The NLVF groundwater control studies indicate a complex hydrogeologic setting, and implicate multiple factors for the rise of the water table. The wells were drilled entirely in relatively young alluvial deposits consisting mainly of sand, silt, and clay. The preliminary geologic interpretation of borehole data indicates that these fine-grained sediments represent a low energy, mid-valley alluvial and fluvial environment. Individual lithologic units are complexly interbedded and several normal faults have been mapped in the vicinity.

The near-surface (unconfined) water table at NLVF was encountered in the depth range of 3.8 to 14.9 m (12.6 to 49 ft). Artesian water flow of 3.0 to 7.6 lpm (0.8 to 2 gpm) was encountered at two wells. The water-table map (potentiometric surface; provided in BN, 2004b and DOE, 2004d) produced from these data shows a rather steep gradient to the southeast in the vicinity of Building A-1.

Water chemistry reveals that this water is not related to the near surface “nuisance water” commonly supplied by excessive irrigation, but is from a deeper alluvial aquifer. The hydrogeologic setting suggests that the source of this rising groundwater is water flowing upward along local faults from deeper confined aquifer(s) (Figure B-3). This condition is considered a long-term adjustment that can be attributed to a combination of causes, including a seasonal water injection program conducted by the Southern Nevada Water Authority and shifting of regional pumping centers away from the vicinity of NLVF.

B.1.2.2 Work Conducted in 2004

The two shallow hydrologic characterization wells near Building A-1, NLVF-12s and NLVF-13s, were converted into dewatering wells with the installation of submersible pumps (Figure B-4). The two wells were brought on-line on May 18, 2004. Their flow was discharged into the CNLV storm-water drain system according to temporary discharge permits issued by NDEP. The objective of this dewatering effort was to lower the water level 4 ft (1.2 m) (or one foot below the lowest building footing) within two years.

Figure B-2. Monitoring wells and hydrologic test wells constructed at NLVF

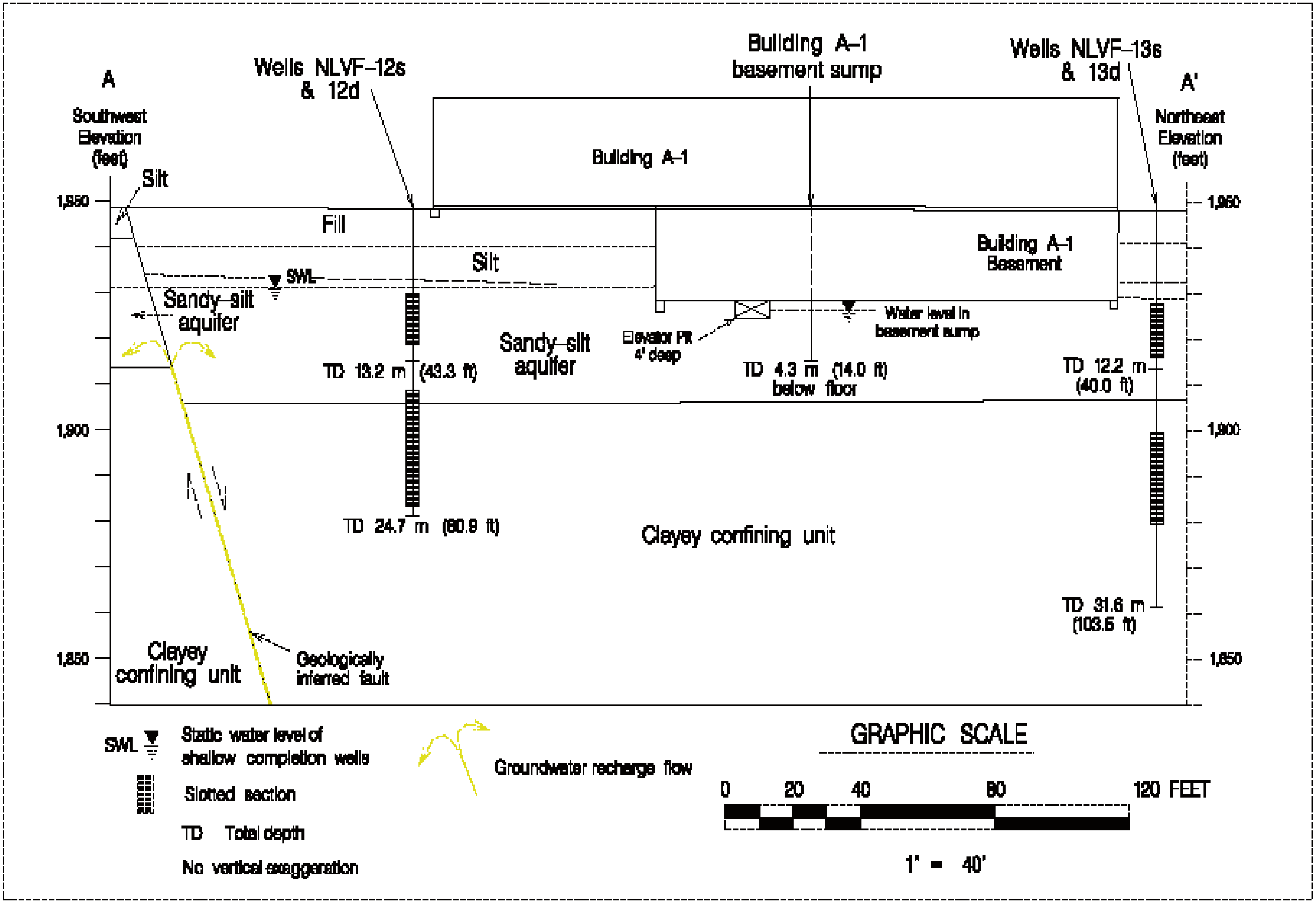
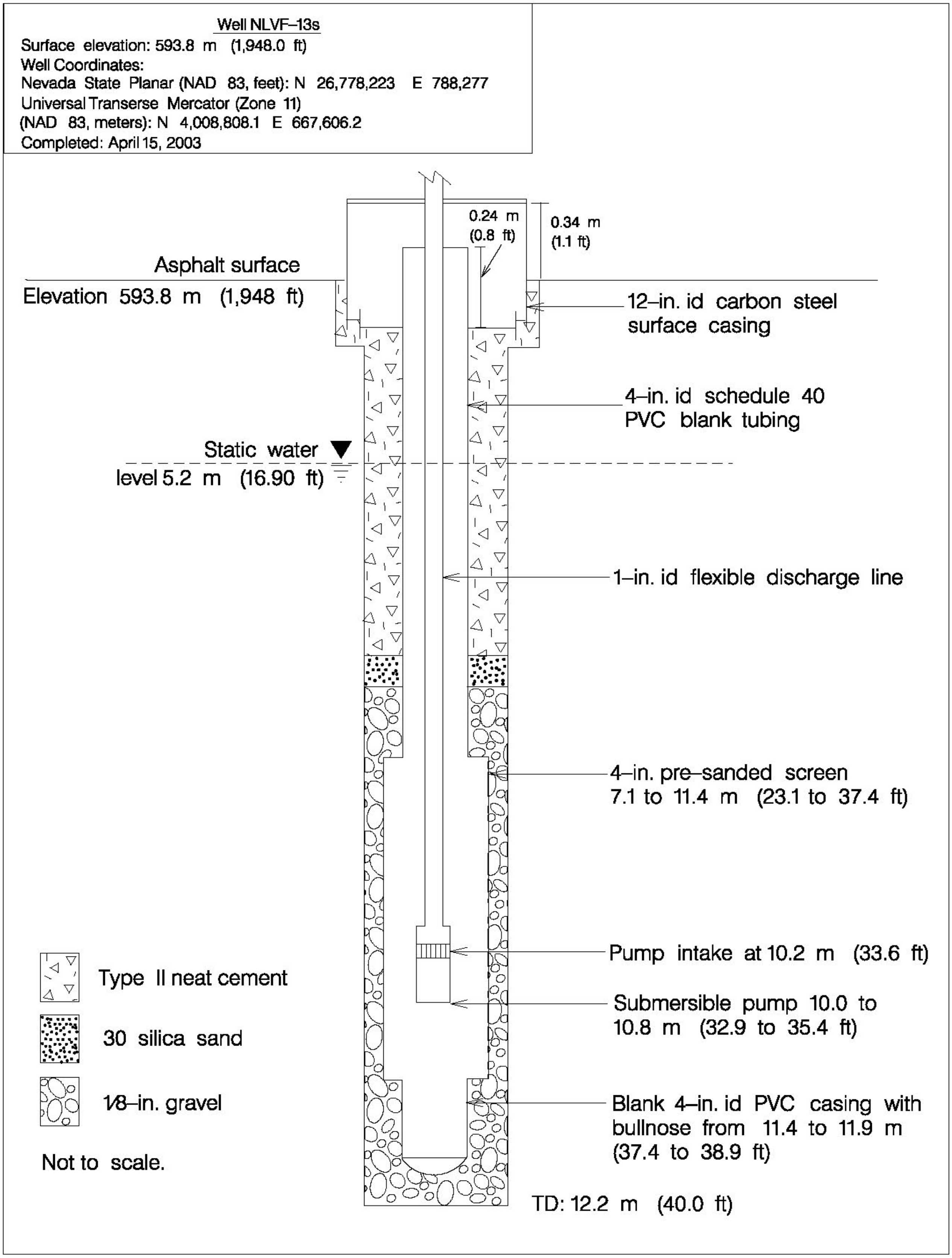


Figure B-3. Hydrogeologic setting for NLVF showing faults and aquifers



Well NLVF–13s
Surface elevation: 593.8 m (1,948.0 ft)
Well Coordinates:
Nevada State Planar (NAD 83, feet): N 26,778,223 E 788,277
Universal Transerse Mercator (Zone 11)
(NAD 83, meters): N 4,008,808.1 E 667,606.2
Completed: April 15, 2003

Figure B-4. Well construction diagram for the dewatering wells at NLVF

Groundwater monitoring activities for the dewatering project include periodic water-level measurements at all accessible wells at NLVF (including continuous measurements at the A-1 Basement Sump Well not shown on Figure B-2) and specific groundwater chemistry analyses conducted quarterly at the two dewatering wells. Water samples are analyzed for tritium and the standard field parameters: pH, conductivity, temperature, and turbidity.

Analytical results for tritium from both dewatering wells have been below the minimum detectable concentration (MDC) of 250 pCi/L. Field parameter values and tritium levels were as expected and compare well with previous sampling events. Well NLVF-12s has been pumping approximately 34,595 liters (9,140 gallons) per month in the year since it was installed, and Well NLVF-13s has pumped about 154,920 liters (40,930 gallons) per month. The average combined discharge from both dewatering wells is about 189,515 liters (50,070 gallons) per month.
Depth-to-water in the A-1 basement sump is plotted versus time (date) in Figure B-5. The raw water-level data have been corrected for barometric pressure. The low water levels depicted on the far left side of Figure B-5 reflect continued pumping of the A-1 Basement Sump Well. The A-1 basement sump pump was turned off on May 22, 2004, several days after the two dewatering wells came on-line. Figure B-5 shows a steady decrease in the water level at the A-1 Basement Sump Well due to pumping at Wells NLVF-12s and NLVF-13s up to about December 20, 2004. After this date, the water level at the A-1 Basement Sump Well has been gradually rising, possibly due to recharge associated with the higher than normal precipitation for this period.

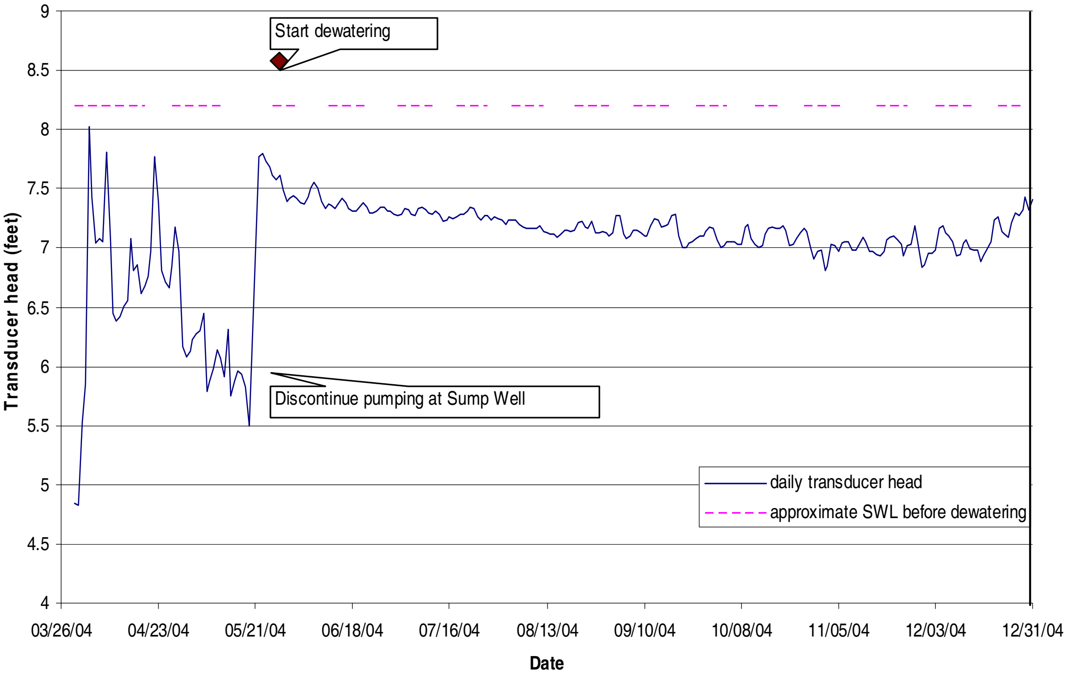


Figure B-5. Diagram showing the daily transducer head at A-1 sump

B.1.2.3 Future Work

Hydrologic modeling conducted in fiscal year 2004 (BN, 2004b) and water-level measurements collected since May 2004, indicate that the two shallow dewatering wells currently on-line are not able to control the rising groundwater beneath Building A-1. Additional dewatering wells have been proposed for fiscal year 2005. Four wells will be drilled near to Building A-1: three on the north side and one at the northwest corner. Hydrologic tests are planned to be conducted at all four wells following completion and development activities. Dedicated submersible pumps are planned for installation in the two best producing wells, and these two wells would then be added to the existing dewatering system.

In order to bring the dewatering operation on-line quickly, water will be disposed directly into the existing storm-water conveyance system. However, the long-range plan is to use the pumped water onsite for irrigation of landscape and possibly in existing cooling towers. Continued monitoring of water levels and water chemistry at selected wells is also planned. More detailed information regarding this project, including figures and data presentations, is reported in annual summary reports (BN, 2003c and BN, 2004b).

B.1.3 Compliance with Air Quality Permits

The NLVF is regulated for the emission of criteria pollutants (see Glossary, Appendix D) and hazardous air pollutants (HAPs). They include sulfur dioxide (SO_2), nitrous oxides (NO_X), carbon monoxide (CO), particulate matter (PM), volatile organic compounds (VOC), and any of 189 defined HAPs. Air quality operating permits are maintained for a variety of equipment that includes boilers, emergency generators, and a paint spray booth. There are no monitoring requirements associated with these permits. The air permits for NLVF were issued in the mid-1980s and early 1990s through the Clark County Department of Air Quality and Environmental Management (DAQEM), formerly the Clark County Health District (CCHD). Permits are amended and revised only if the situation under which the permit has been issued changes. The permits have no expiration date and are renewed automatically each year upon payment of permit fees. The DAQEM requires submittal of an annual emissions inventory. The estimated quantities of criteria air pollutants and HAPs emitted at NLVF in 2004 are presented in Table B-4. The emissions inventory for 2004 was reported to DAQEM on March 23, 2005.

Table B-4. Tons of criteria air pollutant and HAPs emissions estimated for NLVF in 2004

	Criteria Pollutant (Tons/yr)[(a)]					
Facility at NLVF	**CO**	**NO_x**	**PM**	**SO_2**	**VOC**	**HAPs (Tons/yr)**
Atlas Facility	0.034	0.129	0.004	0.002	0.004	0.00011
Losee Facility	0.106	0.491	0.035	0.032	0.040	0.0007
Nevada Support Facility	0.016	0.059	0.002	0.001	0.002	0.00008
Total	**0.156**	**0.679**	**0.041**	**0.035**	**0.046**	**0.0009**

(a) 1 ton equals 0.91 metric tons

B.1.4 Compliance with Hazardous Materials Regulations

In 2004, the chemical inventory at NLVF was updated and submitted to the state in the Nevada Combined Agency (NCA) Report on February 25, 2005, as per the requirements of the Hazardous Materials Permit 2287-5144 (see Section 2.5, Emergency Planning and Community Right-to-Know Act [EPCRA] for description of content, purpose, and federal regulatory driver behind the NCA Report). No accidental or unplanned release of an EHS occurred at NLVF in 2004. Also, no annual usage quantities of toxic chemicals kept at NLVF exceeded specified thresholds (see Section 2.5 concerning Toxic Chemical Release Inventory, Form R [TRI Report]).

B.1.5 Compliance with Radiation Protection Regulations

B.1.5.1 National Emission Standards for Hazardous Air Pollutants (NESHAP)

The Clean Air Act, Title 40 CFR 61, Subpart H (NESHAP) requires managers of U.S. Department of Energy (DOE) facilities to perform an assessment of all radionuclide air emissions caused by their operations and to estimate the radiation dose that a member of the public could receive from them. NESHAP establishes a dose limit for the general public to be no greater than 10 millirems per year (mrem/yr). Building A-1's basement was contaminated with tritium in 1995 when a container of tritium foils was opened, emitting about 1 Curie of tritium (DOE, 1996b). 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. Two air samples were collected from the basement in 2004 (from March 29 to April 6 and from September 1 to September 7). As in previous years, the calculated radiation dose to the nearest member of the general public, located 100 m northwest of the building vent pipe, was less than 2 microrems (μrem)/yr.

B.1.5.2 DOE Order 5400.5

DOE Order 5400.5 *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 the 100 mrem/yr as a result of DOE activities. This dose limit does not include the dose contribution from natural background radiation. The facilities at NLVF which use radioactive sources or where radiation-producing operations are conducted which have the potential to expose the general population or non-project personnel to direct radiation are the Atlas A-1 Source Range Laboratory and the Building C-3 High Intensity Source Building. BN's Environmental Technical Services (ETS) conducts direct radiation monitoring at the site. ETS utilizes thermoluminescent dosimeters (TLDs) to monitor external gamma radiation exposure near the boundaries of these NLVF facilities. The methods of TLD use and data analyses are described in Section 5.0 of this report.

In 2004, two TLD stations were placed along the perimeter fence and one was placed in a control location. The resultant annual exposure rates estimated for those NLVF locations potentially accessible to the public are summarized in Table B-5. These exposures were all less than the 100 mrem/yr dose limit.

Table B-5. Results of 2004 direct radiation exposure monitoring at NLVF

Location	Number of Samples	Gamma Exposure (mR/yr)			
		Mean	Median	Minimum	Maximum
Control	4	70	71	67	72
North Fence of A-1	4	62	63	60	65
North Fence of Bldg C-3	4	64	64	62	66

B.2 Cheyenne Las Vegas Facility

The CLVF Facility is located at the Flynn Gallagher Corporate Center on West Cheyenne Avenue in northwest Las Vegas. It is comprised of five buildings which house engineering, procurement, and administrative functions. Access to the facility requires proper identification, badging, and a security access card. Facility and infrastructure maintenance is provided by the facility owner. No environmental monitoring or compliance activities are conducted at or for this facility.

B.3 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 NLVF. It occupies six facilities on approximately 14 secured hectares (35 acres) at the Nellis Air Force Base. The six NNSA/NSO facilities were constructed on property owned by the U.S. Air Force. There is a Memorandum of Agreement between the U.S. Air Force and the NNSA whereby the land belongs to the Air Force, but is under lease to the NNSA for 25 years (as of 1989) with an option for a 25-year extension. The facilities are owned by NNSA/NSO. RSL - Nellis provides emergency response resources for weapons-of-mass-destruction incidents. The laboratory also designs and field tests counter-terrorism/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 include maintenance of a wastewater contribution permit, six air quality permits, and a hazardous materials permit (Table B-6). Sealed radiation sources are used for calibration at RSL - Nellis, but the public has no access to any area which may have elevated gamma radiation emitted by the sources. Therefore, no environmental TLD monitoring is conducted. Dosimetry monitoring to ensure protection of personnel who work within the facility is performed, however.

Table B-6. Environmental permits for RSL - Nellis

Permit Number	Description	Expiration Date	Reporting
Wastewater Discharge			
CCWRD-080	Industrial Wastewater Discharge Permit	June 30, 2005	March, May, September, December
Air Quality			
A34801	Boiler, Columbia, WL-180	None	March, June
A34802	Boiler, Columbia, WL-90	None	March, June
A34803	Water Heater, #2 Natl. BD	None	March, June
A34804(a)	Emergency Fire Control Pump Engine	None	June
A34804(b)	Emergency Generator, Cummins	None	June
A34805	Spray Paint Booth	None	June
Hazardous Materials			
2287-5145	RSL - Nellis Hazardous Materials Permit	February 28, 2005	Annually

B.3.1 Compliance with Wastewater Contribution Permit CCWRD-080

Discharges of wastewater from RSL - Nellis are required to meet permit limits set by the Clark County Water Reclamation District (CCWRD). These limits support the permit limits for the POTW operated by Clark County. The wastewater permit for this facility requires quarterly monitoring and reporting. Table B-7 presents the mean concentration of outfall measurements collected once per quarter in 2004. All contaminants in the outfall samples fell below permit limits. Quarterly reports were submitted on March 3, May 6, September 7, and December 1, 2004 to the CCWRD. The CCWRD also conducted two inspections of RSL - Nellis in 2004. The inspections resulted in no findings or corrective actions for the facility.

Table B-7. Mean concentration of outfall measurements at RSL - Nellis in 2004

Contaminant/Measure	Permit Limit	Outfall
	mg/L	
Ammonia	NL[(a)]	16.28
Cadmium	0.35	0.0011
Chromium (Total)	1.7	0.0028
Copper	3.36	0.233
Cyanide (Total)	1	0.065
Lead	0.99	0.005
Nickel	10.08	0.0055
Phosphorus	NL	7.83
Silver	6.3	0.0063
TDS	NL	935
TSS	NL	88.55
Zinc	23.06	0.427
	Standard Units	
pH	5.0 – 11.0	7.93
	Degrees Fahrenheit	
Temperature	140	73.1

(a) No limit listed on permit

B.3.2 Compliance with Air Quality Permits

RSL - Nellis is regulated for the emission of criteria pollutants and HAPs. Air quality operating permits are maintained for a variety of equipment (see Table B-6). There are no monitoring requirements associated with these permits. The air permits for RSL - Nellis were issued in the mid-80's and early 90's through the DAQEM. Permits are amended and revised only if the situation under which the permit has been issued changes. The permits have no expiration date and are renewed automatically each year upon payment of permit fees. The DAQEM requires submittal of the annual emissions inventory. The estimated quantities of criteria air pollutants and HAPs emitted at RSL - Nellis in 2004 are presented in Table B-8. Natural gas consumption is also reported as per the requirements of Permit #A34803 issued for the water heater (see Table B-6). The emissions inventory for 2004 was reported to DAQEM on March 23, 2005.

Table B-8. Summary of air emissions for RSL - Nellis in 2004

Criteria Pollutant (Tons/yr)[(a)]					HAPs (Tons/yr)	Natural Gas Consumption (ft^3)
CO	NO_x	PM	SO_2	VOC		
0.734	1.268	0.078	0.022	0.067	0.007	7,087,152

(a) 1 ton equals 0.91 metric tons

B.3.3 Compliance with Hazardous Materials Regulations

In 2004, the chemical inventory at RSL - Nellis was updated and submitted to the state in the Nevada Combined Agency (NCA) Report on February 25, 2005, as per the requirements of the Hazardous Materials Permit 2287-5145 (see Section 2.5 of this NTSER for description of content, purpose, and federal regulatory driver behind the NCA Report). No accidental or unplanned release of an EHS occurred at RSL - Nellis in 2004. Also, no annual usage quantities of toxic chemicals kept at RSL - Nellis exceeded specified thresholds (see Section 2.5 concerning Toxic Chemical Release Inventory, Form R [TRI Report]).

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Appendix C

Helpful Information

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Appendix C: Helpful Information

C.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 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}.

C.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 C-1.

Table C-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	0.000,000,1 (1×10^{-9})
pico-	p	0.000,000,000,0001 (1×10^{-12})

C.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 C-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 are 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 C-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)
aCi	attocurie (1×10^{-18} Ci)

C.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 C-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 percent of the time. Exposure to lower amounts of

Table C-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)

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.

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 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, one roentgen 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 D). A list of the radionuclides discussed in this report, their symbols, and their half-lives are presented in the box below.

C.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 mrem. These units are the becquerel (Bq) and the millisievert (mSv), respectively. The Bq and Sv belong to the International System of Units (SI), and their inclusion in this report is mandated by U.S. Department of Energy. 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 C-4 provides the multiplication factors for converting to and from SI units.

Table C-4. Conversion table for SI units

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

C.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 used in this report are shown in Table C-5 along with the half-life of each radionuclide. The half-life is the time required for one-half 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.

Table C-5. Radionuclides and their half-lives

Symbol	Radionuclide	Half-Life (a)
^{241}Am	americium-241	432.2 yr
^{7}Be	beryllium-7	53.44 d
^{14}C	carbon-14	5,730 yr
^{134}Cs	cesium-134	2.1 yr
^{137}Cs	cesium-137	30 yr
^{51}Cr	chromium-51	27.7 d
^{60}Co	cobalt-60	5.3 yr
^{152}Eu	europium-152	13.3 yr
^{154}Eu	europium-154	8.8 yr
^{155}Eu	europium-155	5 yr
^{3}H	tritium	12.35 yr
^{129}I	iodine-129	1.6 x 10^{7} yr
^{131}I	iodine-131	8 d
^{40}K	potassium-40	1.3 x 10^{8}yr
^{85}Kr	krypton-85	10^{7} yr
^{212}Pb	lead-212	10.6 h
^{238}Pu	plutonium-238	87.7 hr
^{239}Pu	plutonium-239	2.4 x 10^{4} yr
^{240}Pu	plutonium-240	6.5 x 10^{3} yr
^{241}Pu	plutonium-241	14.4 yr
^{226}Ra	radium-226	1.62 x 10^{3} yr

C.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 C-6.

Table C-5. (continued)

Symbol	Radionuclide	Half-Life [(a)]
^{228}Ra	radium-228	5.75 yr
^{220}Rn	radon-220	56 s
^{222}Rn	radon-222	3.8 d
^{103}Ru	ruthenum-103	39.3 d
^{106}Ru	ruthenum-106	368.2 d
^{125}Sb	antimony-125	2.8 yr
^{113}Sn	tin-113	115 d
^{90}Sr	strontium-90	29.1 yr
^{99}Tc	technetium-99	2.1 x 10^{5} yr
^{232}Th	thorium-131	1.4 x 10^{10} yr
U [(b)]	uranium total	- - - [(c)]
^{234}U	uranium-234	2.4 x 10^{5} yr
^{235}U	uranium-235	7 x 10^{8} hr
^{238}U	uranium-238	4.5 x 10^{9} yr
^{65}Zn	zinc-65	243.9 d
^{95}Zr	zirconium-95	63.98 d

(a) From Shleien, 1992.
(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 x 10^{9} years.

Table C-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 (m3)	35.32 cubic feet (ft^{3})	1 cubic foot (ft^{3})	0.028 cubic meters (m^{3})
	1.35 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)	28.6 gram (g)
1 kilogram (kg)	2.21 pounds (lb)	1 pound (lb)	0.373 kilograms (kg)
1 metric ton (mton)	1.10 short ton (2000 pounds)	1 short ton (2000 pounds)	0.90718 metric ton (mton)
Geographic area			
1 hectare	2.47 acres	1 acre	0.40 hectares
Radioactivity			
1 becquerel (Bq)	2.7 x 10^{-11} curie (Ci)	1 curie (Ci)	3.7 x 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 x 1.8) + 32	

C.8 Uncertainty of Measurements

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 percent 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), the sample may not contain that constituent. Such low concentration values are considered to be below detection, meaning the concentration of the constituent in the sample is so low that it is undetected by the method and/or instrument.

C.9 Standard Error of the Mean

Just as individual values are accompanied by counting uncertainties, mean values (averages) are accompanied by uncertainty, known as the standard error of the mean (SE). The SE conveys how accurate of 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 x SE (2 multiplied by the SE). The ± value implies that approximately 95 percent of the time the average of many calculated means will fall somewhere between the reported value minus the 2 x SE value and the reported value plus the 2 x SE value.

C.10 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.

C.11 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 a true 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.

C.12 Understanding Graphic Information

Some of the data graphed in this report are plotted using logarithmic, or compressed, scales. Logarithmic (log) scales are used in plots where the values are of widely different magnitudes at different locations and/or different times.

Log scales use equal distances to represent equal <u>ratios</u> of values, whereas in linear scales equal distances represent equal <u>differences</u> in values. For example, a log scale would use the same distance to represent a change from 2 to 4 as a change from 10 to 20 or a change from 700 to 1400.

For example, compare Figures C-1 and Figure C-2. Figure C-1 shows long-term trends in mean ^3H concentrations. The use of the log scale for the concentration (vertical) axis allows the variation in measurements in all areas of NTS to be seen for the entire time history. Figure C-2 contains the same data, but uses a linear scale for the concentrations. In Figure C-2 only the variation in the highest values (pre-1987 values from Area 23) can be seen clearly; nearly all of the rest of the values are smudges along the bottom of the graph.

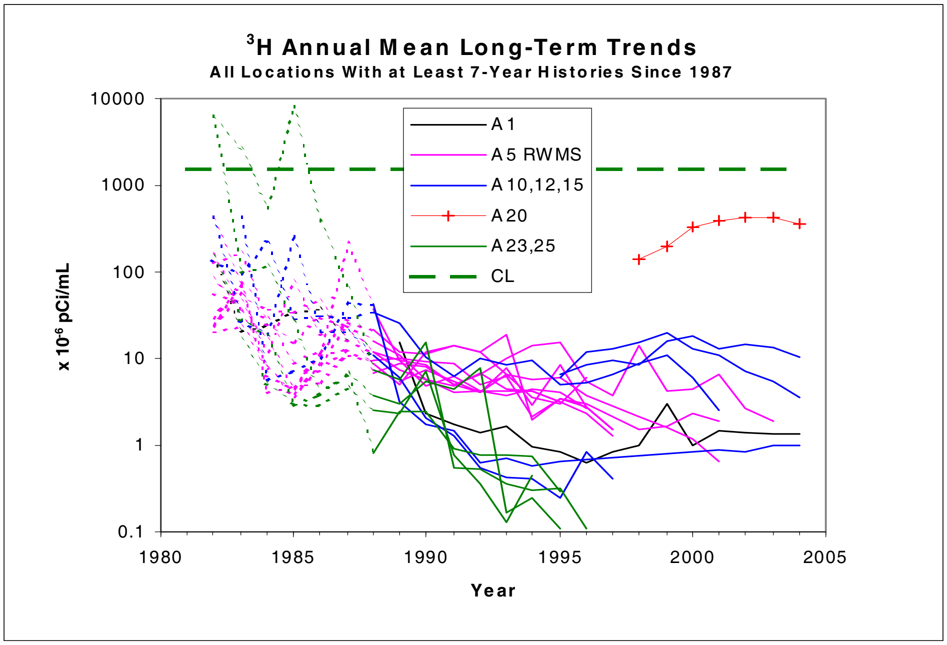

Figure C-1. Data plotted using a log scale

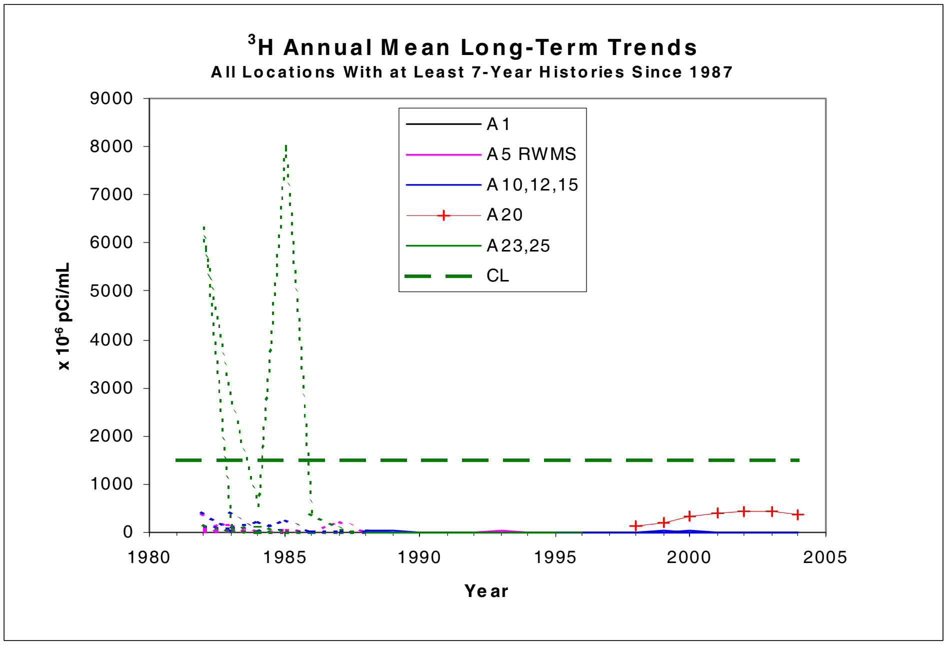

Figure C-2. Data plotted using a linear scale

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Appendix D: Glossary

A **Absorbed dose:** the amount of energy imparted to matter by ionizing radiation per unit mass of irradiated material, in which the absorbed dose is expressed in units of rad or gray (1 rad = 0.01 gray).

Accuracy: the closeness of the result of a measurement to the true value of the quantity measured.

Action level: defined by regulatory agencies, the level of pollutants which, if exceeded, requires regulatory action.

Aerosol: a gaseous suspension of very small particles of liquid or solid.

Alluvium: sediment deposited by flowing water.

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.

Ambient air: the surrounding atmosphere, usually the outside air, as it exists around people, plants, and structures; not considered in monitoring purposes when immediately adjacent to emission sources.

Analyte: the specific component measured in a chemical analysis.

Anion: a negatively charged ion, such as Cl^-.

Aquifer: a saturated layer of rock or soil below the ground surface that can supply usable quantities of ground water to wells and springs, and be a source of water for domestic, agricultural, and industrial uses.

Aquitard: low-permeability geologic formation that bounds an aquifer.

Atom: the smallest particle of an element capable of entering into a chemical reaction.

B **Background:** as used in this report, background is the term for the amounts of chemical constituents or radioactivity in the environment which are not caused by NTS operations.

Becquerel (Bq): the SI 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 ^{137}Cs.

Biochemical (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:** computer code required by the EPA for modeling air emissions of radionuclides.

Chain-of-custody: a method for documenting the history and possession of a sample from the time of its collection, through its analysis and data reporting, to its final disposition.

Code of Federal Regulations (CFR): a codification of all regulations promulgated by federal government agencies.

Collective population dose: the sums of the dose equivalents or effective dose equivalents to all individuals in an exposed population within 80 km (50 mi) of the radiation source. These are evaluated by multiplying the dose received by an individual at each location by the number of individuals receiving that dose, and summing over all such products for locations within 80 km of the source. They are expressed in units of person-rem or person-sievert. The collective EDE is also referred to as the "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; 100 rem equals one sievert).

Committed effective dose equivalent: 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.

Compliance Level (CL): stands for the Clean Air Act National Emission Standards for Hazardous Air Pollutants Concentration Level for Environmental Compliance. The CL value represents the annual average concentration which would result in a dose of 10 mrem/yr which is the federal dose limit to the public from all radioactive air emissions.

Cosmic radiation: radiation with very high energies originating outside the earth's atmosphere; it is one source contributing to natural background radiation.

Criteria pollutants: those air pollutants designated by the Environmental Protection Agency as potentially harmful and for which National Ambient Air Quality Standards (NAAQS) 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 NTS 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 as well as a criteria pollutant, and lead emissions on the NTS are reported as part of the total HAPs emissions. Lead emissions above a specified threshold are also reported under Section 313 of the Emergency Planning and Community Right-to-Know Act.

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} disintegrations per second or 2.22×10^{12} disintegrations per minute; 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 95 percent confidence that the sample contains radioactive material above the background.

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; see Table 3-7 and related discussion.

Derived Concentration Guide (DCG): concentrations of radionuclides in water and air that could be continuously consumed or inhaled for one year and not exceed the DOE primary radiation standard to the public (100 mrem/y EDE).

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 commitment: the dose that an organ or tissue would receive during a specified period of time (typically 50 or 70 years) as a result of one year's intake of one or more radionuclides.

Dose equivalent: the product of absorbed dose in rad (or gray) in tissue and a quality factor representing the relative damage caused to living tissue by different kinds of radiation, and perhaps other modifying factors representing the distribution of radiation, etc. expressed in units of rem or sievert (1 rem = 0.01 sievert).

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.

Downgradient: in the direction of groundwater flow from a designated area; analogous to downstream.

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 nonuniform exposure of the body to be expressed in terms of an effective dose equivalent that is numerically equal to the dose from a uniform exposure of the whole body that entails the same risk as the internal exposure (ICRP 1980). The effective dose equivalent includes the committed effective dose equivalent from internal deposition of radionuclides and the effective dose equivalent caused by penetrating radiation from sources external to the body, and is expressed in units of rem (or sievert).

Effluent: used in this report to refer to a liquid discharged to the environment.

Emission: used in this report to refer to a vapor, gas, air-borne particulate, or radiation discharged to the environment via the air.

Environmental Impact Statement (EIS): a detailed report, required by the National Environmental Policy Act, on the environmental impacts from a federally approved or funded project. An EIS must be prepared by a federal agency when a "major" federal action that will have "significant" environmental impacts is planned.

F **Federal facility:** a facility that is owned or operated by the federal government, subject to the same requirements as other responsible parties when placed on the Superfund National Priorities List.

Federal facility agreement (FFA): a negotiated agreement that specifies required actions at a federal facility as agreed upon by various agencies (e.g., EPA, DOE, DoD).

Federal Register: a document published daily by the federal government containing notification of government agency actions, including notification of EPA and DOE decisions concerning permit applications and rule-making.

Fiscal year: NNSA/NSO's fiscal year is from October 1 through September 30.

G **Gamma ray:** high-energy, short-wavelength, electromagnetic radiation emitted from the nucleus of an atom, frequently accompanying the emission of alpha or beta particles.

Gray (Gy): the SI 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 which 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 which 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.

Groundwater: all subsurface water.

H **Half-life:** the time required for one-half 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 waste: hazardous wastes exhibit any of the following characteristics: ignitability, corrosivity, reactivity, or EP-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 EPA. Although the legal definition of hazardous waste is complex, according to 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 filter (HEPA): a throwaway, extended-media, dry type filter used to capture particulates in an air stream; HEPA collection efficiencies are at least 99.97% for 0.3 micrometer diameter particles.

Hydraulic gradient: in an aquifer, the rate of change of total head (water-level elevation) per unit distance of flow at a given point and in a given direction.

Hydrology: the science dealing with the properties, distribution, and circulation of natural water systems.

I **Inorganic compounds:** compounds that either do not contain carbon or do not contain hydrogen along with carbon, including metals, salts, various carbon oxides (e.g., carbon monoxide and carbon dioxide), and cyanide.

In situ: in the natural or original position. Generally refers to measurements taken in the environment or to the treatment of contaminated areas in place without excavation or removal.

Interim status: a legal classification allowing hazardous waste incinerators or other hazardous waste management facilities to operate while EPA considers their permit applications, provided that they were under construction or in operation by November 19, 1980 and can meet other interim status requirements.

Isotopes: forms of an element having the same number of protons in their nuclei, but differing numbers of neutrons.

L **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 radioactive waste (LLW): waste defined by DOE Order 5820.2A, which contains transuranic nuclide concentrations less than 100 nCi/g.

Lower limit of detection: the smallest concentration or amount of analyte that can be detected in a sample at a 95% confidence level.

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.

Metric units: Metric system and U.S. customary units and their respective equivalents are shown in Table C-6. Except for temperature for which specific equations apply, U.S. customary units can be determined from metric units by multiplying the metric units by the U.S. customary equivalent. Similarly, metric units can be determined from U.S. customary equivalent units by multiplying the U.S. customary units by the metric equivalent.

Mixed waste (MW): waste that has the properties of both hazardous and radioactive waste.

N **National Emission Standards for Hazardous Air Pollutants (NESHAPs):** standards found in the Clean Air Act that set limits for hazardous air pollutants.

National Pollutant Discharge Elimination System (NPDES): federal regulation under the Clean Water Act that requires permits for discharges into surface waterways.

Nonpoint source: any nonconfined area from which pollutants are discharged into a body of water (e.g., agricultural runoff, construction runoff, and parking lot drainage), or into air (e.g., a pile of uranium tailings).

O **Offsite:** for effluent releases or in the nuclear testing area, offsite is any place outside the NTS and adjacent NTTR.

Onsite: for effluent releases or in the nuclear testing area, onsite is any place inside the NTS and adjacent NTTR.

P **Part B permit:** the second, narrative section submitted by generators in the RCRA permitting process that covers in detail the procedures followed at a facility to protect human health and the environment.

Parts per billion (ppb): a unit of measure for the concentration of a substance in its surrounding medium; for example, one billion grams of water containing one gram of salt has a salt concentration of one part per billion.

Parts per million (ppm): a unit of measure for the concentration of a substance in its surrounding medium; for example, one million grams of water containing one gram of salt has a salt concentration of one part per million.

Perched aquifer: aquifer that is separated from another water-bearing stratum by an impermeable layer.

Performance standards (incinerators): specific regulatory requirements established by EPA limiting the concentrations of designated organic compounds, particulate matter, and hydrogen chloride in incinerator emissions.

pH: a measure of hydrogen ion concentration in an aqueous solution. Acidic solutions have a pH from 0 to 7; basic solutions have a pH greater than 7; and neutral solutions have a pH of 7.

Pliocene: geological epoch of the Tertiary period, starting about 12 million years ago.

PM-10: fine particulate matter with an aerodynamic diameter equal to or less than 10 microns.

Point source: any confined and discrete conveyance (e.g., pipe, ditch, well, or stack).

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.

Quaternary: the geologic era encompassing the last 2–3 million years.

R **Rad:** the unit of absorbed dose and the quantity of energy imparted by ionizing radiation to a unit mass of matter such as tissue, and equal to 0.01 joule per kilogram, or 0.01 gray.

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.

Radionuclide: an unstable nuclide. See nuclide and radioactivity.

Rem: a unit of radiation dose equivalent and effective dose equivalent describing the effectiveness of a type of radiation to produce biological effects; coined from the phrase "roentgen equivalent man," and the product of the absorbed dose (rad), a quality factor (Q), a distribution factor, and other necessary modifying factors. One rem equals 0.01 sievert.

Risk assessment: the use of established methods to measure the risks posed by an activity or exposure by evaluating the relationship between exposure to radioactive substances and the subsequent occurrence of health effects and the likelihood for that exposure to occur.

Roentgen (R): a unit of measurement used to express radiation exposure in terms of the amount of ionization produced in a volume of air.

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 subsurface zone below which all rock pore-space is filled with water; also called the phreatic zone.

Sensitivity: the capability of methodology or instrumentation to discriminate between samples having differing concentrations or containing varying amounts of analyte.

Sievert (Sv): the SI unit of radiation dose equivalent and effective dose equivalent, that is the product of the absorbed dose (gray), quality factor (Q), distribution factor, and other necessary modifying factors. 1 Sv equals 100 rem.

Source term: amount of a specific pollutant emitted or discharged to a particular medium, such as the air or water, from a particular source.

Specific conductance: measure of the ability of a material to conduct electricity; also called conductivity.

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 Test Ban Treaty.

Surface impoundment: a facility or part of a facility that is a natural topographic depression, manmade excavation, or diked area formed primarily of earthen materials, although it may be lined with man-made materials. The impoundment is designed to hold an accumulation of liquid wastes, or wastes containing free liquids, and is not an injection well. Examples of surface impoundments are holding, storage, settling and aeration pits, ponds, and lagoons.

Système International d'Unités (SI): an international system of physical units which include meter (length), kilogram (mass), kelvin (temperature), becquerel (radioactivity), gray (radioactive dose), and sievert (dose equivalent).

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 dissolved solids (TDS): the portion of solid material in a waste stream that is dissolved and passed through a filter.

Total organic carbon (TOC): the sum of the organic material present in a sample.

Total organic halides (TOX): the sum of the organic halides present in a sample.

Total suspended solids (TSS): the total mass of particulate matter per unit volume suspended in water and wastewater discharges that is large enough to be collected by a 0.45 micron filter.

Transpiration: a process by which water is transferred from the soil to the air by plants that take the water up through their roots and release it through their leaves and other aboveground tissue.

Tritium: a radioactive isotope of hydrogen, containing one proton and two neutrons in its nucleus, which decays at a half-life of 12.3 years by emitting a low-energy beta particle.

Transuranic waste (TRU): 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 nCi/g of waste.

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.

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; is also referred to as the vadose zone.

V **Vadose zone:** the partially saturated or unsaturated region above the water table that does not yield water to wells.

Volatile organic compound (VOC): liquid or solid organic compounds that have a high vapor pressure at normal pressures and temperatures and thus tend to spontaneously pass into the vapor state.

W **Waste accumulation area (WAA):** an officially designated area that meets current environmental standards and guidelines for temporary (less than 90 days) storage of hazardous waste before off-site disposal.

Wastewater treatment system: a collection of treatment processes and facilities designed and built to reduce the amount of suspended solids, bacteria, oxygen-demanding materials, and chemical constituents in wastewater.

Water table: the water-level surface below the ground at which the unsaturated zone ends and the saturated zone begins, and the level to which a well that is screened in the unconfined aquifer would fill with water.

Weighting factor: a tissue-specific value used to calculate dose equivalents which 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 (ICRP 1980).

Wind rose: a diagram that shows the frequency and intensity of wind from different directions at a specific location.

Appendix E: Acronyms and Abbreviations

AA	alluvial aquifer
ac	acres
AEA	Atomic Energy Act
ALARA	as low as reasonably achievable
ARL	Air Resources Laboratory
ASER	Annual Site Environmental Report
ARPA	Archeological Resources Protection Act
ASA	Auditable Safety Analysis
ASN	Air Surveillance Network
ASTM	American Standard for Testing and Materials
ATM	Atomic Testing Museum
BCG	Biota Concentration Guide
BEEF	Big Explosives Experimental Facility
BEIDMS	Bechtel Environmental Integrated Data Management System
bgs	below ground surface
BHPS	Bureau of Health Protection Services
BLM	Bureau of Land Management
BN	Bechtel Nevada
BOD	biological oxygen demand
BP	before present
BPW	bulk product waste
BREN	Bare Reactor Experiment Nevada
Bq	Becquerel
°C	degree Celsius
ca.	*circa,* meaning "approximately"
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 (EPA software program for estimating doses)
CAS	Corrective Action Site
CAU	Corrective Action Unit
CCHD	Clark County Health District
cc/min	cubic centimeters per minute
CCWRD	Clark County Reclamation District
CEDE	committed effective dose equivalent
CEM	Community Environmental Monitor
CEMP	Community Environmental Monitoring Program
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfm	cubic feet per minute
CFR	Code of Federal Regulations
CG	cloud-to-ground
CGTO	Consolidated Group of Tribes and Organizations
Ci	curie
cm	centimeter(s)
CL	Compliance Level (used in text for the Clean Air Act National Emission Standards for Hazardous Pollutants Concentration Level for Environmental Compliance)
CLVF	Cheyenne Las Vegas Facility (BN)
CNLV	City of North Las Vegas
CO	carbon monoxide
CP	Control Point
CRM	Cultural Resources Management
CWA	Clean Water Act
CX	categorical exclusion

CY	calendar year
d	day
DAF	Device Assembly Facility
DAS	Disposal Authorization Statement
DCG	Derived Concentration Guide
D&D	Deactivation and Disposal
DEA	Dose Evaluation Area
DNWR	Desert National Wildlife Refuge
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOE/HQ	DOE Headquarters
DOT	U.S. Department of Transportation
DQA	Data Quality Assessment
DQO	Data Quality Objectives
DRI	Desert Research Institute, University and Community College System, Nevada
DTRA	Defense Threat Reduction Agency
EA	Environmental Assessment
EDE	effective dose equivalent
EHS	extremely hazardous substances
EIS	Environmental Impact Statement
EM	environmental monitor
EMAC	Ecological Monitoring and Compliance Program
EML	Environmental Measurements Laboratory
EMS	Environmental Management System
EO	Executive Order
EODU	Explosive Ordnance Disposal Unit
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Reporting and Community Right-to-Know Act
ER	Environmental Restoration

ERA	Environmental Resource Associates
ES	Environmental Services (BN)
ESA	Endangered Species Act
ESHD	Environment, Safety and Health Division
ET	evapotranspiration
ETS	Environmental Technical Services (BN)
°F	degree Fahrenheit
FEMA	Federal Emergency Management Agency
FFACO	Federal Facilities Agreement and Consent Order
FFCA	Federal Facilities Compliance Act
FIFRA	Federal Insecticide, Fungicide, Rodenticide Act
ft	foot or feet
ft^3	cubic feet
ft^3/hr	cubic feet per hour
FWS	U.S. Fish and Wildlife Service
FY	fiscal year
g	gram(s)
gal	gallon(s)
GCD	Greater Confinement Disposal
GIS	Geographic Information System
gpm	gallons per minute
GPS	global positioning satellite
Gy	gray
ha	hectare
HAP	hazardous air pollutant
HDP	heat dissipation probe
HENRE	High Energy Neutron Reactions Exxperiment
HEPA	high efficiency particulate air
HGU	hydrogeologic unit

hr	hour
HRMP	Hydrologic Resources Management Program
HSU	hydrostratigraphic unit
HTO	tritiated water
HW	hazardous waste
HWSU	hazardous waste storage unit
ICMP	Integrated Closure and Monitoring Plan
in	inch(es)
INEEL	Idaho National Engineering and Environmental Laboratory
ISMS	Integrated Safety Management System
IT	International Technology
JASPER	Joint Actinide Shock Physics Experimental Research
kg	kilogram(s)
km	kilometer(s)
km^2	square kilometer(s)
kmph	kilometer(s) per hour
LANL	Los Alamos National Laboratory
LAO	Los Alamos Operations (BN)
lb	pound
LCA	lower carbonate aquifer
LCA3	lower carbonate aquifer, upper thrust plate
LCCU	lower clastic confining unit
LCS	laboratory control samples
LFA	lava-flow aquifer
LLNL	Lawrence Livermore National Laboratory
LLW	low level radioactive waste
L/min	liters per minute
LO	Livermore Operations (BN)
lpm	liters per minute

LQAP	Laboratory Quality Assurance Plan
μBq/m^3	microbecquered per cubic meter
μCi/mL	microcurie per milliliter
m	meter(s)
m^3	cubic meter(s)
Ma	million years ago
MAPEP	Mixed Analyte Performance Evaluation Program
MBTA	Migratory Bird Treaty Act
MCL	maximum contaminant level
MDC	minimum detectable concentration
MEDA	meteorological data acquisition
MEI	maximally exposed individual
MGCU	Mesozoic granite confining unit
mGy/d	milligray per day
mi	miles
mi^2	square miles
MLU	Mobile Loading Unit
mm	millimeter(s)
M&O	Management and Operations
MQO	Measurement Quality Objectives
mR	milliroentgen
mrem/yr	millirem per year
MSA	Management Self-Assessments
MSDS	Material Safety Data Sheet
mSv/yr	millisievert per day
mton	metric ton
MW	mixed low level radioactive waste
NAAQS	National Ambient Air Quality Standards
NAC	Nevada Administrative Code

NAGPRA	Native American Graves Protection and Repatriation Act of 1990
NCA	Nevada Combined Agency
NCRP	National Council on Radiation Protection
NDEP	Nevada Division of Environmental Protection
NDOA	Nevada Department of Agriculture
NDWS	Nevada Drinking Water Standards
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NHPA	National Historic Preservation Act
NLV	North Las Vegas
NLVF	North Las Vegas Facility (BN)
NNSA/NSO	U. S. Department of Energy, National Nuclear Security Administration Nevada Site Office
NNSA/NV	U.S. Department of Energy, National Nuclear Security Administration Nevada Operations Office
NOx	nitrous oxides
NPDES	National Pollution Discharge Elimination System
NPTEC	Non-Proliferation Test and Evaluation Complex
NRHP	National Register of Historic Places
NRS	Nevada Revised Statues
NSDO	Nevada State Demographer Office
NSPS	New Source Performance Standards
NTS	Nevada Test Site
NTSER	Nevada Test Site Environmental Report
NTSWAC	Nevada Test Site Waste Acceptance Criteria
NTTR	Nevada Test and Training Range
NVLAP	National Voluntary Laboratory Accreditation Program
ODS	ozone-depleting substances
OI	Operating Instruction
oz	ounce(s)
P2	pollution prevention

P2/WM	pollution prevention/waste minimization
PA	Performance Assessment
PAAA	Price-Anderson Amendments Act
Pb	lead
PCB	polychlorinated biphenyl
pCi/L	picocuries per liter
PHS	Public Health Service
PIC	pressurized ion chamber
PM	particulate matter
PM-OV	Pahute Mesa-Oasis Valley
POTW	publicly-owned treatment works
PST	Pacific Standard Time
PT	proficiency testing
PTE	potential to emit
PWS	public water systems
QA	quality assurance
QAP	Quality Assurance Program
QAPP	Quality Assurance Program Plan
QC	quality control
R	roentgen
RCD	Radiological Control Department
RCRA	Resource Conservation and Recovery Act
RER	Relative Error Ratio
RFP	request for proposal
RIDP	Radionuclide Inventory and Distribution Program
R-MAD	Reactor Maintenance, Assembly, and Disassembly
RPD	Relative Percent Difference
RREMP	Routine Radiological Environmental Monitoring Plan
RSL	Remote Sensing Laboratory

RWMC	Radioactive Waste Management Complex
RWMS	Radioactive Waste Management Site
SA	Supplement Analysis
SAFER	Streamlined Approach for Environmental Restoration
SARA	Superfund Amendments and Reauthorization Act
SCCC	Silent Canyon caldera complex
SDWA	Safe Drinking Water Act
SE	standard error of the mean
SHPO	Nevada State Historic Preservation Office
SI	International System of Units
SNL	Sandia National Laboratory
SNJV	Stoller-Navarro Joint Venture
SOP	Standard Operating Procedure
SORD	Special Operations and Research Division
SOW	Statement of Work
SO_2	sulfur dioxide
SSC	Structures, Systems, and Components
STL	Special Technologies Laboratory
STP	standard temperature and pressure
SWL	static water level
SWNVF	Southwest Nevada Volcanic Field
SWO	Solid Waste Operations
TaDD	Tactical Demilitarization Development Project
TCP	thermocouple psychrometer
TCU	tuff confining unit
TDR	time domain reflectometry
TDS	total dissolved solids
TLD	thermoluminescent dosimeter
TMA	Timber Mountain aquifer

TMCC	Timber Mountain caldera complex
TPCB	Transuranic Pad Cover Building
TRI	Toxic Release Inventory
TRU	transuranic
TSCA	Toxic Substances Control Act
TSS	total suspended solids
TTR	Tonopah Test Range
UCCU	upper clastic confining unit
UGTA	Underground Test Area
U.S.	United States
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
UST	underground storage tank
VCU	volcaniclastic confining unit
VOC	volatile organic compounds
VTA	vitric-tuff aquifer
VZM	vadose zone monitoring
WEF	Waste Examination Facility
WGS	Waste Generation Services
WIPP	Waste Isolation Pilot Plant
WMO	World Meteorological Organization
WSI	Wackenhut Services, Inc.
WSS	Work Smart Standards
WTA	welded-tuff aquifer
WVCU	Wahmonie volcanic confining unit
yd	yard
yd^3	cubic yards
YF-LCU	Yucca Flat lower confining unit
YMP	Yucca Mountain Project

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Public Reading Facility, Nuclear Testing Archive, Nevada Site Office, U.S. Department of Energy, National Nuclear Security Administration P.O. Box 98521 Las Vegas, NV 89193-8521M/S 400 (1 HC)

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