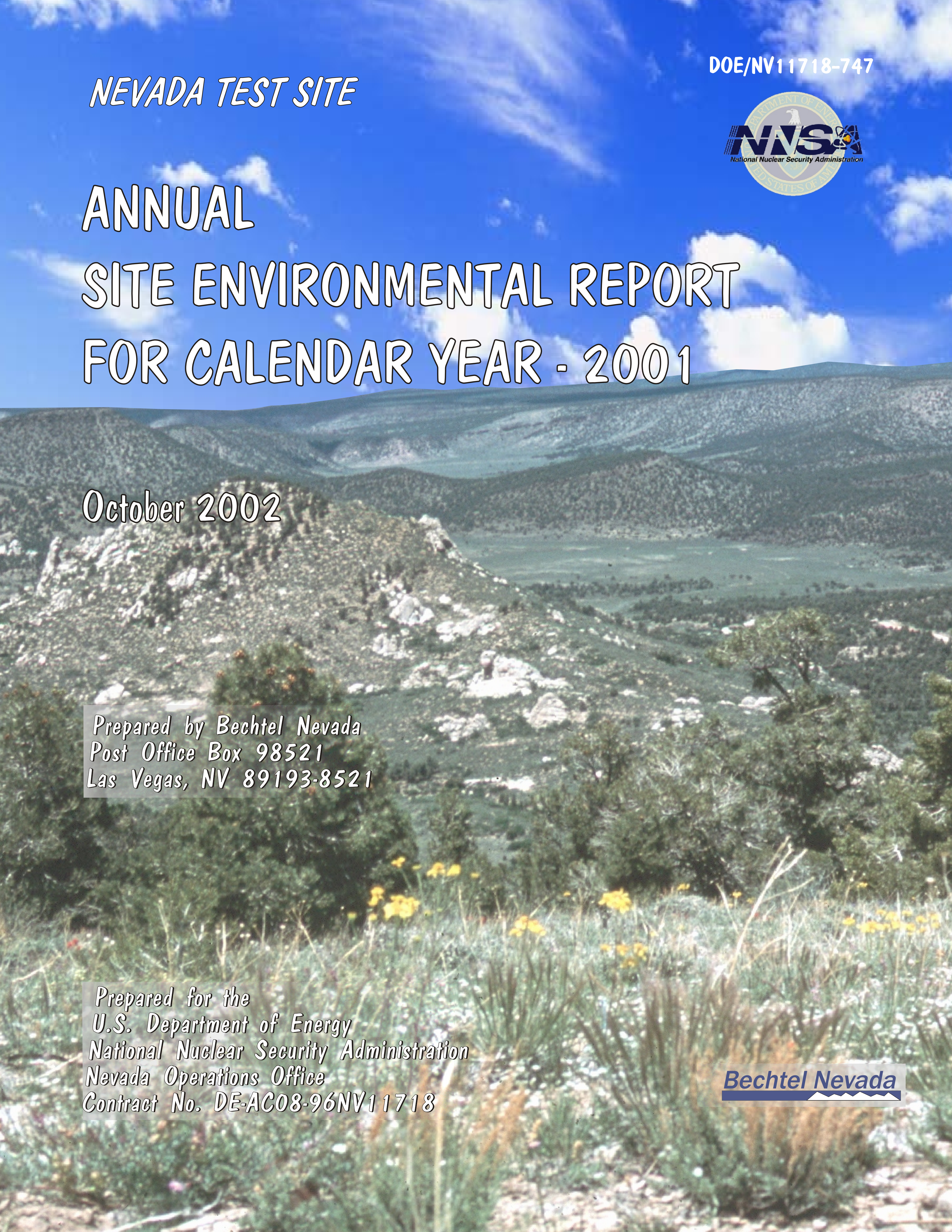

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NEVADA TEST SITE

ANNUAL SITE ENVIRONMENTAL REPORT FOR CALENDAR YEAR - 2001

October 2002

Prepared by Bechtel Nevada
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Editors: Yvonne E. Townsend and Robert F. Grossman

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MEASUREMENT UNITS AND NOMENCLATURE

Radioactivity data in this report are expressed in both traditional units (e.g., pCi/L) and International System (abbreviated SI) units. These units are explained below.

background Ambient background radiation to which people are exposed. Naturally occurring radioactive elements contained in the body, in the ground, and in construction materials, cosmic radiation, and radioactivity in the air all contribute to an average radiation dose equivalent to humans of about 350 mrem per year. In laboratory measurements of radioactivity in samples, background is the activity determined when a sample of distilled water is processed through the system (Also called a blank).

becquerel Abbreviation Bq. The Bq is the SI unit for disintegration rate.
1 Bq = 1 disintegration per second.

concentration Activity per unit volume or weight. Usually expressed as µCi/mL, pCi/m^3 or pCi/g.

curie Abbreviation Ci. The historic unit for disintegration rate. 1 Ci = 3.7 x 10^{10} disintegrations per second = 3.7 x 10^{10} Bq. The usual submultiples of Ci are mCi (10^{-3} Ci or one thousandth Ci), µCi (10^{-6} Ci or one millionth Ci), and pCi (10^{-12} or one trillionth Ci).

EDE Effective dose equivalent - radiation dose corrected by various weighting factors that relate dose to the risk of serious effects.

rem Rem (for roentgen equivalent man) is the unit for expressing dose equivalent, or the energy imparted to a person when exposed to radiation. The commonly used subunit is the millirem (10^{-3} rem or one thousandth rem), abbreviated mrem.

roentgen Abbreviation R. A unit expressing the intensity of X or γ radiation at a point in air. The usual unit is mR or 10^{-3} R (one thousandth R).

volume The SI unit for volume is m^3 (cubic meter). Other units used are liter (L) and mL (10^{-3} L or one thousandth liter). One cubic meter = 1,000 L, 1 L = 1.06 quarts.

The elements and corresponding symbols used in this report are:

Element	Symbol	Element	Symbol
Actinium	Ac	Iron	Fe
Aluminum	Al	Krypton	Kr
Argon	Ar	Lead	Pb
Arsenic	As	Lithium	Li
Barium	Ba	Mercury	Hg
Beryllium	Be	Nitrogen	N
Bismuth	Bi	Oxygen	O
Boron	B	Plutonium	Pu
Cadmium	Cd	Potassium	K
Calcium	Ca	Radium	Ra
Cesium	Cs	Radon	Rn
Chlorine	Cl	Selenium	Se
Chromium	Cr	Silver	Ag
Cobalt	Co	Strontium	Sr
Copper	C	Thallium	Tl
Europium	Eu	Thorium	Th
Fluorine	F	Thulium	Tm
Hydrogen	H	Tritium	^{3}H
Iodine	I	Uranium	U

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LIST OF ACRONYMS AND ABBREVIATIONS

AA	Alluvial Aquifer
AIP	Agreement in Principle
AMEM	Assistant Manager for Environmental Management
APCD	Air Pollution Control Division
ASA	Auditable Safety Analysis
ASER	Annual Site Environmental Report
ASN	Air Surveillance Network
BCG	Biota Concentration Guide
BDAC	Biota Dose Assessment Committee
BEEF	Big Explosives Experimental Facility
BEIDMS	Bechtel Environmental Integrated Data Management System
BN	Bechtel Nevada
CAA	Clean Air Act
CADD	Corrective Action Decision Document
CAP	Corrective Action Plan
CAP88-PC	Clean Air Package 1988 (EPA software program for estimating doses)
CAS	Corrective Action Site
CAU	Corrective Action Unit
CEDE	Committed Effective Dose Equivalent
CEI	Compliance Evaluation Inspection
CEM	Community Environmental Monitor
CEMP	Community Environmental Monitoring Program
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CGTO	Consolidated Group of Tribes and Organizations
CP	Control Point
CWA	Clean Water Act
CX	Categorical Exclusion
CY	Calendar Year
DAC	Derived Air Concentration
DAF	Device Assembly Facility
DAS	Disposal Authorization Statement
DCG	Derived Concentration Guide
DOE	U.S. Department of Energy
DOE/HQ	DOE Headquarters
DOE/NV	DOE Nevada Operations Office
DQO	Data Quality Objectives
DRI	Desert Research Institute, University and Community College System, Nevada
DWR	Division of Water Resources
EA	Environmental Assessment
EDE	Effective Dose Equivalent
EGIS	Ecological Geographic Information System
EHS	Extremely Hazardous Substances
EIS	Environmental Impact Statement
ELU	Ecological Landform Unit
EMAC	Ecological Monitoring and Compliance

EML	Environmental Measurements Laboratory (DOE)
EO	Executive Order
EODU	Explosive Ordnance Disposal Unit
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Reporting and Community Right-to-Know Act
ERA	Environmental Resource Associates
ERP	Environmental Restoration Project
ESA	Endangered Species Act
ESHD	Environment, Safety and Health Division
ET	Evapotranspiration
FFACO	Federal Facilities Agreement and Consent Order
FFCA	Federal Facilities Compliance Act
FIFRA	Federal Insecticide Fungicide and Rodenticide Act
FY	Fiscal Year
GCD	Greater Confinement Disposal
GIS	Geographic Information System
HAER	Historic American Engineering Record
HGU	Hydrogeologic Unit
HRMP	Hydrologic Resources Management Program
HSC	Hazardous Materials Spill Center
HSU	Hydrostratigraphic Unit
HTO	Tritiated Water
ICMP	Integrated Closure and Monitoring Plan
INEEL	Idaho National Engineering and Environmental Laboratory
IT	International Technology
JASPER	Joint Actinide Shock Physics Experimental Research
LANL	Los Alamos National Laboratory
LAO	Los Alamos Operations (BN)
LCA	Lower Carbonate Aquifer
LCA3	Lower Carbonate Aquifer, Upper Thrust Plate
LCCU	Lower Clastic Confining Unit
LDR	Land Disposal Restrictions
LLNL	Lawrence Livermore National Laboratory
LLW	Low Level (Radioactive) Waste
LLWMU	Low Level Waste Management Unit
LO	Livermore Operations (BN)
MAPEP	Mixed Analyte Performance Evaluation Program
MCL	Maximum Contaminant Level
MDC	Minimum Detectable Concentration
MEI	Maximally Exposed Individual
MGCU	Mesozoic Granite Confining Unit
MLLW	Mixed Low Level Waste
MOU	Memorandum of Understanding
MQO	Measurement Quality Objectives
MTRU	Mixed Transuranic
NAC	Nevada Administrative Code
NAFR	Nellis Air Force Range
NAGPRA	Native American Graves Protection and Repatriation Act
NDEP	Nevada Division of Environmental Protection
NDOW	Nevada Division of Wildlife

NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NHPA	National Historic Preservation Act
NIST	National Institute of Standards and Technology
NLV	North Las Vegas
NLVF	North Las Vegas Facility (BN)
NNSA/NV	U.S. Department of Energy, National Nuclear Security Administration, Nevada Operations Office
NPDES	National Pollution Discharge Elimination System
NRHP	National Register of Historic Places
NRS	Nevada Revised Statues
NSHPO	Nevada State Historic Preservation Office
NTS	Nevada Test Site
NTSWAC	Nevada Test Site Waste Acceptance Criteria
OP	Organizational Procedure
P2	Pollution Prevention
PA	Performance Assessment
PCB	Polychlorinated Biphenyl
PEP	Performance Evaluation Program
PIC	Pressurized Ion Chamber
PM-OV	Pahute Mesa-Oasis Valley
PNNL	Pacific Northwest National Laboratory
PPOA	Pollution Prevention Opportunity Assessments
QA	Quality Assurance
QAP	Quality Assessment Program
RCRA	Resource Conservation and Recovery Act
R-MAD	Reactor Maintenance, Assembly, and Disassembly
RMP	Resource Management Plan
RPD	Relative Percent Difference
RREMP	Routine Radiological Environmental Monitoring Plan
RSL	Remote Sensing Laboratory (BN)
RWID	Radioactive Waste Information Document
RWMBART	Radioactive Waste Management Basis Assistance and Review Team
RWMS	Radioactive Waste Management Site
RWMS-3	Radioactive Waste Management Site, Area 3
RWMS-5	Radioactive Waste Management Site, Area 5
SAFER	Streamlined Approach for Environmental Restoration
SARA	Superfund Amendments and Reauthorization Act
SCCC	Silent Canyon Caldera Complex
SDWA	Safe Drinking Water Act
SWL	Static Water Level
SWNVF	Southwest Nevada Volcanic Field
TaDD	Tactical Demilitarization Development
TCP	Traditional Cultural Property
TCU	Tuff Confining Unit
TLD	Thermoluminescent Dosimeter
TMA	Timber Mountain Aquifer
TMCC	Timber Mountain Caldera Complex
TRU	Transuranic
TSA	Topopah Spring Aquifer

TSCA	Toxic Substances Control Act
TTR	Tonopah Test Range
UCCU	Upper Clastic Confining Unit
UGTA	Underground Testing Area
U.S.	United States
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UST	Underground Storage Tank
VCU	Volcaniclastic Confining Unit
VOC	Volatile Organic Compound
VZM	Vadose Zone Monitoring
WAMO	Washington Aerial Measurements Operations (BN)
WIPP	Waste Isolation Pilot Plant
WRCC	Western Regional Climate Center
WVCU	Wahmonie Volcanic Confining Unit
YF-LCU	Yucca Flat Lower Confining Unit
YMP	Yucca Mountain Project

1.0 SUMMARY

Monitoring and surveillance, on and around the Nevada Test Site, (NTS) by United States Department of Energy (DOE) National Nuclear Security Administration Nevada Operations Office (NNSA/NV) contractors and NTS user organizations during 2001, indicated that operations on the NTS were conducted in compliance with applicable NNSA/NV, state, and federal regulations and guidelines. All discharges of radioactive liquids remained onsite in containment ponds, and there was no indication of migration of radioactivity to the offsite area through groundwater. During 2001, no accidental or unplanned releases occurred on the NTS. Oversite surveillance by the Desert Research Institute (DRI) of the University and Community College System of Nevada around the NTS indicated that offsite airborne radioactivity from diffusion and evaporation of liquid effluents was not detectable. Using the U.S. Environmental Protection Agency's (EPA's) Clean Air Package 1988 model (CAP88-PC) and NTS radionuclide emissions by the resuspension of soil and environmental monitoring data, the effective dose equivalent (EDE) to the maximally exposed individual (MEI) offsite was calculated to be 0.17 mrem/yr. This value is 1.7 percent of the federal dose limit prescribed for radionuclide air emissions. A maximized estimate of the EDE to the MEI, from the inhalation of NTS airborne emissions and the ingestion of wild life, was calculated to be 0.24 mrem/yr (0.0024 mSv/yr), which is only 0.24 percent of the 100 mrem/yr dose limit to the general public. The MEI receiving this dose would also have received an external exposure of 394 mrem/yr from natural background radiation. There were no nonradiological releases to the offsite area. Hazardous wastes were shipped to approved offsite disposal facilities. Compliance with the various regulations stemming from the National Environmental Policy Act (NEPA) is being achieved and, where mandated, permits for air and water effluents and waste management have been obtained from the appropriate agencies. Cooperation with other agencies has resulted in 12 different agreements, memoranda, and consent orders.

Biota Concentration Guides derived by the DOE Biota Dose Assessment Committee were used to determine that the radiation doses to terrestrial biota in all areas of the NTS are in compliance with a proposed DOE regulatory standard for biota.

Support facilities at off-NTS locations have complied with the requirements of air quality permits and state or local wastewater discharge and hazardous waste permits as mandated for each location.

1.1 ENVIRONMENTAL MANAGEMENT

The NNSA/NV is committed to increasing the quality of its management of NTS environmental resources. This has been promoted by the establishment of an Environment, Safety and Health Division under the purview of the Assistant Manager for Technical Services and by upgrading the Environmental Management activities to the Assistant Manager level to address those environmental issues that have arisen in the course of performing the original primary mission of the NNSA/NV, i.e., underground testing of nuclear explosive devices. NNSA/NV management has vigorously promoted the practice of pollution prevention, including waste minimization and material recycling.

Operational releases and seepage of radioactivity are reported soon after their occurrence. In compliance with the National Emission Standards for Hazardous Air Pollutants (NESHAP), as set forth in Title 40 Code of Federal Regulations Part 61, the accumulated annual emissions are used as part of the input to the EPA's CAP88-PC software program (DOE 1997b) to calculate potential EDEs to people living beyond the boundaries of the NTS and the surrounding exclusion areas.

RADIOLOGICAL ENVIRONMENT

Radiological effluents in the form of air emissions and liquid discharges are not normally released into the environment as a routine part of operations on the NTS. Radioactivity in liquid discharges released to onsite waste treatment or disposal systems (containment ponds) is monitored to assess the efficacy of treatment and control and to provide an annual summary of released radioactivity. Air emissions are monitored for source characterization and operational safety as well as for environmental surveillance purposes.

Air emissions in 2001 consisted primarily of small amounts of tritium and plutonium that were assumed to be released to the atmosphere and were attributed to:

- Diffusion of tritiated water (HTO) vapor from evaporation of HTO from tunnel and characterization well containment ponds.
- Diffuse emissions calculated from the results of environmental surveillance activities.
- Resuspension of plutonium calculated by use of resuspension equations.

Diffuse emissions in 2001 included (1) HTO, only slightly above detection limits, from the Radioactive Waste Management Site in Area 5 (RWMS-5), the E Tunnel Ponds, the SEDAN crater in Area 10, and the SCHOONER crater in Area 20; and (2) resuspended $^{239+240}$Pu and ^{241}Am from areas on the NTS, where it was deposited by atmospheric nuclear tests or device safety tests in earlier years. Table 1.1 shows the quantities of radionuclides estimated to be released from all sources. The radioactive materials listed in this table were not detected in the offsite area above ambient radioactivity levels. No liquid effluents were discharged to offsite areas.

ONSITE ENVIRONMENTAL SURVEILLANCE

Environmental surveillance on the NTS is designed to cover the entire area with some emphasis on areas of past nuclear testing and present operational activities. During CY 2001, air monitoring was conducted for radioactive particulates and HTO vapor at a total of 29 and 19 locations, respectively. Beginning in July 2001, the sampling locations were changed to 16 and

14 locations, respectively, to accommodate a change in strategy for demonstrating compliance with NESHAPs as approved by the EPA. The changes maintained the monitoring of NTS areas with potential emissions of radioactivity and designated the sampler locations at SCHOONER, Gate 700 South, Mercury, Guard Station 510, Substation 3545, and Yucca as NESHAP compliance stations. These six stations, although located on the NTS, will conservatively represent offsite critical receptors. Grab samples were collected frequently from water supply wells, water taps, containment ponds, and sewage lagoons. Gamma exposures were measured using thermoluminescent dosimeters (TLDs), which were placed at 88 locations on the NTS.

Data from these networks are summarized as annual averages for each monitored location. Those locations with concentrations above the NTS average are assumed to reflect onsite emissions. These emissions arise from diffuse (areal) sources and from certain operational activities (e.g., radioactivity buried in the low-level radioactive waste [LLW] site).

Approximately 243 air samples were analyzed by gamma spectroscopy. All isotopes detected by gamma spectroscopy were naturally occurring in the environment (^{40}K, ^{7}Be, and members of the uranium and thorium series), except for 24 samples in which very low levels of ^{137}Cs were detected.

Gross alpha and beta analysis of the air samples yielded an annual mean for the network of 6.6 x10^{-15} µCi/mL (0.24 mBq/m^3) and 1.9 x10^{-14} µCi/mL (0.70 mBq/m^3) respectively. Plutonium analyses for all locations during 2001, of monthly NTS composited air filters, indicated an annual network mean of 49 x 10^{-18} µCi/mL (1.8 µBq/m^3) for $^{239+240}$Pu and 2.2 x 10^{-18} µCi/mL (0.082 µBq/m^3) for ^{238}Pu.

Slightly higher concentrations were found in samples from certain areas, but they were calculated to be only 0.02 percent or less of the Derived Air Concentration for exposure to workers. Higher than background levels of plutonium are to be expected in some air samples because fallout from atmospheric tests in the 1950s, and nuclear safety tests in the 1950s and 1960s dispersed plutonium over a small portion of the NTS's surface.

Atmospheric moisture was collected for two-week periods at 19 locations on the NTS and analyzed for HTO content. The annual network mean of 35 x 10^{-6} pCi/mL (1.3 Bq/m^3) was slightly lower than last year. The highest annual mean concentrations were at the SCHOONER crater, SEDAN crater, and the E Tunnel pond in that order. The primary radioactive liquid discharge to the onsite environment in 2001 was about 14 Ci (0.52 TBq) of tritium (as HTO) in seepage from E Tunnel and from water pumped from wells into containment ponds. When calculating the dose for the offsite public, it was assumed that all of the HTO had evaporated.

Surface water sampling was conducted at two containment ponds and the effluent for the Area 12 E Tunnel. A grab sample was taken from each of these surface water sites for analysis of gross beta, tritium, gamma-emitters, and plutonium isotopes. Strontium-90 was analyzed once per year for each location. Samples collected from the tunnel containment pond contained detectable levels of radioactivity, as would be expected. Water samples were collected from the sewage lagoons and contained background levels of gross beta, tritium, plutonium, and strontium.

Water samples from onsite supply wells and drinking water distribution systems were also analyzed for radionuclides. The supply well average gross beta activity of 6.6 x 10^{-9} µCi/mL (0.25 Bq/L) was 2 percent of the Derived Concentration Guide for ^{40}K (used for comparison purposes); gross alpha was 5.05 x 10^{-9} µCi/mL (0.19 Bq/L), which was 40 percent of the drinking water standard; the concentrations of ^{3}H, ^{90}Sr, $^{239+240}Pu$, and ^{238}Pu were all below their respective minimum detectable levels. The radium concentrations in supply well samples were less than Safe Drinking Water Act (SDWA) requirements.

Monitoring of the vadose zone beneath the waste management sites in Areas 3 and 5 revealed that wetting fronts extended only a few feet below the surface of these sites. Also, Resource Conservation and Recovery Act (RCRA) monitoring wells, for sampling groundwater under RWMS-5, indicated that contamination from mixed waste buried therein is not detectable in the well samples.

Analysis of data from the TLD network showed statistically significant differences between both locations and quarters, though the quarter-to-quarter variation was much less than the location-to-location variation. The Highest exposure rates were measured at areas associated with historical surface tests. Eighty-three percent of the NTS locations had mean exposure rates within the range measured offsite by DRI, with 93 percent of the NTS locations within the range of background exposures measured across the United States (Bier III 1980). Overall mean exposure rates on the NTS were very similar to those measured in past years.

Monitoring System Design

During 1998, in an effort to make the environmental surveillance system on the NTS more efficient, it was redesigned. Using the Seven-Step Data Quality Objective (DQO) process, published by EPA and information on the distribution and amount of radioactive sources on the NTS, a “Routine Radiological Environmental Monitoring Plan” (RREMP) was developed (DOE 1998a). As a result of the DQO process, some monitoring was eliminated in 1999. The number of air and TLD monitoring stations were reduced, and monitoring frequencies were also changed in 1999. The monitoring was conducted in accordance with the Plan during 2001.

OFFSITE ENVIRONMENTAL SURVEILLANCE

Oversite radiological monitoring is conducted by public individuals in communities and at ranches around the NTS and is coordinated by the DRI of the University and Community College System of Nevada under contract with NNSA/NV. These programs consist of several environmental sampling, radiation detection, and dosimetry networks as described below. A network of 22 Community Environmental Monitoring Program (CEMP) stations were operated continuously during 2001. During 2001, no airborne radioactivity related to current activities at the NTS was detected on any sample from low-volume samplers.

In 2001, external exposure was monitored by a network of 24 TLDs and pressurized ion chambers (PICs) located in towns and communities around the NTS. The PIC network in the communities surrounding the NTS indicated background exposures, ranging from 72 to 168 mR/yr, which were consistent with previous data and well within the range of background data in other areas of the United States. The exposures measured by the TLDs were slightly less, as has been true in the past.

Although no radioactivity attributable to current NTS operations was detected by any of the offsite monitoring networks, based on the NTS airborne releases, an atmospheric dispersion model calculation (CAP88-PC) indicated that the maximum potential EDE to any offsite individual would have been 0.17 mrem (1.7×10^{-3} mSv) at Springdale, and the dose to the population within 80 km of the several emission sites on the NTS would have been 0.44 person-rem (4.4×10^{-3} person-Sv), both of which were similar to last years. If one assumes that the MEI at Springdale also ate the meat of wild life which had migrated off the NTS after eating and drinking in radioactively contaminated areas, he could have received an additional EDE of 0.07 mrem/yr (7.0×10^{-4} mSv/yr). These, added to the air pathway EDE, give a total of 0.24 mrem/yr (2.4×10^{-3} mSv/yr). For comparison, the hypothetical person receiving this dose would also have been exposed to 390mrem/yr (3.94 mSv/yr) from all components of natural background radiation. A summary of the potential EDEs due to operations at the NTS is presented in Table 1.2.

In compliance with the regulatory standards published by the DOE Biota Dose Assessment Committee, the dose to terrestrial biota was calculated for the most contaminated NTS areas. All such areas were in compliance with the committee's technical standard.

LOW-LEVEL WASTE DISPOSAL

Environmental monitoring at the RWMS, Area 3 (RWMS-3) has detected plutonium in air samples. However, the upwind/ downwind sampler results were equivalent, and plutonium was detected in other air samples from Area 3, indicating that the source is resuspended plutonium from areas surrounding RWMS-3. Elevated levels of plutonium have been detected in air samples from several areas on the NTS where operational activities, vehicular traffic, and high winds resuspend plutonium for detection by air sampling. The presence of plutonium on the NTS is primarily due to atmospheric and safety tests conducted in the 1950s and 1960s. These tests spread plutonium on surface soil in the eastern and northwestern areas of the NTS (Figure 5.1, Chapter 5.0 displays these locations).

Environmental monitoring at and around RWMS-5 indicated that HTO in air was detectable at, but not beyond, the waste site boundaries. This monitoring included air sampling, water sampling, and external gamma exposure measurement. Vadose zone monitoring for water seepage is conducted beneath RWMS-3 and RWMS-5, as a method of detecting any downward migration of waste. Also, three monitoring wells, installed to satisfy RCRA requirements for a mixed-waste disposal operation at RWMS-5, have not yet detected any migration of hazardous materials.

NONRADIOLOGICAL MONITORING

Nonradiological environmental monitoring of NTS operations involved only onsite monitoring because there were no discharges of nonradiological hazardous materials to offsite areas. The primary environmental permit areas for the NTS were monitored to verify compliance with ambient air quality and the RCRA requirements. Air emissions sources common to the NTS included particulates from construction, aggregate production, surface disturbances, fugitive dust from unpaved roads, fuel burning equipment, open burning, and fuel storage facilities. NTS environmental permits active during 2001, which were issued by the state of Nevada or by federal agencies, included one comprehensive air quality permit covering emissions from construction of facilities, boilers, storage tanks, and surface disturbances; three onsite open-burn variances; one offsite permit for surface disturbance (environmental restoration activities); six permits for onsite drinking water distribution systems; one permit for sewage discharges to lagoon collection systems; four permits for seepage hauling; one incidental take permit for the threatened desert tortoise; and one permit for the scientific collection and study of various species on the NTS. Further, a RCRA permit has been obtained for general NTS operations and for two specific facilities on the NTS.

Permits at non-NTS operations included 12 air pollution control permits, 3 sewage discharge permits, and 2 hazardous material storage permits.

The only nonradiological air emission of regulatory concern under the Clean Air Act (CAA) has been due to asbestos removal during building renovation projects and from insulated piping at various locations on the NTS. During 2001, there were no projects that required state of Nevada notifications. The annual estimate for non-scheduled asbestos demolition/renovation projects for fiscal year 2001 was sent to EPA Region 9 in December 13, 2000.

RCRA requirements were met through an operating permit for hazardous waste storage and explosives ordnance disposal. NTS operations also include mixed waste storage through a Consent Agreement between NNSA and the state of Nevada.

As there are no liquid discharges to navigable waters, offsite surface water drainage systems, or publicly owned treatment works, no Clean Water Act (CWA) National Pollution Discharge Elimination System (NPDES) permits were required for NTS operations. Under the conditions of the state of Nevada operating permits, liquid discharges to onsite sewage lagoons are regularly tested for biochemical oxygen demand, pH, and total suspended solids. In addition to the state-required monitoring, these influents were also tested for RCRA related constituents as an internal initiative to further protect the NTS environment. The State inspected permitted sewage lagoons on April 3 and 4, 2001, with findings noted.

There were no formal state inspections of NTS equipment regulated by the state air quality permit.

In compliance with the SDWA and four drinking water supply system permits from the state, the onsite distribution systems supplied by onsite wells are sampled either monthly or quarterly for coliform bacteria and water quality parameters, depending on the status as a community or non-community system.

1.2 COMPLIANCE ACTIVITIES

NNSA/NV is required to comply with various environmental laws and regulations in the conduct of its operations. Monitoring activities required for compliance with the CAA, CWA, SDWA, Toxic Substance Control Act, and RCRA are summarized above. Endangered Species Act activities include compliance with the United States Fish and Wildlife Service (USFWS) Biological Opinion on NTS Activities and the Biological Opinion on Fortymile Canyon Activities. NEPA activities include 1 Environmental Assessment, and 17 Categorical Exclusions. Of the 41 NEPA checklist completed, 29 projects were excluded because they had been considered in the site-wide Environmental Impact Statement or the Record of Decision.

Wastewater discharges at the NTS are not regulated under NPDES permits, because all such discharges are to onsite sewage lagoons. Discharges to these lagoons are permitted under the Nevada Water Pollution Control Act. Wastewater discharges from the non-NTS support facilities (North LasVegas Facility, Remote Sensing Laboratory [RSL]-Nellis, RSL-Andrews, and Special Technologies Laboratory) were within the regulated levels established by city or county publicly owned treatment works.

The National Historic Preservation Act directs federal agencies to consult with Native Americans when NNSA/NV programs or activities at the NTS may impact their environmental and cultural interests. In 2001, three surveys were conducted and one historical evaluation was initiated. Consultations with several Native American tribes were conducted to determine whether artifact collections should be repatriated. NNSA/NV published a book "American Indians and the Nevada Test Site," a Model of Research and Consultation (Stoffle et al., 2001).

The Ecological Monitoring and Compliance Program monitoring tasks, which were selected for 2001 included habitat mapping of the NTS, characterizing the natural wetlands on the NTS, conducting a census of the horse population, surveying bat species, surveying for raptors, and periodically monitoring man-made water sources to assess their effects on wildlife. Reviews of spill test plans for the Hazardous Materials Spill Center were also conducted.

The annual compliance report for CY 2001 NTS activities was prepared and submitted to the USFWS.

Pollution prevention activities conducted in CY 2001 at the NTS and its offsite facilities involve active programs for recycling, material exchange, and waste minimization.

1.3 GROUNDWATER PROTECTION

No radioactivity was detected above background levels in the groundwater sampling network surrounding the NTS. Low levels of tritium, in the form of HTO, were detected in onsite wells used only for monitoring purposes and not for drinking water.

Because wells that were drilled for water supply or exploratory purposes are used in the NTS monitoring program, rather than wells drilled specifically for groundwater monitoring, a program of well drilling for groundwater characterization at the NTS is underway. The design of the program is for installation or recompletion of groundwater characterization wells at strategic locations on and near the NTS. During 2001, two wells were completed in Frenchman Flats area. Hydrological tests and sampling were completed at four wells drilled before CY 2000.

Related activities included studies of groundwater transport of contaminants (radionuclide migration studies) and nonradiological monitoring for water quality assessment and RCRA requirements.

1.4 RADIOACTIVE AND MIXED WASTE STORAGE AND DISPOSAL

Two RWMSs are operated on the NTS: one each in Areas 3 and 5. During 2001, the RWMSs received LLW generated at the NTS and other NNSA/NV facilities. Waste is disposed of in shallow pits and trenches in RWMS-5 and in subsidence craters in RWMS-3.

At RWMS-5, LLW is disposed of in standard packages. Transuranic (TRU) and TRU mixed wastes are stored on a curbed asphalt pad on pallets in over packed 55-gal drums and steel boxes. These will be characterized prior to shipment to the Waste Isolation Pilot Plant in New Mexico. The RWMS-3 is used for disposal of bulk LLW waste and LLW that is packaged, including packages that are larger than the specified standard size used at RWMS-5.

Environmental monitoring, at both sites, included air sampling for radioactive particulates and measurement of external exposure using TLDs. Water sampling and vadose zone monitoring for moisture and hazardous constituents are conducted at the RWMS-5, as is monitoring for tritium in atmospheric moisture. Environmental monitoring results for 2001 indicated that measurable radioactivity from waste disposal operations was detectable only in the immediate vicinity of the facilities.

Because the NTS is not a RCRA-permitted disposal facility, RCRA regulations require the shipment of nonradioactive hazardous waste to licensed disposal offsite facilities. Therefore hazardous waste is not disposed of onsite.

LLW is accepted for disposal only from generators (onsite and offsite) that have submitted a waste application that meets the requirements of the Waste Acceptance Criteria document (DOE 2002) and that have received NNSA/NV approval of the waste stream(s) for disposal at the NTS.

1.5 QUALITY ASSURANCE

It is the policy of the DOE NNSA/NV that all data produced for its environmental surveillance and effluent monitoring programs be of known quality. Therefore, a quality assurance (QA) program is used for collection and analysis of samples for radiological parameters to ensure that data produced by the Bechtel Nevada (BN) Subcontracted Radiochemistry Laboratory meets customer-and regulatory-defined requirements. Data quality is assured through process-based QA, procedure-specific QA, measurement quality objectives (MQOs), and performance evaluation programs (PEPs). The QA program for radiological data consists of participation in the Quality Assessment Program (QAP) administered by the DOE/NV Environmental Measurements Laboratory (EML), the InterLaB RadCheM™ Proficiency Testing Program directed by Environmental Resource Associates (ERA), the Radiochemistry Intercomparison Program provided by the National Institute of Standards and Technology (NIST), and the Mixed Analyte Performance Evaluation Program (MAPEP) conducted by the Idaho National Engineering and Environmental Laboratory (INEEL). Thermoluminescent dosimeter (TLD) radiation measurement QA for the program is assessed by the BN Dosimetry Group's participation in the DOE/NV's Laboratory Accreditation Program and intercomparisons provided by the Battelle Pacific Northwest National Laboratory (PNNL) during the course of the year.

1.6 ISSUES AND ACCOMPLISHMENTS

PRINCIPAL COMPLIANCE PROBLEMS FOR 2001

- Results in 2001 for lead were found above the SDWA action level in the Area 12, Building 12-43 drinking water systems. The water is restructured to non-potable use until a remedy is found for this situation.

ACCOMPLISHMENTS FOR 2001

- NEPA Environmental Evaluation Checklists were completed for 41 proposed projects.
- FFACO actions included preparing 16 Post-Closure Monitoring Reports, 11 Closure Reports, and 6 Safer Plans.
- NNSA/NV executed its Implementation Plan for meeting the requirements of DOE Order 435.1 by the agreed-upon compliance date of March 5, 2001.
- NNSA/NV conducted three cultural resource surveys, two inventory projects, and one historical evaluation at the NTS. This resulted in one site and two structures eligible for National Register of Historic Places preservation.
- Ecology of the NTS, an Annotated Bibliography was brought up to date in 2001 to reflect all Ecology related research on the NTS.
- There were nine Environmental Compliance Management Assessments of specific operations, facilities, or projects. These assessments focused mostly on areas of major environmental compliance.
- UGTA Project drilled two wells in Frenchman Flat: ER-5-3#3 and ER-5-4. In addition, hydrologic tests and sampling were conducted at four wells: three wells at the ER-5-3 well cluster and one well at ER-5-4.
- NTS Well and Borehole Plugging Project plugged 18 unused boreholes in Areas 2, 3, 4, and 9.
- Throughout 2001, NNSA/NV continued to maintain and update the “NNSA/NV Compliance Guide” (Volume III), a handbook containing procedures, formats, and guidelines for personnel responsible for NEPA compliance activities.

1.7 CONCLUSION

The environmental monitoring results presented in this report document that operational activities on the NTS in 2001 were conducted so that no measurable radiological exposure occurred to the public in offsite areas. Calculation of the highest individual annual dose that could have been received by an offsite resident (based on estimation of onsite worst-case radioactive releases [totals listed in Table 1.1] obtained by measurement or engineering calculation and assuming the person remained outdoors all year) equated to 0.17 mrem to a person living in Springdale, Nevada. If this same individual also was a hunter who ate a possession limit (12) of chukar which migrated from the NTS after drinking water from the E Tunnel ponds, he would also receive 0.07 mrem for a total of 0.24 mrem. This may be compared to that individual's exposure to 154 mrem/yr from natural background radiation (cosmic and terrestrial) as measured by the PIC instrument at Beatty, Nevada. When the doses (NCRP 1996) from the inhalation of naturally occurring radon in air (200 mrem/yr) and the internal radiation dose one receives from naturally occurring radionuclides in our body

(40 mrem/yr) are included, the total natural background dose becomes 394 mrem/yr (154+200+40). The collective population dose to residents residing within 80 km of the NTS emissions was calculated as 0.44 person-rem/yr and compared to the population dose from the natural environmental background, 13,940 person-rem/yr. The results of the dose calculations are summarized in Table 1.2.

There were no major incidents of nonradiological contaminant releases to the environment in 2001. Many contaminated sites are on schedule for remediation, and intensive efforts to characterize and protect the NTS environment, implemented in 1990, were continued in 2001. The Underground Testing Area program and other activities devoted to characterization and protection of groundwater on and around the NTS continued on schedule.

Table 1.1 Radionuclide Emissions on the NTS - 2001[(a)]

Radionuclide	Half-life (years)	Quantity Released (Ci)[(b)]
Airborne Releases:		
^{3}H	12.35	564[(c)]
$^{239+240}Pu$	24065.[(e)]	3.2×10^{-1}[(d)]
^{241}Am	432.2	4.9×10^{-2}[(d)]

(a) Assumes worst-case point and diffuse source releases; there were no unplanned releases.
(b) Multiply by 37 to obtain GBq.
(c) Estimated from air sampling results and evaporation of water from containment ponds.
(d) Calculated from the resuspension of surface deposits.
(e) This is the half-life of ^{239}Pu.

Table 1.2 NTS Radiological Dose Reporting - 2001

Pathway	Dose to Maximally Exposed Individual (mrem)	Dose to Maximally Exposed Individual (mSv)	Percent of DOE 100-mrem Limit	Estimated Population Dose (person-rem)	Estimated Population Dose (person-Sv)	Population within 80 km	Estimated Natural Radiation Dose (person-rem)
Air	0.17	0.0017	0.17	0.44	0.0044	38,403	13,940[a]
Air and Wild Life	0.24	0.0024	0.24	0.44	0.0044	38,403	13,940[a]

(a) Product of population within 80 km of NTS emissions and natural radiation dose (see Section 5.5 of Chapter 5.0).

View of Shoshone Mountain (No Date Provided)

2.0 INTRODUCTION

The Nevada Test Site (NTS) environment is characterized by desert valley and Great Basin mountain terrain and topography, with a climate, flora, and fauna typical of the southern Great Basin deserts. The key features that afford protection to the inhabitants of the adjacent areas from potential exposure to radioactivity or other contaminants resulting from operations on the NTS are restricted access, extended wind transport times, bounded on three sides by United States Air Force lands, and the general remote location of the NTS. Also, characteristic of this area are the great depths to slow-moving groundwater and little or no surface water. Population density within 80 km of the NTS is only 0.5 persons/km^2 versus approximately 29 persons/km^2 in the 48 contiguous states. The predominant use of land surrounding the NTS is open range for livestock grazing with scattered mining and recreational areas.

The NTS, located in southern Nevada was the primary location for the testing of nuclear explosives in the continental United States from 1951 to 1992. Historically, nuclear testing has included, (1) atmospheric testing in the 1950s and early 1960s; (2) underground testing in drilled, vertical holes and horizontal tunnels; (3) earth-cratering experiments; (4) open-air nuclear reactor and engine testing; and (5) eleven underground tests for various purposes at other locations in the United States.

NTS activities in 2001 continue to be diverse, with the primary role being to help ensure that the existing United States stockpile remains safe and reliable. Facilities that support this mission include the U1a Facility, Big Explosives Experimental Facility (BEEF), and Joint Actinide Shock Physics Experimental Research (JASPER) Facility. Other NTS activities include demilitarization activities, controlled spills of hazardous material at the Hazardous Materials Spill Center (HSC), remediation of industrial sites, processing of waste destined for the Waste Isolation Pilot Plant (WIPP), disposal of radioactive waste, and environmental research. In addition efforts continue to bring other business to the NTS, like aerospace and alternative energy technologies.

2.1 NTS SITE CHARACTERISTICS

The NTS, located in Nye County, Nevada, as shown in Figure 2.1, has been operated by the U.S. Department of Energy (DOE), National Nuclear Security Administration Nevada Operations Office (NNSA/NV), or its predecessors, as the on-continent test site for nuclear explosives testing since 1951. The southeast corner of the NTS is about 88 km (55 mi) northwest of the center of Las Vegas. By highway, it is about 105 km (65 mi) from the center of Las Vegas to Mercury. The NTS encompasses about 3,561 km^2 (1,375 mi^2), an area larger than the state of Rhode Island. The dimensions of the NTS vary from 46 to 56 km (28 to 35 mi) in width (eastern to western border) and from 64 to 88 km (40 to 55 mi) in length (northern to southern border). The NTS is surrounded on the east, north, and west sides by public exclusion areas, called the Nellis Air Force Range (NAFR) (see Figure 2.1). This area provides a buffer zone varying from 24 to 104 km (15 to 65 mi) between the NTS and public lands. The

Figure 2.1 Nevada Test Site Location in Nevada

combination of the NAFR and the NTS is one of the larger unpopulated land areas in the United States, comprising some 14,200 km^2 (5,470 mi^2). Figure 2.2 shows the general layout of the NTS, including the location of major facilities and the NTS Area numbers referred to in this report. The geographical areas previously used for nuclear testing are also indicated in Figure 2.2. Mercury, located at the southern end of the NTS, is the main base camp for worker housing and administrative operations for the NTS.

2.2 TOPOGRAPHY AND TERRAIN

The NTS terrain is typical of much of the Basin and Range physiographic province in Nevada, Arizona, and Utah. There are north to northeast trending mountain ranges separated by gentle sloping linear valleys and broad flat basins at the NTS. The principal valleys within the NTS are Frenchman Flat, Yucca Flat, and Jackass Flats, with the principal highlands consisting of Pahute Mesa, Rainier Mesa, Timber Mountain, and Shoshone Mountain. A large portion of the NTS ranges in elevation from about 914 to 1,219 m (3,000 to 4,000 ft) in the valleys to the south and east to 1,676 to 2,225 m (5,500 to 7,300 ft) in the high country toward the northern and western boundaries.

Surface drainage for Yucca and Frenchman Flats (east side of the NTS) are closed-basin systems that drain onto the dry lake beds (playas) in each valley. The remaining area on the western side of the NTS drains via arroyos and dry stream beds that carry water only during unusually intense or persistent storms. There are no continuously flowing streams on the NTS.

One notable feature of Yucca Flat is the formation of numerous dish-shaped surface subsidence craters as a direct result of nuclear testing (other areas on the NTS are affected on a much smaller scale). Most underground nuclear tests conducted in vertical shafts (also cratering experiments or following some tunnel tests) produced surface subsidence craters that occurred when the overburden above a nuclear cavity collapsed and formed a rubble "chimney" to the surface.

2.3 PRECIPITATION

The NTS is between the northern boundary of the Mojave Desert and the southern limits of the Great Basin Desert. This “Transitional Desert” is considered to be typical of either Dry Mid-latitude or Dry Subtropical climatic zones. The climate is characterized by low precipitation, a large diurnal temperature range, a large evaporation rate, and moderate to strong winds.

Most precipitation in the Transitional Desert occurs in winter and summer. Winter precipitation is generally associated with transitory low-pressure systems originating from the west and occurring as uniform storms over large areas (snowfall to elevations below 5,000 feet in the strongest of these storms). Summer precipitation is generally associated with convective storms originating from the south or southwest and occurring as intense local storms. The average annual precipitation ranges between three and ten inches, depending on elevation. Lower values of this range are typical in valleys, whereas higher values are typical in the surrounding mountains.

2.4 TEMPERATURE

Elevation influences temperatures on the NTS, with higher elevations having a higher sustained cooler temperature and the lower elevations having a higher sustained warmer temperature. At an elevation of 2,000 m (6,560 ft) Pahute Mesa recorded a maximum temperature of 39 ˚C (102 ˚F) and a minimum temperature of -11 ˚C (11 ˚F). The average maximum temperature was 16 ˚C (61 ˚F) and the average minimum was 5 ˚C (41 ˚F). In the Yucca Flat basin at an elevation of 1,195 m (3,920 ft), the maximum temperature recorded was

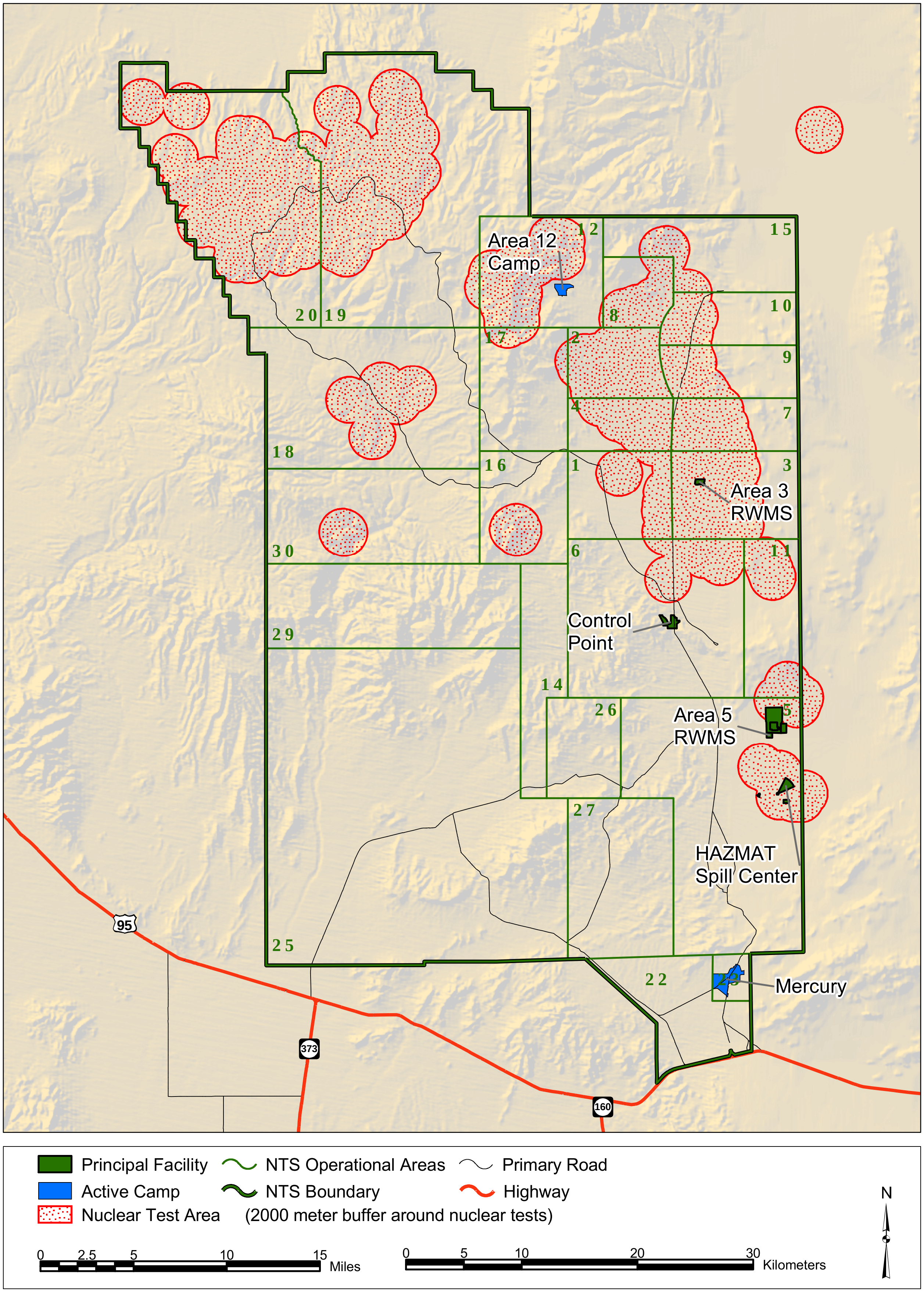


Figure 2.2 Nevada Test Site Operational Areas, Principal Facilities and Testing Areas

48 ˚C (118 ˚F) and the minimum temperature was -13 ˚C (8 ˚F). The average maximum temperature was 23 ˚C (73 ˚F) and the average minimum was 3 ˚C (38 ˚F). The annual average temperature in the NTS area is 19 ˚C (66 ˚F). Monthly average temperatures range from 7 ˚C (44 ˚F) in January to 32 ˚C (90 ˚F) in July.

2.5 WIND

Winds are primarily southerly during summer months and northerly during winter months. Wind velocities tend to be greater in the spring than in the fall. At the Yucca Playa station, the average annual wind velocity was 11 kph (7 mph); the maximum wind velocity was nearby at the Meteorological Data Acquisition System Station 4 at 137 kph (85 mph). At Area 20 Camp on Pahute Mesa, the average annual wind velocity was 16 kph (10 mph) miles per hour; the maximum wind velocity was 83 kph (52 mph). The multi-year wind roses for selected locations around the NTS are shown in Figure 2.3.

2.6 EVAPORATION

Evaporation at the NTS is high in the flats (Frenchman, Yucca, and Jackass) because of the large incident solar radiation and wind. Potential evaporation is evaporation at a potential, or energy-limiting rate; it is calculated using any of a number of available equations. The potential evaporation usually exceeds ten times the annual precipitation on the valleys of the NTS.

2.7 GEOLOGY

The NTS is located in the south central part of the Great Basin section of the Basin and Range physiographic province. The topography of this province is characterized by north- to northeast-tending mountain ranges, separated by broad, linear valleys and is evident on the eastern portion of the NTS. In the vicinity of the NTS, this series of ridges and valleys is locally disrupted by a large volcanic plateau and an associated complex of overlapping collapse calderas.

During the Paleozoic Era, the NTS region was part of the Cordilleran miogeosyncline, a subsiding trough on the submerged western edge of the North American continent. This miogeosyncline, extending from Mexico to Alaska, received thousands of feet of shallow water deposition, derived from erosion of the nearby continental land mass. As a result, in excess of 30,000 feet of Paleozoic clastic and carbonate rocks was deposited in the NTS region. During the Mesozoic Era, these rocks were complexly folded and thrust faulted in several periods of compressional deformation. The CP Thrust and the Mine Mountain Thrust are the major thrust faults formed during this time in the NTS region. These episodes of mountain building were accompanied by intrusions of granitic plutons, which are represented by the Climax, Twin Ridge, and Gold Meadows stocks on the NTS.

A major period of silicic volcanism began in the central portion of the Great Basin approximately 40 million years ago and spread outward through time. The dominant volcanic activity in the NTS region began about 16 million years ago and continued at least until 0.25 million years ago. A complex of six collapsed calderas, five of which overlaps, were active along the western

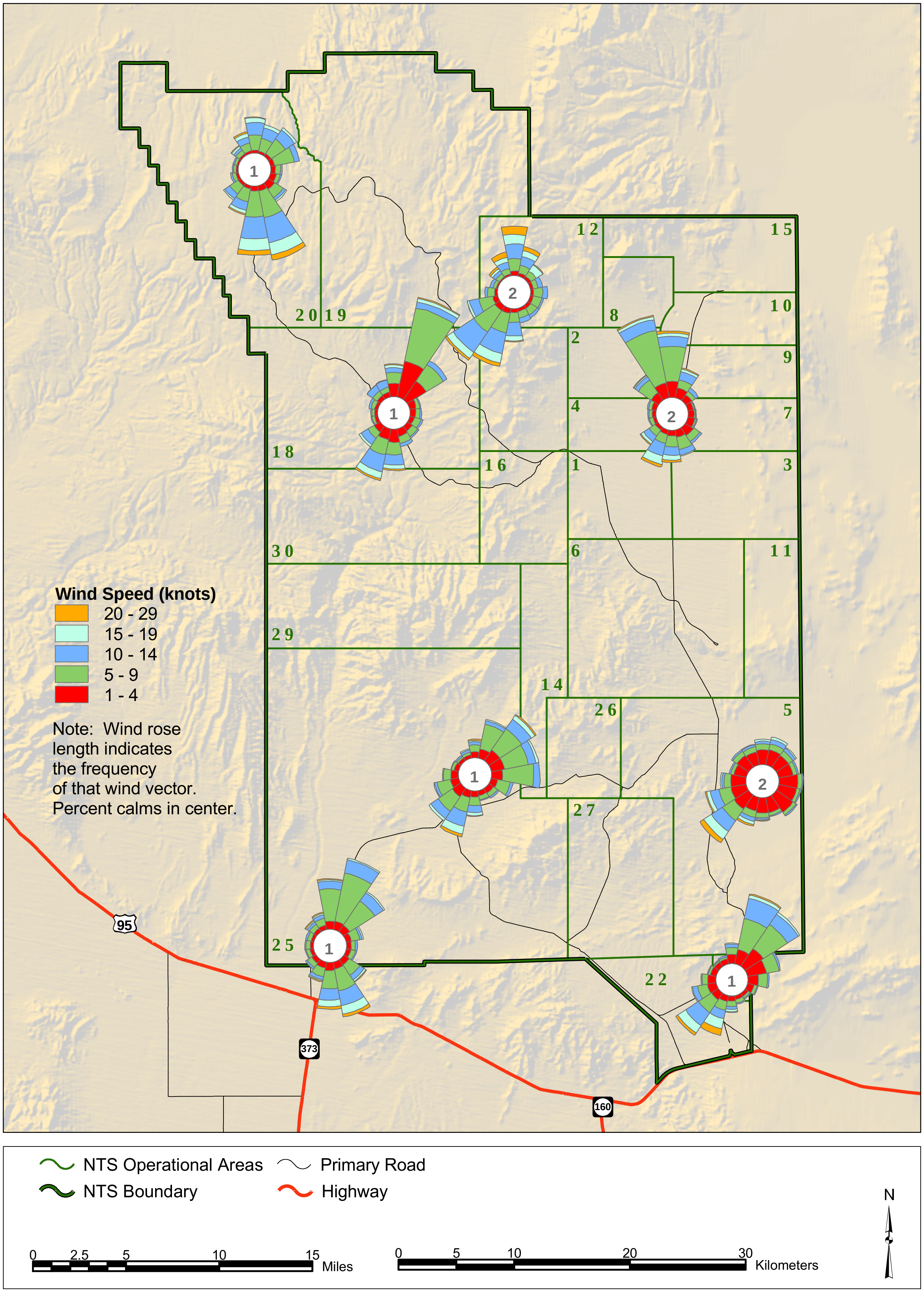


Figure 2.3 Annual Climatological Wind Rose Patterns for the NTS - 2001

portion of the NTS between 16 and 6 million years ago. Ash flow tuffs that erupted from these centers exceed 15,000 ft thickness under Pahute Mesa, a volcanic plateau in the northwestern portion of the NTS. A transition to basalt eruptions occurred approximately six million years ago.

The crustal extension which produced north- to northeast-tending normal faults began between 17 and 14 million years ago in southern Nevada. Uplift and subsidence along these faults resulted in the present-day system of mountain ranges and topographically closed basins.

Alluvium and colluvium from the mountain ranges have filled the basins to depths of several hundred meters or more.

Refer to Chapter 7.0 of this report for a detailed overview of the geology of the NTS.

2.8 HYDROGEOLOGY

Depths to groundwater under the NTS vary from about 210 m (690 ft) beneath the Frenchman Flat playa (Winograd and Thordarson 1975) in the southern part of the NTS to more than 700 m (2,300 ft) beneath part of Pahute Mesa. In the eastern portions, the water table occurs generally in the alluvium and volcanic rocks above the regional carbonate aquifer and is characterized by regional flow from the upland recharge area in the north and east, towards discharge areas at Ash Meadows and Death Valley. In the western portion of the NTS, the water table occurs predominantly in volcanic rocks and moves in a southerly direction toward Oasis Valley, Crater Flat, and/or western Jackass Flats.

Groundwater is the only local source of drinking water in the NTS area. Drinking and industrial water supply wells for the NTS produce from the lower and upper carbonate aquifers and the volcanic and the valley-fill aquifers. Although a few springs emerge from perched groundwater lenses at the NTS, discharge rates are low, and spring water is not used for NNSA/NV activities. North and south of the NTS, private and public supply wells are completed primarily in a valley-fill aquifers.

2.9 ECOLOGY

The NTS is between the northern boundary of the Mojave Desert and the southern limits of the Great Basin Desert. This “Transitional Desert” includes vegetation associations of both deserts. Communities of the Mojave Desert occur over the southern third of the NTS, on bajadas and mountain ranges at elevations below about 4,000 feet. They are limited to areas with mean annual minimum temperatures greater than 28° F and mean annual precipitation less than 7.2 inches (O’Farrell and Emery 1976). Mojave Desert communities can have highly variable floristic compositions, but all are dominated by creosote bush (*Larrea tridentata*) and variable co-dominant shrubs. Shrub coverage varies from 7 to 23 percent for Mojave Desert communities on the NTS (Beatley 1976). Above 5,000 feet, the vegetation mosaic begins to be dominated by sagebrush associations of *Artemisia tridentata* and *Artemisia arbuscula* subspecies *nova*. Above 6,000 feet, piñon pine and juniper mix with the sagebrush associations, where there is suitable moisture for these trees.

Most mammals on the NTS are small and often nocturnal in habitat; hence, they are not often seen by casual observers. Rodents are the most important group of mammals on the NTS, based on distribution and relative abundance. Larger mammals include feral horses, mule deer, mountain lions, bobcats, coyote, kit foxes, and rabbits, among others. Among other taxa, the reptiles include the desert tortoise, more than 12 lizards, and 17 snakes, 4 of which are venomous. Bird species are mostly migrants or seasonal residents. Most nonrodent mammals have been placed in the "protected" classification by the state of Nevada. The Mojave population of the desert tortoise, *Gopherus agassizii*, is listed as threatened by the U.S. Fish and Wildlife Service. The habitat of the desert tortoises on the NTS is found in its southern third, outside the recent areas of nuclear explosives test activities.

2.10 CULTURAL RESOURCES

Human habitation of the NTS area began at least as early as 10,000 years ago. Various indigenous cultures occupied the region in prehistoric times. The survey of less than 5 percent of the NTS area has located more than 2,000 archaeological sites, which contain the only information available concerning the prehistoric inhabitants. The site types identified include rock quarries, tool-manufacturing areas, plant-processing locations, hunting locales, rock art, temporary camps, and permanent villages. The prehistoric people's lifestyle was sustained by a hunting and gathering economy, which utilized all parts of the NTS.

While major springs provided perennial water, the prehistoric people developed strategies to take advantage of intermittent fresh water sources in this arid region. In the nineteenth century, at the time of initial contact, the area was occupied by Paiute and Shoshone Indians. Prior to 1940, the historic occupation consisted of ranchers, miners, and Native Americans. Several natural springs were able to sustain livestock, ranchers, and miners. Stone cabins, corrals, and fencing stand today as testaments to these early settlers. The mining activities included two large mines: one at Wahmonie, the other at Climax Mine. Prospector claim markers are found in these and other parts of the NTS. Cane Springs was the last mining boom town in Nevada and was a sizeable town in the years 1929 and 1930. Native Americans coexisted with the settlers and miners, utilizing the natural resources of the region and, in some cases, working for the new arrivals. They also maintained a connection with the land, especially areas important to them for religious and historical reasons. These locations, referred to as traditional cultural properties, continue to be significant to the Paiute and Shoshone Indians.

2.11 NTS NUCLEAR TESTING HISTORY

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 as the primary location for testing the Nation's nuclear explosive devices. 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, or dropped from an aircraft. Several tests were categorized as "safety" experiments, including transport and storage tests, involving the destruction of a nuclear device with nonnuclear explosives. Some of these tests resulted in dispersion of plutonium in the test vicinity. One of these test areas lies just north of the NTS boundary, and four others, involving transport/storage safety, lie at the north end of the NAFR. All nuclear device tests are listed in DOE/NV Report NV-209 (DOE 2000b).

The first underground test, a cratering test was conducted in 1951. The first test totally contained underground 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. 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 largest Plowshare crater test, SEDAN (PHS 1963) was detonated at the northern end of Yucca Flat on the NTS. There have been no United States nuclear explosive tests since September 1992.

Other nuclear testing history at the NTS has included the Bare Reactor Experiment - Nevada series in the 1960s. These tests were performed with a 14-MeV neutron generator mounted on a 465-m (1,530-ft) 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 was conducted in Area 25, and a series of tests with a nuclear ramjet engine was conducted in Area 26.

2.12 SURROUNDING AREAS

Figure 2.4 is a map of the offsite area showing a variety of lands uses and the various governmental agencies responsible for managing the land. The lands, with the exception of the Department of Defense and NNSA/NV, are open to a wide variety of uses such as farming, mining, grazing, camping, fishing and hunting, within a 300-km (180-mi) radius of the Control Point-1 (CP-1).

2.13 DEMOGRAPHY

The population of the area surrounding the NTS has been estimated by the Nevada State Demographer Office and is predominantly rural. Nevada annual populations estimate for Nevada counties, cities, and unincorporated towns is 2,066,831, with all but 641,108 residing in Clark County. Excluding Clark County, the major population center, the population density within a 150-km (90-mi) radius of the NTS is about 0.5 persons/km^2. In comparison, the 48 contiguous states (1990 census) had a population density near 29 persons/km^2. Several small communities are located in the areas of (populations in parenthesis), Alamo (507), Amargosa (1,271), Beatty (1,255), Goldfield (574), Indian Springs (1,387), Pahrump (26,399), and Tonopah (3,086). The largest of these communities is Pahrump Valley, which is approximately 50 mi (80 km) south of the NTS CP-1, which is near the center of the NTS.

The Mojave Desert of California, which includes Death Valley National Monument, lies along the southwestern border of Nevada. This area is still predominantly rural; however, tourism at Death Valley National Park swell the population 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 largest community is St. George, located 220 km (137 mi) east of the NTS, with a population of 49,600. The next largest town, Cedar City, with a population of 20,500, is located 280 km (174 mi) east-northeast of the NTS.

Figure 2.4 Land Use Around the Nevada Test Site

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 a population estimate of 22,000, and Kingman, located 280 km (174 mi) southeast of the NTS, with a population of about 13,000.

2.14 MISSION AND NATURE OF OPERATIONS

The present mission of the NNSA/NV is described by the following five statements:

- **National Security:** support the Stockpile Stewardship Program through subcritical and other weapons physics experiments, emergency management, test readiness, work for other national security organizations, and other experimental programs.

- **Environmental Management:** support environmental restoration, groundwater characterization, and low-level radioactive waste management.

- **Stewardship of the NTS:** manage the land and facilities at the NTS as a unique and valuable national resource.

- **Technology Diversification:** support nontraditional Departmental programs and commercial activities which are compatible with the Stockpile Stewardship Program.

- **Energy Efficiency and Renewable Energy:** support the development of solar energy, alternative fuel, and energy efficiency technologies.

2.15 STOCKPILE STEWARDSHIP

There were two subcritical experiments which involved small amounts of special nuclear material that does not reach the fissioning stage during the experiment. In addition, 19 experiments were conducted at the BEEF and construction was completed on JASPER.

2.16 ENVIRONMENTAL MANAGEMENT

The Environmental Restoration efforts included remediating 50 industrial sites. The Underground Test Area program drilled three holes and continued work on modeling efforts.

Approximately 1,512,000 cubic feet of low-level waste were disposed of at the Area 3 and Area 5 Radioactive Waste Management Sites (1113 shipments) from offsite generators. In addition, for FY 2001 and the first quarter of FY 2002, 15,666 cubic feet of LLW were disposed of onsite.

2.17 HAZARDOUS MATERIALS SPILL CENTER (HSC)

The NNSA/NV's HSC is a research and demonstration facility available on a user-fee basis to private and public sector test and training sponsors concerned with the safety aspects of hazardous chemicals. The site is located in Area 5 of the NTS and is maintained by Bechtel Nevada. The HSC is the basic research tool for studying the dynamics of accidental releases of various hazardous materials. The facility was active for 37 weeks in Calendar Year 2001.

Rainier Mesa (No Date Provided)

3.0 COMPLIANCE SUMMARY

Environmental compliance activities at the Nevada Test Site (NTS) during calendar year (CY) 2001 involved the permitting and monitoring requirements of numerous state of Nevada and federal regulations. Primary activities included the following: (1) National Environmental Policy Act (NEPA) documentation preparation; (2) Clean Air Act (CAA) compliance for asbestos renovation projects, radionuclide emissions, and state air quality permits; (3) Clean Water Act (CWA) compliance involving state wastewater permits; (4) Safe Drinking Water Act (SDWA) compliance involving monitoring of drinking water distribution systems; (5) Resource Conservation and Recovery Act (RCRA) management of hazardous wastes; (6) Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) reporting; (7) Toxic Substances Control Act (TSCA) management of polychlorinated biphenyls; (8) Endangered Species Act (ESA) compliance involving the conduct of pre-construction and site-wide surveys to document the status of state and federally listed endangered or threatened plant and animal species; and (9) National Historic Preservation Act (NHPA) compliance for the protection of Cultural and Native American Resources. There were no activities requiring compliance with Executive Orders (EOs) on Flood Plain Management or Protection of Wetlands.

Throughout CY 2001 the NTS was subject to several formal compliance agreements with various regulatory agencies. Agreements with Nevada include a Memorandum of Understanding covering releases of radioactivity; a Federal Facilities Agreement and Consent Order (FFACO); an Agreement in Principle covering environment, safety, and health activities; a Settlement Agreement to manage mixed transuranic (TRU) waste; and a Mutual Consent Agreement on management of mixed land disposal restriction (LDR) wastes, among others. Emphasis on pollution prevention and waste minimization at the NTS continued in 2001.

Compliance activities at non-NTS facilities of the U.S. Department of Energy(DOE), National Nuclear Security Administration Nevada Operations Office (NNSA/NV) involved the permitting and monitoring requirements of (1) the CAA for airborne emissions, (2) the CWA for wastewater discharges, (3) SDWA regulations, (4) RCRA disposal of hazardous wastes, and (5) hazardous substance reporting. Pollution prevention and waste minimization efforts continued at all locations.

3.1 COMPLIANCE STATUS

NATIONAL ENVIRONMENTAL POLICY ACT

Rulings by the Council on Environmental Quality, “Regulations of the National Environmental Policy Act” (Title 40 Code of Federal Regulations [CFR] 1500 - 1508) require federal agencies 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.

Since November 1994, NNSA/NV has had full delegation of authority from the DOE Headquarters (DOE/HQ) for Categorical Exclusion (CX) Determinations, Environmental Assessments (EAs), issuing Findings of No Significant Impact, and floodplain and wetland action documentation related to NNSA/NV proposed actions.

The NNSA uses three levels of documentation to demonstrate compliance with NEPA: (1) an Environmental Impact Statement (EIS) is a full disclosure of the potential environmental effects of proposed actions and the reasonable alternatives to those actions; (2) an EA is a concise discussion of proposed actions and alternatives and the potential environmental effects to determine if an EIS is necessary; and (3) a CX is used for classes of action which have been found to have no adverse environmental impacts, based on similar previous activities. NNSA/NV activities involved CXs, EAs, and an EIS during CY 2001.

Completion of a NEPA Environmental Evaluation Checklist is required under the NNSA/NV Work Acceptance Process Procedural Instructions (Carlson 2000) for all proposed projects or activities. The Checklist is reviewed by the NNSA/NV NEPA Compliance Officer to determine whether the project or activity is included in the NTSEIS and record of decision (ROD) or other previously completed NEPA analysis. During CY 2001, checklists were completed for 41 proposed projects or activities at the NTS. Eleven of these 41 were exempted from further NEPA analyses by being a CX; 29 were exempted due to previous analysis in the NTSEIS and ROD; and, 1 was exempted due to previous NEPA analysis and determinations in an EA. An EA for the Hazardous Materials Spill Center (HSC) in Area 5, at the NTS, was initiated in 2001 to more accurately reflect recent activities. The EA is still in progress. The previous EA for the HSC was written in 1994.

Still pending is the following document developed by or with the NNSA/NV involvement:

- Kistler Aerospace Corporation in Areas 18 and 19 EA.

CLEAN AIR ACT (CAA)

The CAA and the state of Nevada air quality control compliance activities were limited to asbestos abatement, radionuclide monitoring, reporting under the National Emission Standards for Hazardous Air Pollutants (NESHAP), and air quality permit compliance requirements. There were no criteria pollutants or prevention of significant deterioration monitoring requirements for NTS operations.

NTS NESHAP Asbestos Compliance

The state Division of Occupational Safety and Health regulations (Nevada Administrative Code [NAC] 618.850, 1989) require that all asbestos abatement projects in Nevada, involving friable asbestos in quantities greater than or equal to three linear feet or three square feet, submit a Notification Form. However, federal facilities are exempt from this requirement, and notification for asbestos abatement projects on the NTS is not necessary. Notification, however, is required to the U.S. Environmental Protection Agency (EPA) Region 9 for projects which disturb greater than 260 linear feet or 160 square feet of asbestos-containing material, in accordance with Title 40 CRF 61.145-146 (CFR 1989).

The annual estimate for non-scheduled asbestos demolition/renovation for fiscal year (FY) 2001 was sent to EPA Region 9 on December 13, 2000. There were no projects in FY 2001 that required notification to EPA Region 9 for removal of 260 linear feet or 160 square feet or more of asbestos-containing material.

Radioactive Emissions on the NTS

NTS operations were conducted in compliance with the NESHAP radioactive air emission standards of Title 40 CFR 61, Subpart H. In compliance with those requirements, a report on airborne radioactive effluents is provided to DOE/HQ and to EPA's Region 9.

During CY 2001, the sources of emissions were identified as: (1) tritium gas released from Area 6 CP-50 equipment calibrations; (2) evaporation of tritiated water (HTO) from containment ponds; (3) diffusion of HTO vapor from the Area 5 Radioactive Waste Management Site (RWMS-5), SEDAN crater in Area 10, SCHOONER crater in Area 20; and (4) resuspension of plutonium and americium from contaminated soil at nuclear device safety test and atmospheric test locations. As explained in the NESHAP report for 2001 (Grossman 2002), the airborne emissions of HTO vapor from the containment ponds were conservatively reported as if all the liquid discharges into the ponds had evaporated and become airborne. For HTO vapor diffusing from the RWMS-5, SEDAN, and SCHOONER, and plutonium/americium particulate resuspension from various areas on and near the NTS, the airborne effluents were conservatively estimated from air sampling measurements and CAP88-PC calculations.

From these conservative estimates of air emissions, the effective dose equivalent reported for CY 2001 was calculated to be only 0.17 mrem (1.7×10^{-3} mSv), much less than the 10-mrem limit that is specified in Title 40 CFR 61.

NTS Air Quality Permit Compliance

Compliance with air quality permits is accomplished by adhering to record keeping and reporting requirements and through renewal and ongoing verification of operational compliance with permit-specified limitations. A list of active NTS air quality permits appears in Table 3.1. Common air pollution sources at the NTS include aggregate production, surface disturbances, fugitive dust from unpaved roads, fuel burning equipment, open burning, and fuel storage facilities.

Quantities of emissions from operations at the NTS are calculated and submitted each year to the state of Nevada using forms provided by the state. The report also includes aggregate production amounts, operating hours of permitted equipment, and surface disturbance information for all disturbances of five acres or greater. During 2001, approximately 32 tons of pollutants were estimated to be emitted from permitted operations at the NTS. The Air Quality Permit Data Report was sent to the state of Nevada in February 2002.

One of the conditions of the permit is to allow the state of Nevada Bureau of Air Quality personnel access to the NTS to conduct inspections of facilities and operations regulated by state air permits. During 2001, there was one state inspection of NNSA/NV facilities possessing air quality permits. There were no violations.

Monthly visible emission readings are a requirement of the NTS air quality operating permit, AP9711-0549. The permit limits particulate emissions to 20 percent opacity, except at the Area 1 Aggregate Plant, where portions of the Plant have a limit of 10 percent. Certification of personnel to perform valid visible emission opacity evaluations is required by the state, with recertification required every six months. During 2001, four employees from Bechtel Nevada (BN) were recertified, and several visible emission evaluations of permitted air quality point sources were conducted. The opacity limit was exceeded once in 2001. A load that included a higher-than-normal volume of plastic materials was mistakenly burned in the Area 23 incinerator in November 2001. The resulting opacity (100 percent) exceeded the 3-minute/hour limit allowed by the state. The state was immediately notified. No violations were issued by the state.

Non-NTS Air Quality Permit Compliance

Under normal conditions, the six non-NTS facilities operated by the NNSA/NV do not produce radioactive effluents. The six are, the North Las Vegas Facility (NLVF) and Remote Sensing Laboratory (RSL) at Nellis Air Force Base in North Las Vegas, Nevada; Special Technologies Laboratory (STL) in Santa Barbara, California; Livermore Operations (LO) in Livermore, California; Los Alamos Operations (LAO) in Los Alamos, New Mexico; and RSL Andrews Air Force Base in Washington, D.C. The NLVF and RSL-Nellis are regulated for the emission of criteria pollutants and maintain air quality operating permits for a variety of equipment that mainly includes boilers and generators (Table 3.2). Twelve air quality operating permits and one dust permit, issued by the Clark County Health District in Las Vegas, Nevada, were required for operations at the NLVF and RSL-Nellis during 2001. There were no effluent monitoring requirements associated with these permits.

No air permits were held or required for the LO, LAO, or RSL-Andrews facilities in 2001.

CLEAN WATER ACT (CWA)

The Federal Water Pollution Control Act, as amended by the CWA, establishes ambient water quality standards and effluent discharge limitations, which are generally applicable to facilities that discharge any materials into the waters of the United States (CFR 1977). Discharges from NNSA/NV facilities are primarily regulated under the laws and regulations of the facility host states. Monitoring and reporting requirements are typically included under state or local permit requirements. A list of applicable permits appears in Tables 3.3, 3.4, and 3.5. There are no National Pollutant Discharge Elimination System permits for the NTS, as there are no wastewater discharges to onsite or offsite surface waters.

NTS Operations

Discharges of wastewater are regulated by the state under the Nevada Water Pollution Control Law (Nevada Revised Statutes 1977). The state of Nevada also regulates the design, construction, and operation of wastewater collection systems and treatment works. Wastewater monitoring at the NTS was limited to sampling wastewater influents to sewage lagoons and containment ponds.

State general permit GNEV93001 (Table 3.3), which regulates the ten usable sewage treatment facilities on the NTS, was issued by the Nevada Division of Environmental Protection (NDEP) and became effective on February 1, 1994. The general permit was renewed for five years on December 7, 1999. The permit was structured to allow the NNSA more flexibility in bringing new industrial processes on line.

Downsizing of NTS operations has resulted in low flow conditions at several sewage lagoon systems. Funding was approved for engineering design of septic tank/leachfield systems to replace these sewage lagoons. Permits to construct new septic systems were issued for the Area 12 Camp, Area 6 Los Alamos National Laboratory (LANL) Construction Camp, Area 23 Gate 100, Area 5 RWMS, Area 6 Device Assembly Facility (DAF), Area 25 Central Support, and Area 25 Radiological Control Point. Construction of these systems is scheduled to be completed in 2002.

Existing septic systems permitted in 2001 included Area 23 Wackenhut Services, Incorporated Range, Area 6 Air Resources Laboratory, Area 22 Air Resources Laboratory, and Area 27 Able Site (Table 3.3).

The Area 23 sewage lagoon system proceeded with design changes to eliminate the six primary lagoons. Calculations indicated that the primary lagoons were no longer necessary due to reduced influent from downsized worker populations. Design criteria and preliminary drawings were submitted to the state, and the Operations and Maintenance Manual for the lagoons was modified. Construction will be completed in 2002.

State inspections of the permitted sewage lagoons were conducted on April 3 and 4, 2001. No findings were noted. All lagoons were being operated in a safe and compliant manner. Permit requirements for quarterly, toxic, and groundwater monitoring were completed, and all parameters were in compliance with permit limits.

Septic hauler permits for the NTS were renewed in 2001 (Table 3.5).

Non-NTS Operations

Three permits for wastewater discharges were held by non-NTS facilities. One permit is required for the NLVF, and the STL holds wastewater permits for the Botello Road and Ekwill Street locations (Table 3.3). Additionally, a new permit was issued to the RSL-Nellis. No wastewater permits were required for the LO, LAO, or RSL-Andrews facilities in 2001.

The Wastewater Contribution Permit for NLVF (VEH-112) was renewed in 2001. This permit expires in December 2006. In October 2001, self-monitoring was conducted, as required. Total phosphorus levels were exceeded. Exceedence of phosphorus levels does not constitute a non-compliance of the permit, but is a surcharge item. Resampling by the city of North Las Vegas (NLV) indicated no exceedance of permit limits for phosphorus. Inspection of the permitted facility by the city of NLV resulted in no findings; however, recommendations were made concerning secondary containment for drummed liquids and berms to protect floor drains. All recommendations were implemented in a timely manner.

A new pretreatment permit (CCSD-080) was issued to NNSA/NV by the Clark County Sanitation District pursuant to the Categorical Pretreatment regulations. The permit is good for one year, beginning in June 2001, and covers wastewater discharge from the RSL-Nellis. Two monitoring episodes were conducted in 2001, and both were in compliance with permit requirements.

SAFE DRINKING WATER ACT (SDWA)

NTS Operations

The SDWA and state of Nevada regulations (NAC 445A) constitute the basis for drinking water compliance at the NTS. The state of Nevada has enforcement authority for the SDWA and has promulgated regulations covering operation and maintenance, water haulage, operator certification, permitting, and SDWA monitoring requirements.

Until October 1, 2001, BN operated four public water systems for the NNSA/NV at the NTS. The permit for the Area 1 system (NY-5024-12NCNT) was discontinued at that time, because there are no longer any active service connections in that system. Permits are renewed annually in September. The water systems are monitored for coliform bacteria, volatile organic chemicals, inorganic chemicals, synthetic organic compounds, and other water quality parameters on a schedule established by the state of Nevada in accordance with federal requirements.

In 2001, the four systems were in compliance with SDWA monitoring requirements, with one exception. During 2001, lead was found above the action level in one system. Corrective action was initiated to resolve this problem (see Chapter 6.0 for details). Coliform bacteria were detected in two water systems in June and July, but the samples were invalidated after an investigation determined the contamination occurred after sample collection, due to poor handling procedures. The problems were corrected, and all samples since July have been negative for coliform bacteria. All other monitoring results for 2001 were within regulatory limits and are discussed in Chapter 6.0.

NTS Water Haulage

To accommodate the diverse and often transient field work locations at the NTS, a water haulage program is used. To ensure potability of hauled water, permitted water hauling trucks use a sanitary connection to obtain and deliver potable water from a permitted water system. In 2001, the NTS maintained two permitted water hauling trucks. Water hauling permits are renewed annually at the same time as the regular water system permits (Table 3.4).

Water hauling trucks are sampled monthly for coliform bacteria. Both trucks had positive coliform bacteria samples in 2001, but confirmation samples and repeat monitoring all showed no bacteria. Detailed information appears in Chapter 6.0.

Non-NTS Operations

All non-NTS operations receive municipal water and have no compliance activities under the SDWA and state/local regulations.

RESOURCE CONSERVATION AND RECOVERY ACT (RCRA)

RCRA (RCRA 1976) 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 of RCRA, the EPA may authorize states to administer and enforce hazardous waste regulations. Nevada has received such authorization and acts as the primary regulator for many NNSA/NV facilities. The Federal Facilities Compliance Act (FFCA) of 1992 extends the full range of enforcement authorities in federal, state, and local laws for management of hazardous wastes to federal facilities, including the NTS.

NTS RCRA Compliance

In 2002, the NNSA/NV operated the Hazardous Waste Storage Unit and Explosive Ordnance Disposal Unit in accordance with the RCRA Hazardous Waste Operating Permit issued in 2001. No violations were noted.

HAZARDOUS WASTE REPORTING FOR NON-NTS OPERATIONS

The NLVF, LO, STL, and LAO locations generate hazardous waste and have EPA Identification numbers, but have no reporting requirements because they are operated as conditionally exempt small quantity generators of hazardous waste.

UNDERGROUND STORAGE TANKS (USTs)

NTS Operations

The NTS UST program has met regulatory compliance schedules for the reporting, upgrading, or removal of documented USTs. During 2001, there were no regulated USTs removed or upgraded, as all requirements had been satisfied in 1998.

The NNSA/NV operates one deferred UST and three excluded USTs at the DAF. The NNSA/NV also maintains a fully-regulated UST that is not currently in service at the Area 6 heli-pad.

During 2001, one heating oil tank was removed, and the impacted soil from historic spills was excavated. That removal reduces the number of unregulated underground heating oil tanks on the NTS to eleven.

Non-NTS Operations

The RSL operates three fully-regulated USTs, one deferred UST, and two excluded USTs. In November 2001, the Clark County Health District cited two of the tanks as out of compliance. Corrective actions were pursued, but not completed in 2001.

COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, AND LIABILITY ACT (CERCLA)/SUPERFUND AMENDMENTS AND REAUTHORIZATION ACT (SARA)

In April 1996, the NNSA/NV, Department of Defense, and the NDEP entered into a FFACO pursuant to Section 120(a)(4) of CERCLA (CERCLA 1980) and Sections 6001 and 3004(u) of RCRA (RCRA 1976) to address the environmental restoration of historic contaminated sites at the NTS, parts of Tonopah Test Range (TTR), parts of the Nellis Air Force Range (NAFR), the Central Nevada Test area, and the Project SHOAL area. Appendix VI of the FFACO describes the strategy that will be employed to plan, implement, and complete environmental corrective action at facilities where nuclear-related operations were conducted.

FEDERAL FACILITIES AGREEMENT AND CONSENT ORDER (FFACO)

Remedial Activities - Surface Areas

Environmental restoration activities continued at the NTS and TTR in calendar year 2001. These activities comply with the agreements specified in the FFACO signed between the NNSA/NV and the NDEP and follow a formal work process beginning with a Data Quality Objectives (DQO) meeting between NNSA, NDEP, and contractors. The purpose of the DQO meeting is to define the scope of work, how the site characterization is to be done (sampling strategy), and to develop the conceptual model for the site. The conceptual model defines the nature and extent of waste in the subsurface and guides the investigation. A Corrective Action Investigation Plan is prepared, providing the information on how the site is to be characterized.

Site characterization is carried out and documented in the Corrective Action Decision Document (CADD). This report provides the information that either confirms the conceptual model or modifies it. If suitable information is available to make a decision, a remedial alternative is selected from several alternatives identified for analysis 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 (if appropriate), waste management, etc.

The NDEP is a participant throughout the remediation process. The Community Advisory Board is also kept informed by NNSA/NV of the progress made.

Some sites are closed under the Streamlined Approach for Environmental Restoration (SAFER) process. These sites typically have suitable information available and can be remediated under a shorter schedule. 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.

During CY 2001, all FFACO deadlines were met. The actions taken are summarized below:

- Annual Post-Closure Monitoring Reports were submitted to comply with the conditions of the RCRA Part B Permit for the Area 2 Bitcutter Shop and Lawrence Livermore National Laboratory (LLNL) Post Shot Containment Building Injection Wells (corrective action unit [CAU] 90), Area 23 Landfill Hazardous Waste Trenches (CAU 112), U3fi Injection Well (CAU 91), and Area 6 Decontamination Pond (CAU 92) RCRA Closure Units.

- Several other CAUs also had Post-Closure Monitoring reports prepared. These were the Area 12 Steam Fleet Operations Steam Cleaning Discharge Area (CAU 339), Roller Coaster Sewage Lagoons, TTR (CAU 404), Roller Coaster RADSAFE Area, TTR (CAU 407), Area 3 Landfill Complexes, TTR (CAU 424), Cactus Springs Waste Trenches, TTR (CAU 426), Area 3 Septic Waste Systems 2 and 6, TTR (CAU 427), and Area 9 UXO Landfill, TTR, (CAU 453).

- The closure report for CAU 110, Area 3 RWMS U3ax/bl Disposal Unit, was prepared and approved by NDEP.

- A SAFER plan for CAU 113, Reactor Maintenance, Assembly, and Disassembly Building, was prepared and approved by the NDEP.

- A closure report for CAU 135, Area 25 Underground Storage Tanks, was prepared and approved by the NDEP.

- The CAP for CAU 143, Area 25 Waste Dumps, was prepared and approved by the NDEP, March 2001.

- A SAFER plan for CAU 230, Area 22 Sewage Lagoons and CAU 320, Area 22 Desert Rock Airport Strainer Box, was prepared and approved by the NDEP.

- A closure report for CAU 230, Area 22 Sewage Lagoons and CAU 320, Area 22 Desert Rock Airport Strainer Box, was prepared and approved by the NDEP.

- A closure report for CAU 240, Area 25 Vehicle Washdown, was prepared and approved by the NDEP.

- A closure report for CAU 261, Area 25 Test Cell A Leachfield System, was prepared and approved by the NDEP.

- A SAFER plan for the closure of CAU 326, Areas 6 and 27 Release Sites, was prepared and approved by the NDEP.

- A SAFER plan for CAU 330, Areas 6, 22 and 23 Tanks and Spill Sites, was prepared and approved by the NDEP.

- The draft closure report for CAU 343, Areas 1, 3, and 4 Housekeeping Sites, was prepared and submitted for the NDEP approval.

- The closure report for housekeeping CAU 387, Spill Sites and Releases, was prepared and approved by the NDEP.

- A SAFER plan for CAU 398, Area 25 Spill Sites, was prepared and approved by NDEP.

- The closure report for CAU 417, The Central Nevada Test Area Surface, was completed and approved by the NDEP.

- The closure report for CAU 407, The ROLLER COASTER Radsafe Area, was prepared and approved by the NDEP.

- A closure report for CAU 428, Area 3 Septic Waste Systems one and five, TTR, was prepared and approved by the NDEP.

- The closure report of CAU 486, DOUBLE TRACKS RADSAFE Area, was prepared and approved by the NDEP.

- A SAFER plan for the closure of CAU 499, Radar 24 Diesel Spill Site, was prepared and approved by the NDEP.

EMERGENCY PLANNING AND COMMUNITY RIGHT-TO-KNOW ACT (EPCRA)

EPCRA compliance activities for 2001 included upgrading of the inventory system to accommodate intranet data submittal, improved reporting, and standardization of hazard classifications for chemicals reported.

In March 2001, the Nevada Combined Agency Report was submitted to the state Fire Marshall's office by NNSA/NV. EPCRA compliance with Section 302 (Planning Notification) and Sections 311-312 (Material Safety Data Sheet/Chemical Inventory) for the NTS, HSC, NLVF, and the RSL was met. No planning thresholds were exceeded at these facilities. Chemical Catastrophe Prevention Program requirements were also met for these facilities. The latter program covers extremely hazardous substances (EHSs).

A Toxic Release Inventory Report required by Section 313 of the SARA Title III must be provided if the facility, any time in the prior CY, exceeds any Section 313 threshold for manufacture, process, or other use. In CY 2000, no thresholds were exceeded, so no report was required in 2001.

Non-NTS Tier II Reporting Under SARA Title III

The reports for the off-NTS Nevada facilities, RSL, and NLVF, are described under EPCRA above.

Other non-Nevada operations either had no chemicals above reporting thresholds or submitted their chemical inventories to the cities/counties as part of their business plans.

DOE ORDER 435.1 RADIOACTIVE WASTE MANAGEMENT

During the reporting period, NNSA/NV executed its Implementation Plan for meeting the requirements of DOE Order 435.1 by the agreed-upon compliance date of March 5, 2001. Objectives in support of this plan include completion of activities for the review of processes related to the development of an NNSA/NV Site-Specific Manual, finishing research in support of the identification of facilities and activities subject to 435.1, and finalizing the development of an integrated Site-Wide Radioactive Waste Management Program requiring full implementation by the established deadline.

In support of the above objectives, NNSA/NV held two Radioactive Waste Management Basis Assistance and Review Team (RWMBART) meetings in January 2001 that were attended by federal and contractor representatives appointed by the Assistant Manager for Environmental Management (AMEM). The purpose of these meetings was to provide a background and introduction to DOE Order 435.1, the NNSA/NV-specific DOE Order 435.1-1 manual, and RWMBART requirements regarding the review of programmatic Radioactive Waste Information Documents (RWIDs). Team members were provided with informational materials for review, and each RWMBART member was assigned a number of action items to be completed in support of Order compliance of March 5, 2001.

During the second quarter of CY 2001, the Maintenance and Operations Contractor performed an internal assessment to determine its level of compliance with the requirements of DOE Order 435.1-1. The assessment was also performed in anticipation of future DOE/HQ's audits of the NNSA/NV Radioactive Waste Management Program. As part of assessment closure, issues and concerns were compiled and presented before the RWMBART. These items were discussed in further detail and provided additional opportunities for program enhancements.

During the remainder of the CY, four additional RWMBART meetings were held in support of DOE Order 435.1-1 and associated NTS waste management activities. These included RWMBART review of RWIDs, submitted by the following programmatic entities: (1) waste management, (2) environmental restoration, and (3) national laboratories. This information, as approved by AMEM, includes documented revisions and changes which are maintained by the Chairperson of RWMBART (also the Division Director, Waste Management Division).

In support of DOE Order 435.1-1 activities for calendar year 2002, plans include the development of process enhancements to expand organizational roles and responsibilities in support of Order compliance. This includes completion of a document revision to NNSA/NV DOE Order 435.1-1 to incorporate lessons learned from the Maintenance and Operations Internal Assessment, creation of RWID process approval and revision flow diagrams, and discussions regarding optimal configuration management of RWIDs to ensure organizational reliability and access. Other activities include additional RWMBART meetings as necessary to review new or revised RWIDs.

STATE OF NEVADA CHEMICAL CATASTROPHE PREVENTION ACT

The state of Nevada Chemical Catastrophe Prevention Act of 1992 contains regulations for facilities defined as Highly Hazardous Substance Regulated Facilities (NAC 1992). This law requires registration of facilities storing highly hazardous substances above listed thresholds. Reporting for this program is also covered by the Nevada Combined Agency Report discussed under EPCRA above.

A Chemical Catastrophe Accident Prevention registration form was submitted by NNSA/NV for ammonia, chlorine, hydrogen chloride, nitrogen dioxide, oleum, sulfur dioxide, and thionyl chloride in June 2001.

There were no reportable EHS chemicals at any other NNSA/NV facilities (NTS, RSL, NLVF) in 2001.

TOXIC SUBSTANCES CONTROL ACT (TSCA)

The state of Nevada regulations implementing TSCA require transmittal of an annual report describing polychlorinated biphenyl (PCB) control activities. There are no known pieces of PCB Electrical Equipment (transformers/capacitors/regulators) at the NTS, and during 2000 there was also no disposal of PCB equipment or fluids; therefore, no annual report was required in 2001 reporting PCB activity for 2000.

FEDERAL INSECTICIDE, FUNGICIDE, AND RODENTICIDE ACT (FIFRA)

Pesticide usage included insecticides, herbicides, and rodenticides. Insecticides were applied twice a month at the food service and storage areas. Herbicides were applied once or twice a year at NTS sewage lagoon berms. All other pesticide applications were on an as-requested basis. General-use pesticides are used exclusively at the NTS. Contract companies applied pesticides at all non-NTS facilities in 2001.

THREATENED AND ENDANGERED SPECIES PROTECTION

The ESA (CFR 1973) requires federal agencies to insure that their actions do not jeopardize the continued existence of federally listed endangered or threatened species or their critical habitat. The desert tortoise (*Gopherus agassizii*) and bald eagle (*Haliaeetus leucocephalus*) are the only threatened species which occur on the NTS. No endangered animals and no threatened or endangered plants are known to occur on the NTS. Consultation with the United States Fish and Wildlife Service (USFWS) resulted in receipt of a non-jeopardy Biological Opinion in August 1996 for planned activities at the NTS for a ten-year period (USFWS 1996).

The Desert Tortoise Compliance Program implemented the terms and conditions of the USFWS Biological Opinion and documented compliance actions taken by NNSA/NV. The terms and conditions, which were implemented in 2001 included pre-construction tortoise clearance surveys for 12 projects, onsite monitoring of construction for the 12 projects, and preparation of an annual compliance report for the USFWS of NTS activities that were conducted in CY 2001. Project activities conducted in CY 2001 resulted in the loss of 22 acres of undisturbed tortoise habitat. Since issuance of the first non-jeopardy Biological Opinion in 1992, no tortoises have been accidentally injured or killed; no tortoises have been captured and displaced from project sites; and a total of 198.6 acres of desert tortoise habitat has been disturbed as a result of NTS activities (Table 3.6).

In October 2001, a team of volunteer biologists, led by the Southern Nevada Field Office of the USFWS, captured, measured, and weighed desert tortoises within three 21-acre circular enclosures in Rock Valley. The circular enclosures were constructed during 1962-1963 to study the effects of chronic, low-level ionizing radiation on the desert flora and fauna. Over the past decades, at least 24 tortoises have been found, individually marked, and periodically measured. There are approximately 18 adult tortoises remaining in the enclosures. They are considered captive by the USFWS and are not protected under the 1996 Biological Opinion. In 2001, one immature, seven adult male, and five adult female tortoises were captured, measured, and weighed.

The threatened bald eagle is an uncommon transient to the NTS and is not expected to be impacted by NTS activities. No sitewide surveys to determine its distribution or abundance have been conducted. Records of all bird sightings, which are made opportunistically, are maintained to provide some data on the occurrence of various birds on the NTS. There were no reported sightings of bald eagles on the NTS in 2001.

HISTORIC PRESERVATION

The NHPA of 1966, the Archeological Resources Protection Act of 1979, and the regulations related to these laws direct federal agencies to identify, inventory and manage the cultural resources under their stewardship. The NHPA also requires consultation with interested parties, especially Native Americans, in regard to historic preservation activities and proposed decisions affecting cultural resources.

Section 106 Surveys

As required under Section 106 of the NHPA, the NNSA/NV conducted cultural resources surveys and historical evaluations prior to undertakings in order to determine if proposed activities would adversely affect significant historic properties. Significant historic properties are those sites, locations, and structures that are determined to be eligible to the National Register of Historic Places (NRHP) through consultation between the NNSA/NV and the state of Nevada Historic Preservation Office (NSHPO). Under the NHPA, all NNSA/NV cultural resources reports and plans are reviewed by the NSHPO for compliance with the NHPA. All consultations with the NSHPO were completed successfully, with reports finalized and distributed to the Nevada State Cultural Resources Archives.

There were three survey projects conducted in 2001.

- Four Seismic Refraction Lines and 34 Integrated Seismic Stations in Area 12 (22.7 acres)
  One site eligible to the NRHP (preserved).

- Frenchman Flat Seismic Survey in Area 5 (2,287.6 acres)
  Two structures eligible to the NRHP (preserved).

- Wind Farm Project in Areas 16, 29, and 30 (2,135 acres)
  Forty-seven sites that may be eligible to the NRHP (consultation regarding eligibility to take place in 2002).

One historical evaluation was initiated in 2001, a study of the T-3b FIZEAU Underground Bunker in Area 3. This project will be completed in 2002.

Section 110 Surveys

Two inventory projects, meeting the requirements of the NHPA, Section 110, were conducted in 2001. These were surveys of the Bower Cabin site and the Whiterock Spring area. The Bower Cabin site is a mining camp dating back to the early part of the twentieth century and identified with the Oak Spring Mining District of Nye County. B.M. Bower and her family lived on the NTS in the 1920s and worked the nearby El Picacho mines for several years. The cabin and one ancillary structure are still standing but only the foundations of her writing studio and other buildings remain. The technical report on the Bower Cabin is in draft final format with the site being recommended as eligible to the NRHP.

The inventory at Whiterock Spring is a continuation of archaeological investigations at spring locations on the NTS. The area is an ethnographically documented Shoshone residential base with evidence of habitation dating back eight thousand years. From the 1880s through the 1930s, the spring was used by miners, ranchers, and Native Americans, with the ranchers constructing dwellings and corrals. The draft technical report summarizing this work is in progress.

Mitigation of Adverse Effects to Significant Cultural Resources

In cases when project activities will adversely affect properties eligible to the NRHP, actions to mitigate the effects are required by law. During 2001, mitigation was completed for ten buildings that are to be demolished and are eligible to the NRHP. In all ten cases, mitigation consisted of preparing Historic American Engineering Record (HAER) documentation for each building. This documentation is prepared in consultation with the National Park Service and upon acceptance, is archived in the Library of Congress to serve as the permanent record for the buildings.

HAER documentation was completed for five buildings within the Frenchman Flat Historic District in Area 5, that are to be demolished in FY 2002. Four are pumping stations (Well 5 Booster Stations 1, 2, 3, and 4), and one is the switching station for the timing and firing of the atmospheric tests (Building F-370). HAER documentation also was completed for the primary buildings at the Reactor Maintenance Assembly and Disassembly (R-MAD) facility (Building 3110), Test Cell A (Building 3113/3113A), and Test Cell C (Building 3210) in Area 25; Pluto (Building 2201) in Area 26; and Super Kukla (5400/5400A) in Area 27. R-MAD and the test cells were used in the testing and development of nuclear reactors for rocket propulsion into space. At the NTS, this research was conducted by the LANL from the late 1950s to the early 1970s. Building 2201 was the reactor disassembly building for the LLNL's Pluto program work that ran from the late 1950s to early 1960s. The goal of this project was to test and develop a nuclear reactor for a ramjet propulsion system. The primary building at the Super Kukla facility contained a nuclear reactor for testing nuclear device components for their response to neutron burst exposure. It was built in 1964 and used by LLNL until 1979.

Monitoring of Cultural Resources

The Cultural Resources Management Plan for the NTS formalized a program that meets requirements of the NRHP, which focuses on monitoring the condition of archaeological sites and historic structures that have been determined to be eligible to the NRHP. Following the monitoring of 11 locations in 2000, no formal monitoring was conducted in 2001. Monitoring will be conducted again in 2002.

Curation of Archaeological Collections

Under Title 36 CFR Part 79, a regulation for the NHPA, the NNSA/NV is required to maintain the archaeological materials recovered from the lands under the control of the NNSA/NV in a secure and environmentally-controlled facility. This curatorial facility houses more than a half million artifacts. Most were collected during data recovery (mitigation) activities at NRHP eligible sites. Site and survey records also are curated at this facility.

Consultation with Native Americans

In the Fall of 2001, a two-day meeting of the representatives for the Consolidated Group of Tribal Organizations (CGTOs) and the NNSA/NV was held in Las Vegas. The purpose of the meeting was to identify potential future ethnographic projects and to discuss the issues of concern to the CGTO.

Ethnographic consultation with the CGTO, regarding the Wind Farm Project area, was initiated in 2001 to determine if any of the proposed project locations are Traditional Cultural Properties (TCPs) and if they are eligible to the NRHP as TCPs. Also, this consultation program was designed to meet the NHPA Section 106 consultation directives.

The Native American Graves Protection and Repatriation Act (NAGPRA) requires federal agencies to consult with Native Americans regarding items in their artifact collections that may qualify for repatriation to a tribe. NAGPRA consultations for the main NNSA/NV collection were completed several years ago. Consultations have been completed for two collections, known as the Worman and McKinnis collections with repatriation of requested objects rescheduled for 2002. In 2001, the consultations regarding collections from the Hot Creek Valley, collected during DOE/NV activities in the 1960s, were completed with more items identified for repatriation.

Also, NNSA/NV sponsored and published a book,"American Indians and the Nevada Test Site, a Model of Research and Consultation" (Stoffle et al., 2001), that provides an overview of the past ten years of consultations with the American Indians for NTS programs.

MIGRATORY BIRD TREATY ACT

The Migratory Bird Treaty Act governs the taking, killing, or possession of migratory birds. All but a few of the 239 species of birds which are known to occur on the NTS are protected under this Act. Several buildings scheduled for demolition on the NTS were surveyed in 2001 to determine the presence of roosting or nesting birds. A pair of breeding barn owls was found in each of two buildings: Building 210 in Mercury and the R-MAD Decon building in Area 25. Demolition of both these buildings was postponed until all young owls had fledged from the nests and no birds were present in the buildings. No migratory birds were known to have been harmed during any demolition activities elsewhere on the NTS.

During CY 2001, two mourning doves, two Gambel's quail, and two chukar were collected and sacrificed for radionuclide tissue analysis under the state of Nevada Division of Wildlife Scientific Collection Permit Number S20571. One adult red-tailed hawk that was found dead in Mercury near Building 550 was salvaged under this same state permit and taken to a taxidermist for mounting and use in wildlife education.

Sightings of dead birds are reported to biologists and are investigated to determine if NTS facilities/activities need to be modified to reduce the incidence of bird mortality. Eight other raptors and one game bird was found dead on the NTS in 2001: one juvenile barn owl that had become trapped in a room in Building 210 in Mercury; one juvenile barn owl that had fallen to the floor from its rafter nest in Building 210; one juvenile barn owl found in its nest in the R-MAD Decon building in Area 25; one adult barn owl killed by a predator at the Area 6 LANL pond; one adult American kestral that had flown into a power pole in Mercury; one juvenile great-horned owl found in a nest in a building in Area 3; one adult sharp-shined hawk found dead outside Building 111 in Mercury; one adult golden eagle that was hit by a car in Area 3 when it flushed from the roadside and flew over the road; and one Gambels' quail killed by a car in Area 1. No mitigation actions were identified in 2001 that may reduce the incidence of bird mortality on the NTS.

EXECUTIVE ORDER (EO) 11988 FLOODPLAIN MANAGEMENT

NTS design criteria do not directly address floodplain management; however, all projects are reviewed for areas which would be affected by a 100-year flood pursuant to DOE Order 6430.1A (DOE 1989). There were no projects in 2001 that required consultation for floodplain management.

EXECUTIVE ORDER (EO) 11990 PROTECTION OF WETLANDS

There were no projects in 2001 which required consultation for protection of wetlands. NTS design criteria do not specifically address protection of wetlands; however, all projects are reviewed pursuant to the requirements of DOE Order 5400.1 (DOE 1990a). Limited monitoring of selected wetlands occurred during 2001 to further characterize the biological and physical conditions at the five new wetlands discovered during 1998.

3.2 AGREEMENTS WITH STATES AND AGENCIES

During 2001, the NTS was subject to several agreements with regulatory agencies and states. These agreements are listed below.

- an Interagency Agreement with EPA covering environmental monitoring, emergency response, and related activities.
- a Memorandum of Understanding (MOU) with EPA regarding NESHAP compliance.
- a MOU with Nevada covering releases of radioactivity.
- a MOU with Nellis Air Force Base for environmental restoration on the TTR.
- a FFACO with the state of Nevada on environmental restoration activities.
- a Consent Order under the FFCA with the state of Nevada regarding the storage of restricted mixed waste streams on the NTS.
- an Agreement in Principle (AIP) with Nevada on environment, safety, and health oversight activities.
- an AIP with Mississippi on environment, safety, and health oversight activities.
- an AIP with Alaska on environment, safety, and health oversight activities.
- a Settlement Agreement with Nevada concerning the of existing inventory of mixed TRU waste.
- a Mutual Consent Agreement with Nevada on storage and management of newly generated mixed LDR wastes on NTS.

3.3 CURRENT ENVIRONMENTAL COMPLIANCE ISSUES AND ACTIONS

There were numerous activities and actions relating to environmental compliance issues in 2001. These activities and actions are discussed below, grouped by general area of applicability.

CLEAN AIR ACT (CAA)

Under Title V, Part 70 of the CAA amendments, all owners or operators of Part 70 sources must pay annual fees to the state that are sufficient to cover the costs of operating permit programs.

Sources such as the NTS that have a potential to emit 50 tons or more of any regulated pollutant, except carbon monoxide, must pay an annual fee of $3,000. Sources that have a potential to emit less than 25 tons per year, such as the Tactical Demilitarization Development (TaDD) and Underground testing Area (UGTA) projects, must pay an annual fee of $250. Maintenance and emissions fees of approximately $3,000 were paid to the NDEP in June 2001.

The NTS Class II Air Quality Operating Permit (AP9711-0549) expires in 2002. In the Spring of 2001, preparation of the permit renewal application was initiated. Meetings were held with the state to verify requirements. In the summer of 2001, a subcontractor was obtained to perform air dispersion modeling, a new requirement for submittal of the application. Preliminary approval of the dispersion model must be received prior to submittal of the final. A draft of the dispersion model was submitted to the state and approved in the latter part of 2001. Preparation of the main portion of the application form was ongoing through the end of the 2001 calendar year.

During 2001, several open burn permits, know as Open Burn Variances, were issued by the state for NTS activities. These variances included 01-33 for training fires, 01-128 for sensor tests, and 01-136 for weapons of mass destruction training exercises. The Open Burn Variance for the Area 27 burn box is now required to be renewed quarterly. Variances issued for the burn box during 2001 included 01-29, 01-72, 01-96 and 01-146.

Storage of hazardous wastes at the NTS is regulated by Nevada Hazardous Materials Storage Permit 13-00-0034-X, and the HSC has Permit 13-00-0037-X. These are issued by the state Fire Marshall and are renewed annually when a facility makes a report required by the state's Chemical Catastrophe Prevention Act (NAC 1992).

Table 3.7 contains a summary of the permits issued for NTS activities and for offsite activities that support the NTS.

Non-NTS Air Quality Permits

Five air quality operating permits were active for emission units at the NLVF, and seven permits were active for the RSL. These permits were issued through the Clark County Health District. Annual renewal is contingent upon payment of permit fees. Permits are amended and revised only if the situation under which the permit has been issued changes. For the other non-NTS operations, no air quality permits have been required, or the facilities have been exempted.

During 1998 the Air Pollution Control Division (APCD) of the Clark County Health District began requiring an "Emissions Inventory" submittal for all permitted sources. The 1999 Emissions Inventory was submitted by BN to the APCD on September 6, 2000. Submittal of an Emissions Inventory was not required in 2001.

CLEAN WATER ACT (CWA)

Low flows in several NTS sewage lagoons has reduced the efficiency of the lagoons to properly treat effluents. In response, the NNSA/NV has requested funding to install septic tank systems in these areas.

SAFE DRINKING WATER ACT (SDWA)

One public water remains out of compliance with the Lead and Copper Rule. Several buildings in this system have copper piping joined by lead solder. The state of Nevada has not initiated any enforcement action, while the NNSA/NV has studied options to achieve compliance.

The cross-connection control program at the NTS is not well documented, and NNSA/NV was not able to complete a Cross-Connection Control Plan, as required by state regulation. An engineering study was completed, and modifications began on the backflow prevention maintenance program.

SDWA Permits are listed in Table 3.4.

COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, AND LIABILITY ACT (CERCLA)

Other than the reporting covered in Section 3.1, there is no formal CERCLA program at the NTS. The FFACO, with the state, may preclude the NTS from being placed on the National Priority List. More of a RCRA approach in remediating environmental problems will be taken under the FFACO.

POLLUTION PREVENTION (P2) AND WASTE MINIMIZATION

The CY 2001 P2, waste minimization, and recycling efforts for waste generated at the NTS, NLVF, and offsite locations complied with DOE Order 5400.1 requirements for a P2 program. The NNSA/NV P2 program establishes a process to reduce the volume and toxicity of waste generated at all locations and ensures that the proposed method of treatment and/or disposal minimizes the present and future threat to human health and the environment.

It is a priority of NNSA/NV to minimize the generation, release, and/or disposal of pollutants to the environment by implementing cost-effective P2 technologies, practices, and policies in partnership with government and industry. A commitment to P2, waste minimization, and recycling manages operations in such a way as to minimize impact on the environment, improve the safety of operations, and promote energy efficiency and the sustainable use of natural resources. This commitment includes providing adequate administrative and financial materials on a continuing basis to ensure source reduction, recycling, and affirmative procurement goals are achieved.

Chapter 4.0 provides a summary of the P2 program, P2 accomplishments achieved during CY 2001, and activities that achieved reduction in volume and toxicity of waste.

SOLID/SANITARY WASTE

During CY 2001, landfills were operated in Areas 6, 9, and 23. The amount of waste disposed of in each is shown in Table 3.8, and their operating permits are in Table 3.7. State inspections of permitted landfills were conducted in March 2001. No compliance issues were noted. In January 2001, NNSA/NV submitted modifications to the Area 9 landfill permit. The modifications were made to allow the disposal of PCB Bulk Product Waste. The primary waste to be disposed of is applied dried PCB paint, which is being generated from Environmental Restoration projects. The modification was approved by the state in September 2001. Subsequent revisions were made to the applicable Operations and Maintenance Manual for the landfill.

RADIATION PROTECTION

NTS Operations

Results of monitoring during 2001 indicated full compliance with the radiation exposure guidelines of DOE Order 5400.5, "Radiation Protection of the Public and the Environment", and the Title 40 CFR 141 “National Primary Drinking Water Regulations”. Onsite air monitoring results for the networks showed average annual concentrations ranging from 0.4 percent of the DOE Order 5400.5 guidelines for HTO in air to 2.5 percent of the guidelines for $^{239+240}Pu$ in air. Drinking water supplies on the NTS contained no man-made radioactivity above detection limits, and levels of naturally occurring radioactivity were in compliance with the National Primary Drinking Water Regulation.

Offsite monitoring in the vicinity of the NTS confirmed that emissions of radioactivity from the NTS were less than 2 percent of the guideline set forth in Title 40 CFR 61, Subpart H (CFR 1989).

Non-NTS BN Operations

Results of environmental monitoring at the off-NTS operations performing radiological work during 2001 indicate full compliance with the radiation exposure guidelines of DOE Order 5400.5. With one exception, no radioactive or nonradioactive surface water/liquid discharges, subsurface discharges through leaching, leaking, or seepage into the soil column, well disposal, or burial occurred at any of the BN operations. The exception was the NLVF Building A-1 radiation source well, in which water was found with concentrations of tritium that were above the drinking water standard of 20,000 pCi/L. From a review of geologic reports, historical aerial photos, Geoprobe borings, installation of temporary monitoring wells, and water analyses, the tritium was concluded to be from past local operations and was not found in ground water surrounding the facility.

Use of radioactive materials is primarily limited to sealed sources. Facilities, which use radioactive sources or radiation producing equipment, with the potential to expose the general population or non-project personnel to direct radiation, are the Atlas NLVF A-1 Source Range, Building C-3 (x-ray radiography operation), and the STL, during the operation of the sealed tube neutron generator or during operation of the Febetron. Sealed sources are tested every six months to ensure there is no leakage of radioactive material. Operation of any radiation generating devices is controlled by BN procedures. At least two thermoluminescent dosimeters (TLDs) are placed at the fence line of these facilities or where non-project personnel could be for limited periods and are exchanged quarterly. The TLD results were consistent with previous data indicating no exposures to the public from any of the monitored facilities.

ENVIRONMENTAL COMPLIANCE AUDITS

There were nine Environmental Compliance Management Assessments of specific operations, facilities, or projects for CY 2001. These assessments focused, in most cases, on one or two major areas of Environmental Compliance; for example, hazardous waste or universal waste management.

OCCURRENCE REPORTING

Occurrences are environmental, health, and/or safety-related incidents, which are reported in several categories in accordance with the requirements of DOE Order O 232.1A, "Occurrence Reporting and Processing of Operations Information," (DOE 1997a). The 11 reportable environmental occurrences for 2001 on NTS facilities appear in Table 3.9.

LEGAL ACTIONS

No legal actions were filed against NNSA/NV during 2001.

3.4 PERMITS FOR NTS OPERATIONS

Federal and state permits have been issued to NNSA/NV and to BN (Table 3.7). These permits are required for the conduct of such NNSA/NV activities as hazardous and solid waste storage and disposal for certain ecological studies, processes that emit air pollutants, tests at the HSC, and for operations involving endangered species. All BN non-NTS facilities are located in existing metropolitan areas and are not subject to the Endangered Species Act. Annual reports associated with these permits are filed as stipulated in each permit.

The only RCRA permit in use at the NTS is the Hazardous Waste Management Permit NEV HW009. With this permit, hazardous waste generated at the NTS can be stored at the Area 5 HWSU for up to one year. It is then shipped offsite for treatment and/or disposal. The permit also allows for the thermal treatment (disposal) of explosives at the Area 11 Explosive Ordnance Disposal Unit.

The NLVF has a Waste Generator number of 03990265X that covers generation and a 90-day accumulation of hazardous waste. The waste is shipped offsite for final treatment and/or disposal.

NNSA/NV activities on the NTS comply with all terms and conditions of a desert tortoise incidental take authorization issued in a Biological Opinion (File Number 1-5-96-F-33) from the USFWS.

The Nevada Division of Wildlife issued a scientific collection permit, S20571, to BN that allows collection of wildlife samples.

Table 3.1 Active Air Quality Permits - 2001

Permit	Description	Expiration Date	Annual Reporting
	NTS Air Quality Permits		
AP9711-0549		02/07/2002	February 1
Area 1 Facilities	Shaker Plant Circuit		
	Rotary Dryer Circuit		
	Wet Aggregate Plant		
	Concrete Batch Plant		
	Sandbag Facility		
	Cedar Rapids Screen		
	Shotcrete Hopper/Conveyor		
	Cambilt Conveyor		
	Commander Crusher		
	Kolberg Screen Plant		
Area 3 Facilities	Mud Plant		
Area 5 Facilities	Navy Thermal Treatment Unit		
Area 6 Facilities	Cementing Equipment (Silos)		
	Decontamination Facility Boiler		
	Diesel Fuel Tank		
	Gasoline Fuel Tank		
	Portable Field Bins		
	Portable Stemming Systems 1 & 2		
	Diesel Engines (11)		
	Two-Part Epoxy Batch Plant		
Area 12 Facilities	Concrete Batch Plant		
Area 23 Facilities	Building 753 Boiler		
	Diesel Fuel Tank		
	Gasoline Fuel Tank		
	NTS Surface Disturbances		
	Incinerator (Wackenhut)		
AP9711-0556	Area 5 HSC	10/20/2002	February 1
AP9711-0814	Area 11 TaDD Facility	07/21/2003	February 1
AP9711-0785	UGTA Surface Disturbance Permit	03/20/2003	February 1
00-24	Burn Variance, NTS (Training Fires)	03/09/2002	None
01-128	Burn Variance (Divine Invader Sensor Tests)	11/24/2001	None
00-136	Burn Variance (Weapons of Mass Destruction)	10/31/2002	None
	Non-BN Operated NTS Air Quality Permits		
01-146	Burn Variance Area 27 (LLNL)	02/21/2002	None
	BN Operated Off-NTS Air Quality Permits (TTR and NAFR)		
AP9711-0785	UGTA Class II Air Quality Permit	04/16/04	February 1

Table 3.2 Active Air Quality Permits for Non-NTS Facilities - 2001

Permit	Description	Expiration Date	Annual Reporting
Remote Sensing Laboratory			
A0034811	Excimer Laser, Lumonics, EX-700	None	June 1
A34801	Boiler, Columbia, W1-180	None	March 1
A34802	Boiler, Columbia, WL-90	None	March 1
A34803	Heater, No. 2 National BD	None	March 1
A34804(a)	Emergency Fire Control Pump Engine	None	June 1
A34804(b)	Emergency Generator, Cummins	None	June 1
A34805	Spray Paint Booth	None	June 1
North Las Vegas Facility			
A38701	Spray Paint Booth (A-16)	None	June 1
A38703	Emergency Generators (C-1)	None	June 1
A06503	Emergency Generator (A-1/A-5/B-2)	None	June 1
A06505	Aluminum Sander (A-16)	None	June 1
A06507	Trinco Dry Blaster (A-1)	None	June 1

Table 3.3 Sewage Discharge Permits - 2001

Permit No./Location	Areas	Expiration Date	Reporting Required
NTS Permits			
GNEV93001	NTS General Permit	12/07/2004	Quarterly
NY-17-05704	X Tunnel Collection System	09/30/2002	None
Off-NTS Permits			
North Las Vegas Facility			
VEH-112	Class II Wastewater Contribution Permit	12/31/2006	Annually
Special Technologies Laboratory			
AII-204/Santa Barbara, California		12/31/2001	
III-331/Santa Barbara, California		12/31/2001	
Remote Sensing Laboratory			
CCSD# 080	Pretreatment Permit	6/30/2002	Quarterly
NY-1080	Area 23 WSI Septic Tank	None	None
NY-1081	Area 6 ARL Septic Tank	None	None
NY-1082	Area 22 ARL Septic Tank	None	None
NY-1087	Area 27 Able Site Septic Tank	None	None

Table 3.4 NTS Drinking Water System Permits - 2001

Permit No.	Area(s)	Expiration Date	Reporting Required
NY-5024-12CNT (dropped)	Area 1	09/30/2001	None
NY-4099-12CNT	Area 2 & 12	09/30/2002	None
NY-360-12CNT	Area 5, 6, 22, 23	09/30/2002	None
NY-4098-12CNT	Area 25	09/30/2002	None
NY-835-12H	Sitewide Truck	09/30/2002	None
NY-836-12H	Sitewide Truck	09/30/2002	None

Table 3.5 Permits for NTS Septic Waste Hauling Trucks - 2001

Permit Number	Vehicle Identification Number	Expiration Date
NY-17-03313	Septic Tank Pumper E-106785	11/30/2002
NY-17-03315	Septic Tank Pumper E-107105	11/30/2002
NY-17-03317	Septic Tank Pumper E-105918	11/30/2002
NY-17-03318	Septic Tank Pumping Subcontractor	11/30/2002

Table 3.6. Allowable take of Desert Tortoises and their Habitat Permitted by the U.S. Fish and Wildlife Service for NTS Activities

Type of Take	Allowable Take Limit	2001 Status of Take Limit
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 is use during a project	Unlimited	5
Number of total acres of desert tortoise habitat disturbed during NTS project construction since 1992	3015	198.6

Table 3.7 Permits Required for NTS Operations - 2001

EPA Generator ID		
NV3890090001	NTS Activities	
NTS Permits		
Permit No.	**Areas**	**Expiration Date**
NEV HW009	NTS Hazardous Waste Management (RCRA)	11/01/2005
SW 13 097 02	Area 6 Hydrocarbon Disposal Site	Post Closure
SW 13 097 03	Area 9 U-10c Solid Waste Disposal Site	Post Closure
SW 13 097 04	Area 23 Solid Waste Disposal Site	Post Closure
13-00-0034-X	NTS Hazardous Materials	02/29/2002
13-00-0037-X	HSC Hazardous Materials	02/29/2002
S20571	Scientific Collection of Wildlife Samples	12/31/2002
1-5-96-F-33	USFWS -- Desert Tortoise Incidental Take Authorization	12/31/2006
Off-NTS Permits		
03-01-0265-X	North Las Vegas Facility Hazardous Materials	02/29/2002
03-01-0266-X	Remote Sensing Laboratory Hazardous Materials	02/29/2002
EPA Generator ID Numbers		
NVD097868731	North Las Vegas Facility Activities, NV	
CAL00177640	Santa Barbara Operations, CA	
CAL00177642	Santa Barbara Operations, CA	
CAL00197065	Livermore Operations, CA	
NMD986670370	Los Alamos Operations, NM	

Table 3.8 Quantity of Wastes Disposed of in Solid Landfills - 2001

Quantity (in tons)			
Month	**Area 9**	**Area 23**	**Area 6**
January - March	1254	203	2120
April - June	2385	204	4
July - September	2655	299	565
October - December	713	335	25
Totals	**7007**	**1041**	**2714**

Table 3.9 Off-Normal Occurrences at NTS Facilities - 2001

Date	**Report Number**	**Description**	**Status**
03/20/2001	NVOO-BNLV-NTS 2001-0002	An instrument with a radioactive source was improperly stored.	Closed
04/10/2001	NVOO-BNLV-NTS 2001-0004	A fuel line on diesel generator failed, and the cleanup was reportable to the state of Nevada.	Closed
05/03/2001	NVOO-BNLV-NTS 2001-0006	Potential improper hazardous material shipment concern when erroneous radioactive label discovered on jar of elemental mercury.	Closed
06/13/2001	NVOO-DTRA-NTS 2001-0001	Personnel exposure to chemical while offloading drum that was improperly loaded.	Closed
06/28/2001	NVOO-BNLV-NTS 2001-0008	Personnel violated posting radiological requirements at R-MAD.	Closed
06/28/2001	NVOO-BNLV-NTS 2001-0009	Historic heating oil spill at Area 23, Building 754, resulting in state notification.	Closed
07/12/2001	NVOO-BNLV-NTS 2001-0010	Historic heating oil spill at Area 25, Building 156, resulting in state notification.	Closed
08/21/2001	NVOO-BNLV-NTS 2001-0013	Near miss when worker picked up old brittle tritium sampling line and only got one drop on his face.	Open
08/21/2001	NVOO-BNLV-NTS 2001-0014	Historic heating oil spill at Area 12, Bldg 12-16-1, resulting in state notification.	Closed
09/27/2001	NVOO-BNLV-NTS 2001-0015	Concern over use of NE Electra radiological instrument that was out of calibration.	Open
11/16/2001	NVOO-BNLV-NTS 2001-0018	Near miss when two workers breached radiological area boundary, but no contamination was detected.	Open

Frenchman Flat Under Water (No Date Provided)

4.0 ENVIRONMENTAL PROGRAM INFORMATION

Reported in this section are the environmental stewardship programs for the Nevada Test Site (NTS). These programs are under the purview of the Environment, Safety and Health Division (ESHD) of the U.S Department of Energy (DOE), National Nuclear Security Administration Nevada Operations Office (NNSA/NV) for environmental management and compliance, field investigations for impact assessment, ecosystem management, pollution prevention (P2), waste minimization, science, and technology development.

4.1 ROUTINE RADIOLOGICAL ENVIRONMENTAL MONITORING PLAN

The NNSA/NV manages the NTS in a manner that meets evolving NNSA missions and responds to the concerns of affected and interested individuals and agencies. The Routine Radiological Environmental Monitoring Plan (RREMP) addresses compliance with DOE Orders and other drivers requiring routine effluent monitoring and environmental surveillance on the NTS. The RREMP describes the objectives and design elements for all media: air, water, soil, biota, and direct radiation sources. Existing and historical site information and regulatory requirements were reviewed and site characteristics, transport and exposure pathways, regulatory requirements, and historical data evaluated to support the monitoring designs. Both onsite and offsite monitoring objectives are addressed under the RREMP.

The RREMP identifies the requirements for radiological monitoring on and off the NTS and focuses on the need to ensure that the public and the environment are protected, compliance with the letter and the spirit of the law is achieved, and good land stewardship is practiced. The monitoring plan uses a decision-based approach to identify the environmental data that are collected and provides Quality Assurance, Analysis, and Sampling Plans, which ensure that defensible data are generated.

AIR MONITORING

Environmental monitoring includes the activities of environmental surveillance, effluent monitoring, and operational monitoring. For air monitoring, the principal difference among these three activities is the placement of the air sampling equipment. Environmental surveillance targets ambient air, but not specific facilities, while effluent and operational monitoring target facilities or activities. Effluent monitoring is directed at the measurement of a specific emission point, while operational monitoring is used to assess total emissions from an operating facility. The rationale, supporting the design of the air monitoring network for the NTS, addresses these types of monitoring and is discussed thoroughly in the RREMP.

The objective for the air monitoring network is to monitor all NTS radionuclide emissions above some reasonable lower limit, such that no significant emission source that contributes to calculable offsite exposures is ignored and to ensure that the NTS is in full compliance with the requirements of the Clean Air Act. The regulatory driver for this network includes Title 40 Code of Federal Regulations (CFR) 61, "National Emission Standards for Hazardous Air Pollutants (NESHAPs): Radionuclides," Subpart H – "National Emission Standards for Emission of Radionuclides Other Than Radon From Department of Energy Facilities." Other drivers include DOE Order 5400.1 – "General Environmental Protection Program," DOE Order 5400.5 – "Radiation Protection of the Public and the Environment," and DOE/EH-0173T – "Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance." These documents prescribe dose limits and air monitoring requirements.

To comply with the regulations listed above, a combination of approaches is used:

- Evaluating operational contributions through measurement of particulate-in-air and tritium-in-air emissions from such sources as the Radioactive Waste Management Sites (RWMSs) in Areas 3 and 5, and the Waste Examination Facility.

- Monitoring air at locations on the NTS known to be contaminated with radionuclides in order to evaluate the behavior of radionuclide emissions from those locations.

- Calculation of tritium in air based on the amounts of tritium in surface waters, confirmed through the observed behavior of tritium in air near tritium sources.

- Modeling particulate emissions in air using a soil resuspension model, based on the observed behavior of particulate emissions in air and confirmed by particulate air monitoring data from SCHOONER (Area 20), Gate 700 S (Area 10), Mercury (Area 23), Guard Station 510 (Area 25), 3545 Substation (Area 16) and Yucca (Area 6).

- Calculating an effective dose equivalent for each specific emission source at the NTS, using the CAP88-PC model as prescribed by NESHAPs, to provide dose calculations for all populated locations within 80 km (50 mi) (the location of the general public is assessed annually).

During the year 2001, no point sources qualified for offsite monitoring under NESHAPs requirements (capable of emitting $\geq$1 percent of the standard); however, point sources are continually evaluated for this potential. Accidental releases from facilities such as U-1a, Area 27, or the Device Assembly Facility will be monitored by the ambient monitoring network.

SURFACE WATER

The objectives of the routine radiological monitoring program for surface water are to determine (1) if concentrations of radionuclides in surface water bodies at the NTS and its vicinity are a threat to public health and the environment, and (2) if permitted facilities are in compliance with permit discharge limits.

The surface water sample locations on the NTS include the E Tunnel containment ponds and nine sewage lagoons. Offsite locations include nine natural springs. The criteria for selection were based on the monitoring objectives. Water sources have been selected based on potential for exposing the public, onsite biota, or the environment to significant levels of radionuclides, or requirements for monitoring under existing state discharge permits. The sources are as follows:

- Discharge from E Tunnel is collected in containment ponds and monitored under the current state permit.

- The nine sewage lagoons at the NTS receive effluents from sewage treatment plants permitted by the state (Bechtel Nevada [BN] 1997). Radionuclide monitoring of these lagoons is required under the current state permit.

Several offsite springs have historically been monitored and will continue to be monitored under this program. Six of the historically monitored springs are included in this plan; three springs not previously monitored will be added to the program; one for semiannual and two for annual sampling. These springs are discharge sites for the local and regional aquifers, for which the upgradient direction may be the underground testing area on Pahute Mesa. The offsite springs chosen for the monitoring network are therefore used as groundwater monitoring points in this hydrologic system. Continued monitoring will document and track trends in groundwater quality downgradient of the underground nuclear test sites on the NTS. Levels of radionuclides at all of the surface water sources mentioned above have consistently been below the Derived Concentration Guides listed in DOE Order 5400.5 over recent years (DOE 1990b).

GROUNDWATER

The characteristics of regional and local groundwater regimes at the NTS and the sources of radionuclides with potential impacts on groundwater are presented in Chapters 7.0 and 8.0 of this report. Groundwater is monitored onsite and offsite to comply with several regulatory drivers.

The objectives of the routine radiological monitoring program for groundwater include:

- **Water Supply Well Monitoring:** Determine if onsite water supply wells are impacted from radionuclides originating from NNSA operations on the NTS.

- **Permitted Facilities Monitoring:** Determine if there are groundwater impacts from surface and shallow vadose zone sources of radionuclides on the NTS.

- **Aquifer Monitoring:** Determine if groundwater at the NTS and its vicinity is further degraded as a result of the expansion of the radionuclide plumes associated with the underground test areas.

- **Water-level Information:** Determine the potential impact of demand for groundwater around the NTS on the long-term availability of water.

Water Supply Wells

Groundwater is the only local source of drinking water at the NTS and the surrounding area. The state permit for the NTS includes four drinking water supply systems that consist of ten potable water wells. These wells are sampled to determine compliance with the Safe Drinking Water Act (SDWA) and Nevada Revised Statutes (NRS), which include standards for radionuclides. In addition to the onsite water supply wells, the network will include offsite water supply and existing monitoring wells selected based on the following criteria:

- Select point-of-use water supply wells downgradient of the NTS (in the general direction of regional groundwater flow). Current site knowledge eliminates the possibility of transport of radionuclides from source areas to wells upgradient of the NTS, or opposite to the general direction of regional groundwater flow.

- Select wells close to the NTS boundary and in close proximity to the underground testing areas.
- Give preference to community wells.
- Give preference to high-yield, high-volume wells.
- Give preference to wells with appropriate construction/condition.
- Select wells where access is possible.
- Consult with Community Environmental Monitoring Programs to ensure that the concerns of local communities are addressed.

Permitted Facilities Wells

Five wells located at three facilities require routine groundwater monitoring under the terms of permits issued by the state of Nevada. These facilities are the Area 5 RWMS (RWMS-5), the Area 23 Infiltration Basin, and the Area 12 E Tunnel pond.

The Pit 3 Mixed Waste Disposal Unit located in the RWMS-5, currently under Resource Conservation and Recovery Act (RCRA) Interim Status, maintains compliance with Title 40 CFR 264/265 by monitoring three wells around the RWMS-5.

To comply with the groundwater protection requirements of the state General Permit GNEV93001, a monitoring well was installed (SM-23-1) in 1996 for the Area 23 Infiltration Basin.

Water Pollution Control Permit NEV96021, in compliance with the provisions of the Federal Water Pollution Control Act and NRS, allows NNSA/NV and the Defense Threat Reduction Agency to manage and operate a system for the treatment and disposal of waste water discharging from the portal of E Tunnel in Area 12 of the NTS. The effluent from the portal is conveyed into six earthen impoundments for disposal by means of infiltration.

Groundwater from the five permitted wells is sampled for the necessary constituents and at the required frequency as stated in the permit.

Aquifer Monitoring

The RREMP includes an interim effort to identify existing wells and boreholes (called point-of-opportunity wells), which are located downgradient of the Corrective Action Units (CAUs) and/or are in the regional aquifer. Point-of-opportunity wells located within CAUs have been screened based on the following criteria for their inclusion in the proposed network:

- Select point-of-opportunity wells downgradient of source areas.
- Give preference to wells within 1,000 m (3,280 ft) of underground tests, which are located below or within two cavity radii of the water table.
- Select wells accessing relevant hydrostratigraphic units within structural blocks having an upgradient source or sources.
- Give priority to wells in those transmissive units which also contain most of the underground test locations.

Wells screened have been further scrutinized to select those which would be most cost-effective to monitor, with the following construction criteria:

- Give priority to wells with immediate access to the aquifer.
- Give priority to wells with diameters appropriate for sampling.
- Give priority to wells that are completed (developed, casing exists, etc.).

Point-of-opportunity wells are existing wells which, according to the present level of understanding, appear to be at appropriate locations and completed in appropriate hydro-stratigraphic units. It is important to note that the groundwater monitoring in the RREMP is an interim program until the final CAU postclosure monitoring network can be designed and implemented.

Hot wells, also referred to as source-term characterization wells, are those used to sample groundwater from within or near the cavities produced by underground nuclear tests that were conducted below the water table. These groundwater samples are used to define the hydrologic source term (the type and concentration of radionuclides dissolved in groundwater, or potentially available to groundwater). Source term information fulfills the requirement in DOE Order 5400.1 to monitor the effects of NNSA/NV activities on the environment. This monitoring allows estimates to be made of the rate of radionuclide migration from the underground nuclear tests.

In addition to wells monitored for potential releases, water-level measurements will be performed for each sampling event at all wells if practical (e.g., no downhole pump in well). There are wells onsite and offsite that are monitored only for water levels by the U.S. Geological Survey (USGS). Data from these wells are analyzed for trends, impacts of water usage, and used to calibrate groundwater flow models.

VADOSE ZONE MONITORING (VZM)

The vadose zone is being monitored at three general types of sites on the NTS: RWMSs (Areas 3 and 5); RCRA closure sites (Area 23 Hazardous Waste Landfill and U-3fi); and permitted sanitary landfills (U-10c Landfill and the Area 6 Hydrocarbon Landfill) in addition to, or in lieu of, groundwater monitoring for the purpose of protecting groundwater resources. VZM at these sites generally consists of monitoring changes in soil moisture.

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.

VZM at the RWMSs is driven by DOE Orders and conducted to confirm Performance Assessment (PA) assumptions regarding the hydrologic conceptual models including soil water contents, and upward and downward flux rates. VZM at RCRA closure sites and sanitary landfills is driven entirely by agreements with the Nevada Division of Environmental Protection (NDEP). Vadose zone monitoring at all NTS sites is also conducted to:

- Demonstrate negligible infiltration of precipitation into zones of buried waste.
- Detect changing trends in performance.
- Establish baseline levels for long term monitoring.

Compliance at the RWMSs is achieved by demonstrating that PA assumptions are valid, and that there is negligible infiltration of precipitation into zones of buried waste. Compliance at the RCRA sites and sanitary landfills is achieved by demonstrating that soil moisture levels remain within limits agreed to with NDEP.

At the RWMSs, VZM is conducted by measuring all the water balance components at several locations to account for some spatial variability and to apply that water balance to an entire RWMS using a concept of surrogate sampling. This type of VZM is not leak detection, it is performance monitoring.

Water balance measurements activities include:

- **Meteorological monitoring** to measure precipitation (the driving force for downward flow) and to calculate potential evapotranspiration (the driving force for upward flow).
- **Lysimeters** (weighing and drainage) to measure infiltration, soil water redistribution, bare-soil evaporation, evapotranspiration, and deep drainage.
- **Neutron logging** through access tubes to measure infiltration, soil water redistribution, and monitor a large spatial area (in some locations to depths of hundreds of feet).
- **Automated VZM systems** with *in situ* sensors (time domain reflectometry probes, and heat dissipation probes) to measure soil water content and soil water potential over a large spatial area, but usually to a limited depth.
- **Soil-gas sampling** for tritium to confirm PA assumptions and transport coefficients.

This strategy provides an accurate estimate of the RWMS water balance, including any drainage through the RWMS waste covers, and therefore, potential recharge. Based on these data, as well as other work (Tyler et al., 1996), there is essentially no recharge to the groundwater under current conditions in the valleys of the NTS (including the RWMSs), and all precipitation is effectively returned to the atmosphere by plant transpiration and soil evaporation.

The VZM strategy for the two RCRA closure sites and permitted sanitary landfills is similar to the RWMS strategy and is based on monitoring soil moisture at points of opportunity. At these sites, neutron logging is conducted in boreholes that were originally drilled for site characterization purposes. Neutron logging at these sites provides data to confirm that there is negligible infiltration of precipitation into zones of buried waste.

A summary of some selected NTS VZM data can be found in Chapter 8.0.

BIOTA MONITORING

Historical radionuclide studies on the NTS focused on man-made transuranics and showed declining concentrations in plants and animals over time (DOE 1992), although some plant and animal samples still contain measurable levels (EG&G/EM 1993; U.S. Environmental Protection Agency [EPA] 1996). These past studies indicate that significant radionuclide damage to plants and animals on the NTS would occur only during atmospheric nuclear testing. Given the current NNSA/NV project and land use policy, it is unlikely that NTS radionuclide contamination poses a significant threat to biota, although data to confirm this conclusion have yet to be taken. Past studies, although limited in scope and area, indicate that radionuclides in NTS plants and animals posed no significant threat of radiation exposure to the offsite public.

Current NTS land use precludes the harvest of plants or plant parts (e.g., pine nuts, wolf berries) for direct consumption by humans. Therefore, the primary potential exposure pathway of radionuclides in NTS plants to the public is through ingestion of game animals. Game animals (e.g., mourning doves, chukar, rabbits as surrogates for Deer) may eat contaminated plants, seeds, or soil or they may drink contaminated water on the NTS and then travel offsite where they are subsequently hunted by the public for food. The expected public dosage via these pathways from NTS biota are well below established dose limits.

Offsite plants and animals, namely crops and livestock in neighboring communities, have also been monitored for years to document possible radionuclide exposure to the public (EPA 1978; EPA 1996). The only possible current pathway for radiation exposure through crops is their uptake of radionuclides from soil which was contaminated during past atmospheric tests. There are several communities to the north and east of the NTS (e.g., Rachel, Alamo, Hiko) that have received radioactive fallout in the past from these tests. Recent radioanalysis of selected fruits and vegetables from these communities has shown levels of tritium, strontium, and plutonium near or below detection limits (EPA 1996). Livestock or game animals within the same downwind fallout areas could ingest contaminated forage and then be consumed by humans. Strontium levels in the bones of deer, cattle, and bighorn sheep sampled in 1993 off the NTS were above detection limits, but have consistently decreased in samples since the early 1960s since cessation of aboveground testing (EPA 1996). The edible portions of these offsite animals historically contain nondetectable levels of radionuclides. However, strontium levels in milk from pasture-fed cows sampled from neighboring Nevada ranches have been periodically measured at levels above detection limits (EPA 1996).

Given the assumption that there exists no significant risk to plants, animals, or the public through the food chain from radionuclide contamination, it is still expedient to include biota samples within the framework of this monitoring at the NTS for the following reasons:

- Some level of biota monitoring is needed to comply with DOE Order 5400.1.
- Biota monitoring data are needed to validate the integrity of land buffers.
- Biota data will be needed to address current and future land-use issues.

The NTS Biota monitoring effort is designed for radiological monitoring of NTS plants and animals and focused on sampling those sites having the highest known concentrations of radionuclides in other media. The intent is to concentrate monitoring efforts at sites where the likelihood for radionuclides to enter plants and game animals is the highest on the NTS, including:

- Runoff areas or containment ponds associated with underground or tunnel test areas.
- Plowshare sites.
- Atmospheric test areas.
- Atmospheric and underground safety experiment sites.

A control site for each contaminated site will be selected and will have similar biological and physical features, but will have no history of radionuclide contamination from NNSA/NV activities above worldwide levels of fallout. Measurements from the control sites will be used to document radionuclide levels in biota from areas believed to be uncontaminated by past and ongoing NNSA/NV activities and representative of background levels.

NTS Chukar Sampling Sites

In the past, the Nevada Division of Wildlife (NDOW) has requested, and has been granted, permission to trap and remove chukar from the NTS. The chukar are then released in areas open to public hunting. Chukar are trapped by the NDOW at one to three of the numerous natural springs on the NTS. Chukar trapped at these springs are not expected to be contaminated, but they will be sampled from these springs for radiological analysis on a routine basis. In 2001, two Chukar were trapped at the E Tunnel Pond site.

DIRECT RADIATION MONITORING

Direct radiation monitoring is used to detect radiation exposures caused by sources that emit X rays, gamma rays, charged particles, and/or neutrons. Such monitoring can be done in real time by use of appropriate survey meters or by pressurized ion chambers (PICs) to obtain exposure rate and by various types of solid-state dosimeters to obtain total exposure.
The objective of onsite Thermoluminescent Dosimeter (TLD) and PIC monitoring is to assess the state of the NTS's external radiation environment, detect changes in that environment, and measure gamma radiation levels near and in contaminated areas on the NTS. The onsite monitoring program will be used for trend analysis, in conjunction with fly-over data and demarcation studies, and to comply with DOE Orders. The data from environmental TLDs may also be used during future facility siting decisions.

4.2 POLLUTION PREVENTION AND WASTE MINIMIZATION PROGRAM

When economically feasible, source reduction is the preferred method of handling waste, followed by reuse and recycling, treatment, and, as a last resort, land disposal. The NNSA/NV systematic approach to source reduction is achieved by performing Pollution Prevention Opportunity Assessments (PPOAs). The objective of a PPOA is to identify methods to reduce energy consumption and/or eliminate waste streams via a planned and documented procedural process. Subsequently, the technical and economical feasibility of options are evaluated, and the most feasible option is selected for implementation. Options include product substitution, process change (i.e., use of alternate equipment or procedure), and onsite and offsite recycling. When selecting which PPOA to perform, the goal is to reduce or eliminate the volume and/or toxicity of waste.

An effective method for reuse is the coordination of the material exchange program within NNSA/NV, between NNSA/NV, other DOE sites, and other government agencies (e.g., EPA). Unwanted chemicals, supplies, and equipment are made available through electronic mail or postings on the internet material exchange list 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 to be recycled or reused.

EMPLOYEE AND PUBLIC AWARENESS

As stated in DOE Order 5400.1, chapter III-4c, NNSA/NV's P2 program must include the implementation of an employee awareness program. Employee awareness of P2 issues throughout NNSA/NV is accomplished by dissemination of articles through both electronic mail and NNSA/NV newsletters, the maintenance of a P2 intranet website, employee training courses, and participation at employee and community events. These activities are intended to increase awareness of P2 and environmental issues and their role in improving environmental conditions in the workplace and community.

The following activities enhanced employee awareness of P2 practices:

- **Family Day at the Nevada Test Site:** The event included an exhibit of the various P2 and Waste Minimization activities performed at the NTS; an interactive P2 question and answer exhibit; literature containing P2 tips; literature about composting; and distribution of promotional items made from recycled materials as daily reminders regarding the benefits of recycling.

- **Integrated Safety Management Day at the NTS and North Las Vegas Facility:** The event included an exhibit of various P2 success stories; an interactive P2 question and answer exhibit; literature about various P2 and waste minimization issues; and distribution of promotional items made from recycled materials as daily reminders regarding the benefits of recycling.

- **Earth Day:** The event, sponsored by the University of Nevada, Las Vegas, included an exhibit on recycling; and distribution of promotional items made from recycled materials as daily reminders regarding the benefits of recycling.

- **Eco Jam:** The event, sponsored by the city of Las Vegas, included an interactive P2 question and answer exhibit; an exhibit of various P2 success stories; literature about various P2 and waste minimization issues; and distribution of promotional items made from recycled materials as daily reminders regarding the benefits of recycling.

- **Training:** Employees are instructed in P2 and waste minimization policies and practices during classroom training courses (e.g., Hazardous Waste Site General Worker Operator and Emergency Response, Waste Management for the Generator, Rad Worker II, and General Employee Orientation).

POLLUTION PREVENTION ACCOMPLISHMENTS

The following list of activities were major P2/Waste Minimization accomplishments for Calendar Year 2001:

- 80 cubic meters of Mixed Low Level Waste (MLLW) was generated at the NTS. Lead contaminated metal and ash was segregated from the material and packaged in two 55 gallon drums (0.44 cubic meters). The drums were sent offsite for treatment and disposal. The remaining material was surveyed and found to be free of lead contamination. This material was then disposed of as Low Level Waste (LLW) at the NTS LLW Disposal Facility. This waste minimization effort reduced the toxicity of 79.56 cubic meters of MLLW to LLW and resulted in considerable disposal costs savings.

- Through the material exchange program, approximately 171 mt of material and equipment destined for disposal were reused. These materials included both hazardous and non-hazardous materials.

- Decommissioned buildings destined for disassembly and disposal were donated or sold to other agencies/schools who disassemble and remove the buildings from the Site for reuse at new offsite locations. Approximately 52 metric tons of waste was diverted from landfills by this waste minimization effort.

- The NTS Area 11 Explosive Ordnance Disposal Unit (EODU) obtained approximately 1,660 pounds (lbs) of reactive hazardous material (smoke grenades) that were destined for treatment/disposal. The material was reused by finding another government agency that could utilize the material as intended.

- The NTS Area 11 EODU obtained approximately 60 lbs of reactive hazardous material that were destined for treatment/disposal. The material was reused by finding another government agency that could utilize the material as intended.

- A new design for the management of investigation derived waste at NNSA/NV Environmental Restoration (ER) sites reduces the amount of waste entering potentially hazardous and radioactive waste streams at the source of generation. This new process utilizes onsite inspection, survey, and testing to determine waste disposition. By instituting this new method, the NNSA/NV will enhance work place safety, reduce potentially hazardous and/or radioactive waste streams by an estimated 316 cubic meters over the five year life cycle of the ER project.

VOLUME AND TOXICITY REDUCTION

An overview of the estimated volume reductions accomplished during CY 2001, through implementation of P2/Waste Minimization activities, recycling, and material exchange, is shown in Tables 4.1 and 4.2.

An overview of the estimated toxicity reductions accomplished during CY 2001, through segregation, is shown in Table 4.3.

4.3 HAZARDOUS MATERIALS SPILL CENTER (HSC)

Biological monitoring at the HSC is required for certain types of chemicals under the Center's Environmental Assessment. These chemicals have either not been tested before, have not been tested in large quantities, or have uncertain modeling predictions of downwind air concentrations. In addition, the NNSA's ESHD has requested that BN monitor (downwind) any test which may impact plants or animals outside the experimental area.

A document entitled "Biological Monitoring Plan for Hazardous Materials Testing at the Liquefied Gaseous Fuels Spill Test Facility on the Nevada Test Site" (BN 1996) has been prepared that describes the conduct of field surveys used to determine test impacts on plants and animals and verify that the spill program complies with pertinent state and federal environmental protection legislation. The monitoring plan calls for the establishment of three control transects and three treatment transects, which have similar environmental and vegetational characteristics at three distances from the chemical release point. BN biologists review spill test plans to determine if field monitoring along the treatment transects is required as per the monitoring plan criteria.

BN reviewed chemical spill test plans for one experiment: REOP-CHLOREP Special Equipment and Techniques Mercury Workshop. Biota monitoring was not conducted for any of the chemical tests at the HSC during 2001. No baseline monitoring was conducted at established control-treatment transects near the HSC due to insufficient funding.

4.4 RADIOACTIVE WASTE MANAGEMENT SITES

DISPOSAL ACTIVITIES

The Areas 3 and 5 RWMSs, at the NTS, are designed and operated for disposal of LLW from onsite, NNSA offsite, and other offsite generators and mixed waste from onsite. All generators of waste streams must first request to dispose of waste, submit an application for specific waste streams, meet NTS Radioactive Waste Acceptance Criteria, and receive approval for disposal by NNSA/NV. Waste Acceptance criteria are based on how well the site is predicted to perform as described in Performance Assessment/Composite Analysis documents. Environmental Monitoring collects data to determine if performance is as expected and to meet regulatory compliance requirements. Disposal consists of placing waste in various sealed containers in the unlined cells and trenches. Soil backfill is pushed over the containers in a single lift, approximately 2.4 m (8 ft) thick, as rows of containers reach approximately 1.2 m (4 ft) below original grade.

Waste disposal at the RWMS-5 has occurred in a 37-hectare (92-acre) portion of the site, referred to as the LLW Management Unit (LLWMU), since the early 1960s. The LLWMU consists of 23 landfill cells (pits and trenches) and 13 Greater Confinement Disposal (GCD) boreholes. Four of the GCD boreholes were used to dispose of transuranic (TRU) waste and are no longer active; five contain LLW and are no longer active; and the remaining four have not been backfilled with soil. Of the 23 landfill cells, 5 are open for disposal of LLW, 1 is an active mixed waste disposal unit, and 1 is used for disposal of asbestos-form LLW. The remaining 16 landfill cells are covered and are no longer active (15 contain low-level radioactive waste and 1 contains TRU waste). In CY 2001, the RWMS-5 received 454 shipments containing 570,724 cubic feet of LLW and no shipments containing MLLW for disposal.

Key documents in place that are necessary for disposal operations to occur are as follows:

- A Disposal Authorization Statement (DAS) was issued in December 2000 for RWMS-5.
- Performance Assessment for the RWMS-5 at the NTS, Nye County, Nevada, Revision 2.1, January 1998.
- Composite Analysis for the RWMS-5 at the NTS, Nye County, Nevada, February 2000.
- NTS Waste Acceptance Criteria (NTSWAC) Revision 4, February 2002.
- Integrated Closure and Monitoring Plan (ICMP) for the Areas 3 and 5 RWMSs at the NTS, October 2000.
- Auditable Safety Analysis (ASA) for the Areas 3 and 5 RWMSs, August 2000.

Waste disposal cells within the RWMS-3 are subsidence craters resulting from underground nuclear testing. Disposal operations began in the late 1960's. Of the seven craters within the RWMS-3, three are active, two are closed, and two are not in use. In CY 2001, the RWMS-3 received 659 shipments containing 941,276 cubic feet of LLW for disposal.

Key documents in place that are necessary for disposal operations to occur are as follows:

- A DAS was issued in October 20, 1999, for the RWMS-3.

- Performance Assessment/Composite Analysis for the RWMS-3 at the NTS, Nye County, Nevada, Revision 2.0, September 1997. This document was revised in response to the DAS conditions and submitted to the DOE Headquarters for review and approval. The document is currently under review.

The NTSWAC, ICMP, and ASA are the same as described for RWMS-5.

STORAGE ACTIVITIES

The RWMS-5 stores LLW, MLLW, TRU, and Mixed TRU (MTRU) waste for characterization to determine treatment and disposal options. TRU and MTRU waste is being characterized for disposal at Waste Isolation Pilot Plant in New Mexico. LLW and MLLW are being characterized to determine treatment and disposal options. In Fiscal Year (FY) 2001 and the first quarter of FY 2002, 15,666 cubic feet of LLW were disposed of onsite, and no MLLW was disposed of onsite. In the first quarter of FY 2001, 9.2 cubic feet of MLLW were shipped offsite for treatment and disposal.

The NNSA/NV assesses the long-term performance of LLW disposal sites by conducting a PA. A PA is a systematic analysis of the potential risks posed by a waste disposal site to the public and to the environment.

4.5 HISTORIC PRESERVATION

The National Historic Preservation Act (NHPA) of 1966, the Archeological Resources Protection Act of 1979, and the regulations related to these laws directs federal agencies to identify, inventory and manage the cultural resources under their stewardship. The NHPA also requires consultation with interested parties, especially Native Americans, in regard to historic preservation activities and proposed decisions affecting cultural resources.

As required under Section 106 of the NHPA, in 2001, the NNSA/NV conducted three cultural resource surveys, two inventory projects, and one historical evaluation at the NTS prior to undertakings in order to determine if proposed activities would adversely affect significant historic properties. Significant historic properties are those sites, locations and structures that are determined eligible to the National Register of Historic Places (NRHP) through consultation between the NNSA/NV and the state of Nevada Historic Preservation Office (NSHPO). Under the NHPA, all NNSA/NV cultural resource reports and plans are reviewed by the NSHPO for compliance with the NHPA. All consultations with the NSHPO were completed successfully with reports finalized and distributed to the Nevada State Cultural Resources Archives.

In cases when project activities will adversely affect properties eligible to the NRHP, actions to mitigate the effects are required by law. During 2001, mitigation was completed for ten buildings that are to be demolished and are eligible to the NRHP. In all ten cases, mitigation consisted of preparing Historic American Engineering Record documentation for each building. This documentation is prepared in consultation with the National Park Service and, upon acceptance, is archived in the Library of Congress, to serve as the permanent record for the buildings.

The field aspect of the program to monitor the historic properties on the NTS was initiated in 2000. The purpose of this program is to determine if NRHP eligible sites are being adversely affected by natural and human activities.

Since 1990, the NNSA/NV has been involved in consultations with Native American tribal groups in Nevada, California, Arizona, and Utah, who have historical ties to NTS land. The three major groups are the Western Shoshone, the Southern Paiute, and the Owens Valley Paiute.

4.6 ECOLOGICAL MONITORING AND COMPLIANCE PROGRAM

The Ecological Monitoring and Compliance (EMAC) Program provides ecological monitoring and compliance support for activities and programs conducted at the NTS. It is designed to ensure compliance with laws and regulations related to plants, animals, and ecosystems on the NTS, and to provide information that can be used to predict and evaluate the potential impacts of proposed projects and programs on species and ecosystems. There are four major components of the program: (1) compliance with federal and state acts and regulations, (2) sensitive species and sensitive habitat monitoring, (3) ecosystem mapping, and (4) biological monitoring for specific NTS programs.

Biological surveys are routinely conducted each year at proposed project sites on the NTS that will cause disturbance of native soils and vegetation. These surveys identify the presence of the threatened desert tortoise and breeding birds and identify any necessary mitigation to comply with the Endangered Species Act and the Migratory Bird Treaty Act. In CY 2001, biological surveys for 26 projects were conducted.

Long-term monitoring of several species considered sensitive by state or federal agencies are conducted annually or periodically. In CY 2001, such monitoring was conducted for three plants species, seven bat species, the western burrowing owl, feral horses, and raptors. Sensitive habitats monitored for wildlife use in CY 2001 included 12 natural seeps and springs, and 54 man-made sumps and ponds.

Digital mapping of vegetation associations and wildlife habitats and their linkage with animal historical sightings and distribution data are ongoing efforts of EMAC. In CY 2001, efforts were focused on the publication and distribution of the keystone document “Classification of Vegetation of the Nevada Test Site,” (Ostler et al., 2000). This document was the product of multiple years of field mapping. Another significant accomplishment within EMAC in CY 2001 was the compilation and publication of an annotated bibliography of all ecological research conducted on the NTS: “Ecology of the Nevada Test Site: An Annotated Bibliography With Narrative Summary, Keyword Index, and Species List,” (Wills and Ostler 2001). Both of these documents will be valuable resources to current and future DOE NNSA/NV management and to researchers utilizing the NTS as a National Environmental Research Park.

Specific biological monitoring is conducted each calendar year under EMAC at the HSC on Frenchman Flat for testing activities which may have an impact on downwind plants or animals. In CY 2001, no biological monitoring was recommended or conducted for tests conducted at the HSC in 2001.

4.7 UNDERGROUND TEST AREA PROJECT

The Underground Test Area (UGTA) Project is the largest project in the Environmental Restoration Division and addresses groundwater contamination resulting from past underground nuclear testing conducted in shafts and tunnels by the NNSA/NV on the NTS. From 1951 to 1992, more than 800 underground nuclear tests were conducted at the NTS. Most of these tests were conducted hundreds of feet above the groundwater table; however, over 200 of the tests were in proximity of, or within, the water table. This 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 formation 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 determine whether or not radionuclides resulting from nuclear testing have moved appreciable distances from the original test location. Numerous surface and subsurface investigations are ongoing to assure 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 any radioactive contaminants.
- Assessing NTS hydrology and subsurface geology to determine possible groundwater flow direction.

A regional three-dimensional computer groundwater model (International technology [IT] 1996a) has already 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 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, one has been built: Frenchman Flat (IT 1998b). The Pahute Mesa and Yucca Flat models are in progress. The 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 a monitoring network to ensure public health and safety.

In 2001, the UGTA Project drilled a total of two wells, both located on the NTS in Frenchman Flat. The UGTA Project initiated a hydrogeologic investigation well drilling program for the Frenchman Flat CAU in 2000 (IT 2000). The goal of this program is to collect additional subsurface geologic and hydrologic data in the Frenchman Flat CAU, where ten underground nuclear tests were conducted between 1965 and 1971 (DOE 2000b) (see Figure 7.5). Data from these wells will allow for more accurate modeling of groundwater flow and radionuclide migration in this former test area. Some of the new wells may also function as long-term monitoring wells.

The two most recent wells drilled under the Frenchman Flat drilling program during 2001 were Wells ER-5-3#3 and ER-5-4. Both of these wells were completed in the alluvial aquifer. Preliminary (predevelopement) groundwater characterization samples were collected from each of these wells. A small concentration of tritium (up to 5,028 pCi/l) was measured while drilling through the 274.6 - 311.8 m (901 - 1,023 ft) depth interval. The origin of this tritium is believed to be the CAMBRIC underground nuclear test conducted at a similar depth in nearby emplacement hole U-5e. No man-made radionuclides were detected while drilling Well ER-5-3#3.

Hydrological tests and sampling were conducted at four wells (three wells now at the ER-5-3 well cluster, and at ER-5-4) in 2001. Groundwater characterization samples were collected from each of these wells, and no man-made radionuclides were detected during such testing.

4.8 HYDROLOGIC RESOURCES MANAGEMENT PROGRAM

The NNSA's Hydrologic Resources Management Program's (HRMP's) primary responsibility is to acquire hydrologic data and information of groundwater supplies to support ongoing activities and to assist in planning new uses for the 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.

MISSION

The mission 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 these objectives 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.

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.

Hydrology and Radionuclide Investigations for Operations

The HRMP assists the NNSA/NV 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/NV to provide detailed information on hydrologic conditions of the NTS. At the request of NNSA/NV 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/NV 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, location of groundwater table, perched water zones, and regions of enhanced permeability.

- using and developing state-of-the-art radiochemical instrumentation to analyze rocks and water samples in order to predict 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 impact of nuclear testing on water resources at the NTS.

- investigating the free water/bound water relationship in boreholes and cores.

Long-Term Groundwater Stewardship

A major element of the HRMP mission is the protection and long-term stewardship of NTS groundwater resources. A range of activities including, monitoring of groundwater levels, quality and consumption, monitoring well evaluation, and maintaining a wellhead protection program are conducted to accomplish this element. HRMP supports groundwater flow model development for both the Death Valley Region, which includes the NTS, and for the NTS itself, and will continue to support refinement of these models. 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/NV 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 needs of NNSA/NV 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 SDWA 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/NV. HRMP scientists conduct competent, informed, and independent reviews of NNSA/NV 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/NV program documentation.

4.9 NTS WELL AND BOREHOLE PLUGGING PLAN

Since the late 1950s, approximately 4,000 wells and boreholes have been constructed at the NTS to support uses ranging from water supply wells to large-diameter nuclear device emplacement holes. Most of the existing wells and boreholes were originally constructed to support the Weapons Testing Program.

In 1997, the Nevada Division of Water Resources (DWR) issued revised regulations for water-wells and related drilling, which expanded its regulations to address a category of boreholes that are drilled for purposes other than evaluating or producing water. In March 1998, a letter from the NNSA/NV Manager to the President and General Manager of BN stated that compliance with the revised DWR regulations will achieve the goal of protecting groundwater resources from contamination, as well as satisfy state of Nevada and SDWA objectives. The NNSA/NV tasked BN to develop a plan for the management of all existing wells and boreholes and the construction of new wells and boreholes at the NTS in a manner that procedurally meets state regulations. The result of this effort was the NTS Well and Borehole Management Plan.

This plan discusses the objectives/intent of the DWR regulations and how these objectives will be applied to the management of the existing NTS well and borehole inventory and the construction and management of future wells and boreholes. The objectives include the prevention of contamination or waste of the groundwater resource during the drilling, construction, or plugging of wells and boreholes; drilling, construction, and plugging programs designed to isolate zones of poor-quality water from zones of good-quality water; isolation of artesian zones; and prevention of surface contamination and unauthorized entry. A detailed strategy and process for plugging of the existing unused wells and boreholes is provided within the plan because open wells and boreholes represent a significant potential risk for impacting the quality of the groundwater resource. The process produces a prioritized list of open NTS wells and boreholes that should be plugged, with corresponding cost estimates and tentative schedules.

During Calender Year 2001, a total of 18 unused boreholes were plugged in Areas 2, 3, 4, and 9 under this plan. Additional unused or abandoned boreholes will be plugged each fiscal year under this multi-year initiative.

4.10 INDUSTRIAL SITES PROJECT

The Industrial Sites Project includes areas located on the NTS and the Tonopah Test Range that were used to support past testing operations. Over 1,500 of these historic areas, or industrial sites, have been identified, verified, and inventoried for characterization, closure, and/or restoration. Of these, nearly 750 sites have been formally closed. The remaining sites have been grouped according to source of contamination, location, and other technical characteristics. Industrial Sites Project activities focus on the characterization and applicable corrective actions for these sites.

The Deactivation and Decommissioning process is also included under the Industrial Sites Project. This process supports the cleanup of the six remaining surplus facilities transferred from the NNSA/NV Defense Programs to the Environmental Restoration Division. These facilities include the Pluto Facility; Super Kukla Facility; RMAD Facility; Engine Maintenance, Assembly, and Disassembly Facility; Test Cell A; and Test Cell C.

Deactivation is the process used to remove radioactive, chemical, or other hazardous contamination from facilities, structures, soils, or equipment. Methods of deactivation include washing, scraping, or cleaning. Decommissioning involves stabilizing, reducing, or removing radioactive and/or other types of contamination and can consist of dismantling a facility, entombing or covering part or all of the facility, or converting a facility for other uses.

Table 4.1 Reduction in Volume of Hazardous Waste Generated at the Nevada Operations Office - 2001

Waste Minimization Category	Activity	Volume Reduction
Recycle/Reuse Project	Lead acid batteries were shipped to an offsite vendor for recycle.	26.59 mt
Recycle/Reuse Project	Lead scrap metal was sold for reuse/recycle instead of disposed of as hazardous waste.	1.69 mt
Recycle/Reuse Project	Spent fluorescent light bulbs, mercury lamps, metal hydride lamps, and sodium lamps were sent to an offsite vendor for recycle.	2.66 mt
Recycle/Reuse Project	Bulk used oil was sent to an offsite vendor for recycle.	89.73 mt
Recycle/Reuse Project	When the Analytical Laboratory at the NTS was decommissioned, the material exchange program was able to place miscellaneous hazardous chemicals, destined for disposal, with new users.	1.11 mt
Recycle/Reuse Project	Three large barometers containing mercury, destined for hazardous waste disposal, were relocated to new users through the material exchange program.	0.02 mt
Recycle/Reuse Project	Lead tire weights were reused instead of being disposed of as hazardous waste.	0.64 mt
Recycle/Reuse Project	Rechargeable batteries were sent to an offsite vendor for recycle.	0.26 mt
Recycle/Reuse Project	Liquid mercury was sent to an offsite vendor for recycle.	0.01 mt
Recycle/Reuse Project	The NTS Area 11 EODU obtained reactive hazardous material (smoke grenades) that was destined for treatment/disposal. The material was reused for its intended purpose by another government agency.	0.75 mt
Recycle/Reuse Project	The NTS Area 11 EODU obtained reactive hazardous material that was destined for treatment /disposal. The material was reused for its intended purpose by another government agency.	0.03 mt
Total		**123.49 mt**

Table 4.2 Reduction in Volume of Solid Waste Generated at the Nevada Operations Office - 2001

Waste Minimization Category	Activity	Volume Reduction
Recycle/Reuse Project	Decommissioned buildings destined for disassembly and disposal were donated or sold to other agencies/schools who disassemble and remove the buildings from the Site for reuse at new offsite locations.	52.19 mt
Recycle/Reuse Project	Mixed paper/cardboard was sent offsite for recycle.	420.14 mt
Recycle/Reuse Project	Aluminum cans were sent offsite for recycle.	1.35 mt
Recycle/Reuse Project	#1 PET Plastic was sent offsite for recycle.	0.19 mt
Recycle/Reuse Project	Food waste from the cafeterias was sent offsite to be reused as pig feed for a local pig farmer.	47.45 mt
Recycle/Reuse Project	Spent toner cartridges were sent offsite for recycle.	2.63 mt
Recycle/Reuse Project	Obsolete software, video tapes, and audio tapes were sent offsite for recycle.	2.10 mt
Recycle/Reuse Project	Scrap ferrous metal was sold to a vendor for recycle.	101.30 mt
Recycle/Reuse Project	Scrap non-ferrous metal was sold to a vendor for recycle.	2.19 mt
Recycle/Reuse Project	When the Analytical Radiological Laboratory at the NTS was decommissioned, the material exchange program was able to place miscellaneous non-hazardous chemicals, supplies, and equipment,	4.26 mt
Recycle/Reuse Project	Non-hazardous chemicals, equipment, and supplies were relocated to new users through the material exchange program, diverting them from landfill disposal.	165.19 mt
Total		**798.99 mt**

Table 4.3 Reduction in Toxicity of Waste Generated at the Nevada Operations Office - 2001

Waste Minimization Category	Activity	Toxicity Reductio
Segregation	80 cubic meters of MLLW was generated at the NTS. Lead contaminated metal and ash was segregated from the material and packaged in two 55-gallon drums (0.44 cubic meters). The drums were sent offsite for treatment and disposal. The remaining material was surveyed and found to be free of lead contamination. This material was then disposed of as LLW at the NTS LLW Disposal Facility.	79.56 m^3
Total		**79.56 m^3**

5.0 RADIOLOGICAL ENVIRONMENTAL PROGRAMS

The radiological environmental surveillance at the Nevada Test Site (NTS) addresses compliance with U. S. Department of Energy (DOE) Orders, state and federal regulations, stakeholder issues, and other drivers as defined in the Routine Radiological Environmental Monitoring Plan (RREMP). The radiological compliance monitoring brings together sitewide environmental surveillance, site-specific effluent monitoring, and operational monitoring conducted by various missions, programs, and projects on the NTS. Monitoring used a decision-based approach to identify the environmental data that must be collected and provided Quality Assurance, Analysis, and Sampling Plans which ensure defensible data are generated. Sampling and analysis plans provide for monitoring five media in the environment onsite and offsite: air, water, soils (not collected in 2000), plants, and animals. Oversite environmental surveillance is conducted for stakeholders by Desert Research Institute (DRI) of the University and Community College System of Nevada. This program consists of a network of monitoring stations operated by offsite residents. During 2001, no radioactivity related to current activities at the NTS was detected by environmental surveillance programs.

5.1 AIR SURVEILLANCE ACTIVITIES

The air surveillance network on the NTS monitors for radionulcides to demonstrate compliance with the Clean Air Act (for a complete description, see Chapter 4.0). During CY 2001, air monitoring was conducted for radioactive particulates and tritiated water (HTO) vapor at a total of 29 and 19 locations, respectively. Beginning in July 2001, the sampling locations were changed to 16 and 14 locations, respectively, to accommodate a change in strategy for demonstrating compliance with National Emission Standards Hazardous Air Pollutants (NESHAP) as approved by the U. S. Environmental Protection agency (EPA) (EPA 2001). The changes maintained the monitoring of NTS areas with potential emissions of radioactivity and designated the sampler locations at SCHOONER, Gate 700 South, Mercury, Guard Station 510, Substation 3545, and Yucca as NESHAP compliance stations. These six stations, although located on the NTS, will conservatively represent offsite critical receptors. The air sampling locations and the ambient gamma radiation monitoring locations relative to the sites with potential for airborne radioactive emissions are shown in Figure 5.1.

In the following sections, each description of the sampling or monitoring method is followed by a summary of the analytical results and a discussion of the results. The highest annual average concentration for each radionuclide is compared to its derived concentration guide (DCG) for the general public as specified in Federal regulations. This DCG is the concentration that will deliver a 10 mrem/yr effective dose equivalent (EDE), assuming that the receptor resides at the sampling location throughout the year.

AIR PARTICULATE SAMPLING

A sample of airborne particulates is collected by drawing air through a 9-cm (3.5 in) diameter Whatman GF/A glass-fiber filter at a constant flow rate of 85 L/min (3 cfm). The particulate filter is mounted in a filter holder that faces downward at a height of 1.5 m (5 ft) above ground. A run-time clock measures the operating time. The run time, multiplied by 85 L/min yields the

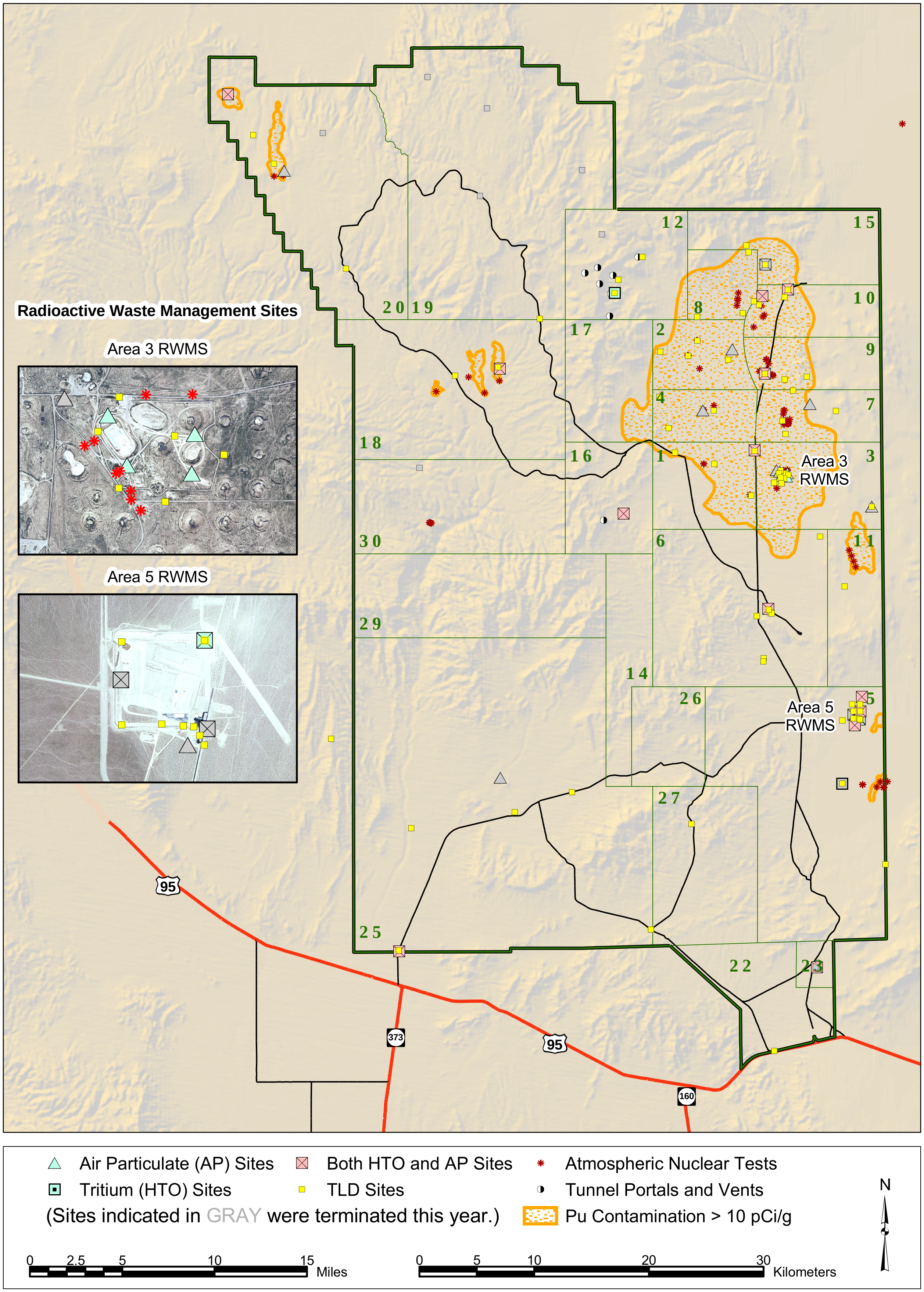


Figure 5.1 Air Sampling Network on or near the NTS - 2001

volume of air sampled, which is about 860 m^3 (30,000 ft^3) during a typical seven-day sampling period. Flows and subsequent volumes are measured with a mass-flow meter which corrects for variations in temperature and elevation on the NTS.

The 9-cm diameter filters are analyzed for gross alpha and gross beta radioactivity no sooner than five days after collection to allow for the decay of naturally-occurring radon and its progeny. The filters from four weeks of sampling were composited, analyzed by gamma spectroscopy, and then analyzed for $^{239+240}$Pu and ^{241}Am. To monitor for any potential emissions from ordinance tests using depleted uranium, beginning in July, filter composites from Guard Station 510, Substation 3545, and Yucca were also analyzed for uranium isotopes.

Although high-volume air sampling was terminated offsite last year, the Community Environmental Monitoring Program (CEMP) continues to collect offsite data as oversite verification of the results of the onsite source term monitoring.

Gross Alpha and Beta Results

Gross alpha and gross beta radioactivity measurements in airborne particulates are used as a weekly screening of long-lived radionuclides in air. Descriptive statistics for the gross alpha and gross beta results, in units of µCi/mL of air, are given in Tables 5.1 and 5.2, respectively. The variation in the gross alpha and gross beta radiation measurements during the year is shown in time series plots in Figures 5.2 and 5.3, respectively. As seen in Figure 5.2, there is relatively little variation in gross alpha among locations. The one high value is actually an average of a higher measurement and its duplicate; the latter was not different from the remaining measurements. There is a good deal of systematic week-to-week variation, but no particular patterns during the year. The cause of the systematic variation is being investigated.

The gross beta results, shown in Figure 5.3, also show systematic week-to-week variation along with little variation among locations. In addition to the week-to-week variation, however, there are time trends within the year, peaking in late summer. The patterns for both gross alpha and gross beta are consistent with those from 2000. Gross alpha measurements were slightly higher in 2001 than in 2000 (median of location means was 5.8 in 2001 compared with 5.1 $\times 10^{-15}$ µCi/mL in 2000), whereas, gross beta measurements were slightly lower (median of means was 1.7 $\times 10^{-14}$ µCi/mL in 2001 compared with 2.0 $\times 10^{-14}$ µCi/mL in 2000).

Plutonium Results

Descriptive statistics for ^{238}Pu are given in Table 5.3. ^{238}Pu was detected above the minimum detectable concentration (MDC) in only 8.6 percent of measurements overall. The highest mean concentration was at Bunker T-4 (14 $\times 10^{-18}$ µCi/mL or 0.51 µBq/m^3), which is surrounded by areas with known deposits of radioactive fallout from past nuclear tests. This concentration was 0.14 percent of the DCG. Mean concentrations at other locations range from 0.2 to 5.6 $\times 10^{-18}$ µCi/mL or 7.4 to 200 nBq/m^3.

Table 5.4 gives descriptive statistics for $^{239+240}$Pu. Overall 42 percent of measurements were above their MDCs; 75 percent or more measurements exceeded their MDCs at six locations (U-3ah/at N and S, U-3bh N and S, Bunker 9-300, and SEDAN north). The highest mean concentration occurred at U-3ah/at S (3.0 $\times 10^{-16}$ µCi/mL or 11 µBq/m^3); this is 70 percent of the highest mean observed in 2000. The relatively high values for $^{239+240}$Pu occurred during the summer months, as seen in the time series plots in Figure 5.4. When Figures 5.2 and 5.4 are compared, the highest peak in plutonium concentration (U-3ah/at S) occurred on the same date as the high gross alpha concentrations after allowing for the differences in sampling periods; weekly for the gross alpha and monthly for the $^{239+240}$Pu.

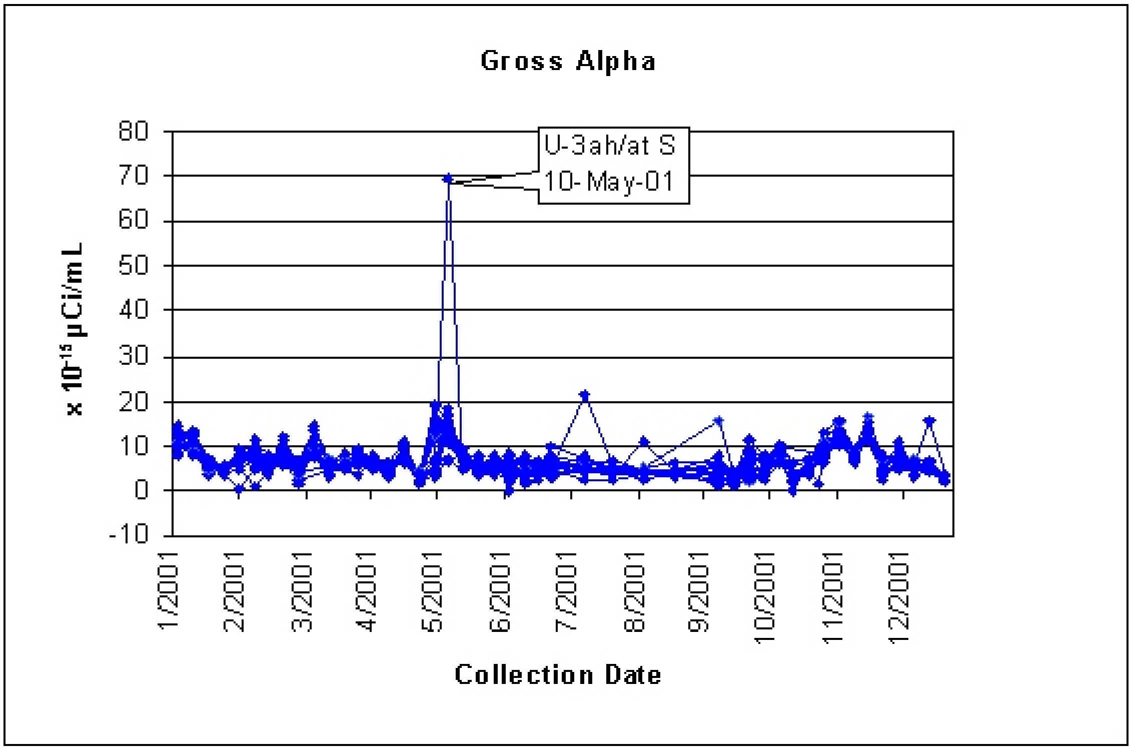


Figure 5.2 Times Series Plot of Alpha - 2001

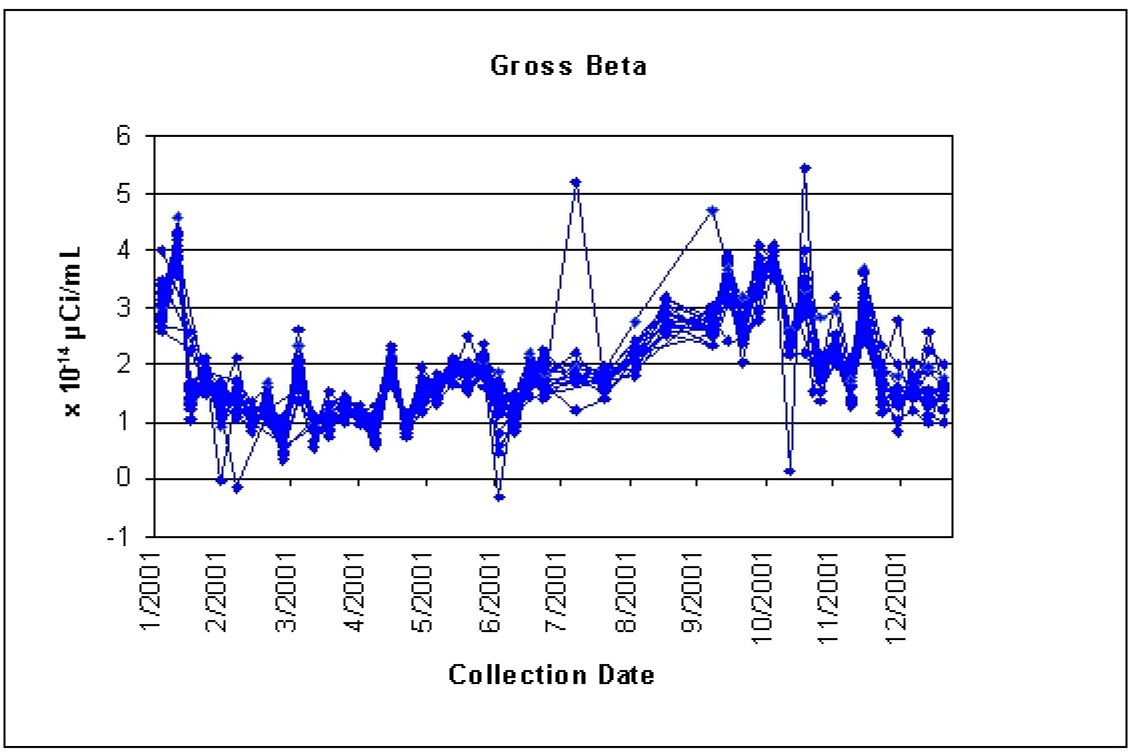


Figure 5.3 Times Series Plot of Beta -2001

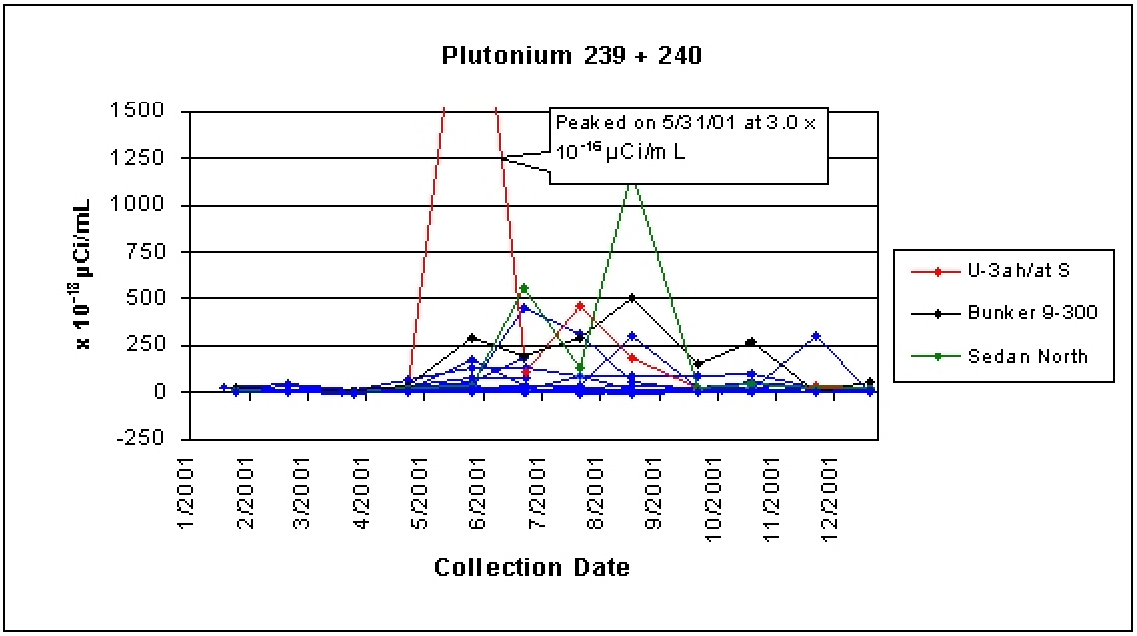


Figure 5.4 Time Series Plot of Plutonium in Air - 2001

Figure 5.5 shows the trend in the highest annual station averages of $^{239+240}$Pu for 1991 to 2001and compares those values with the DCG. Figure 5.6 is a historical time series plot of the annual mean concentrations of $^{239+240}$Pu for the years 1971-2001 at several locations with extended data histories, focusing on locations at Yucca Flat and Frenchman Flat where many nuclear tests have been conducted in the past. The thick green line is a three-year moving average of the average annual concentrations for the stations for which data are available for each year; this shows the decreasing trend in $^{239+240}$Pu during this 31-year period. The decrease is attributed to the termination of nuclear testing in 1992 and the general reduction of field activities that can cause a resuspension of the plutonium in the surface soil.

Americium Results

Descriptive statistics for ^{241}Am are given in Table 5.5. Overall, 67 percent of observations exceeded their MDCs; that proportion ranges from 100 percent at Bunker 9-300, Gate 700 South, and Sugar Bunker N to 25 percent at LITTLE FELLER 2 N, and is 75 percent or greater at 12 of the 28 locations sampled. The highest annual mean concentration was at U-3ah/at S, 5.7 x 10^{-17} µCi/mL (2.1 µBq/m^3), which is 2.9 percent of the DCG. The time series plots for 2001 (Figure 5.7) resemble those for $^{239+240}$Pu, as was the case with the 2000 data. The highest peak (U-3ah/at S) in this figure occurred on the same date as the gross alpha peak in Figure 5.2.

Uranium Results

Table 5.6 presents the descriptive statistics for the uranium analyses performed on the monthly filter composites from 3545 Substation, Yucca, and Guard Station 510. Concentrations of ^{233,234}U and ^{238}U exceeding their MDCs ranged from 67 to 100 percent and 83 to 100 percent, respectively. All concentrations of ^{235,236}U were below the MDCs of their measurements except for the October composite from Guard Station 510,which had a value of 5.9 x 10^{-18} µCi (0.22 µBq/m^3) and a MDC of 3.5 x 10^{-18} µCi/mL (0.13 µBq/m^3). This value may be a statistical anomaly because it is less than twice the MDC of the measurement and the MDCs for all of these analyses varied considerable (3.4 to 180 x 10^{-18} µCi/mL or 0.13 to 6.7 µBq/m^3). Since the ^{235,236}U concentrations were not detectable at the other two stations and the ^{233,234}U/^{238}U ratios for the three stations ranged from 0.9 to 1.3, all the concentrations were attributed to naturally occurring uranium in the environment. Figures 5.8, 5.9, and 5.10 are time series plots of the concentrations showing the variability over the six-month period.

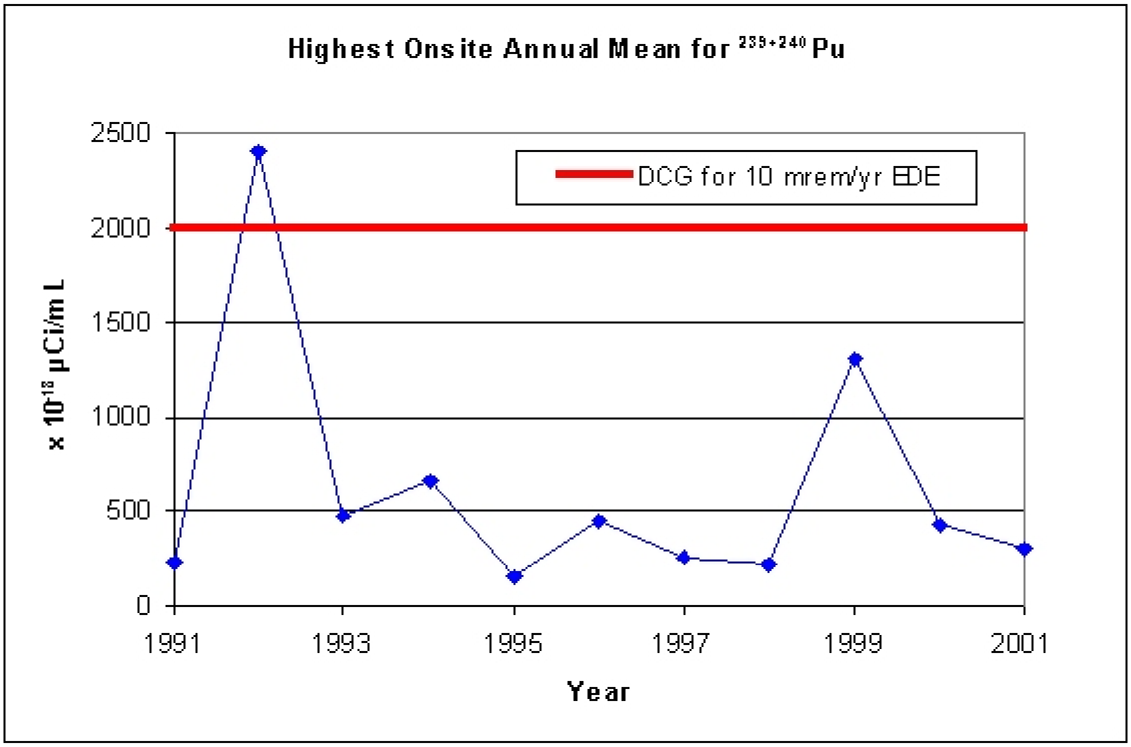


Figure 5.5 Trend in Annual Averages for $^{239+240}Pu$ Concentrations

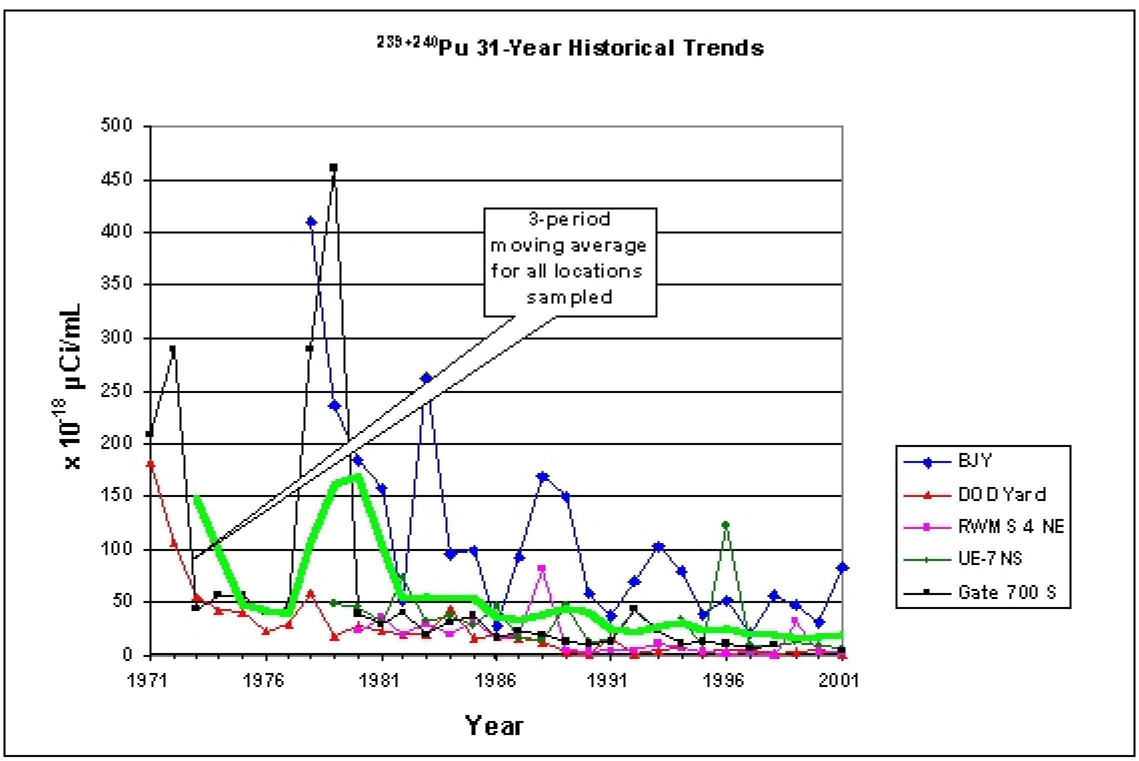


Figure 5.6 Time Series Plot for $^{239+240}Pu$ Annual Averages

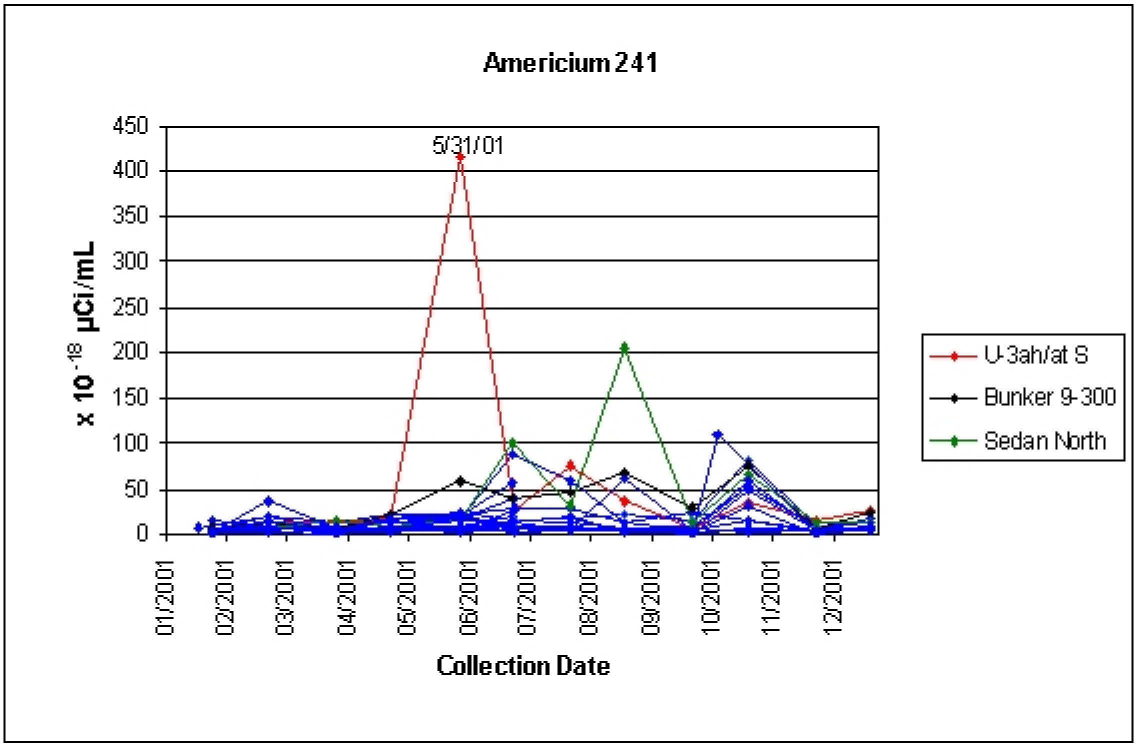


Figure 5.7 Time Series Plot of ^{241}Am in Air, all Locations - 2001

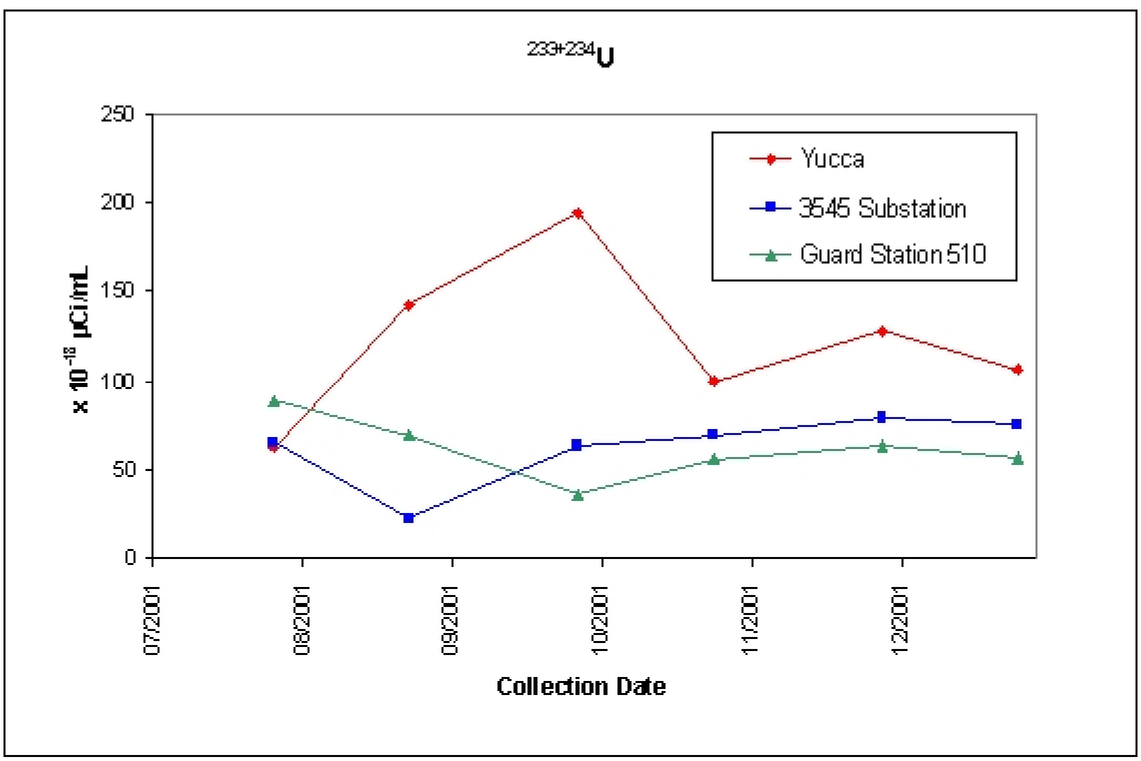


Figure 5.8 Time Series Plot of $^{233+234}$U

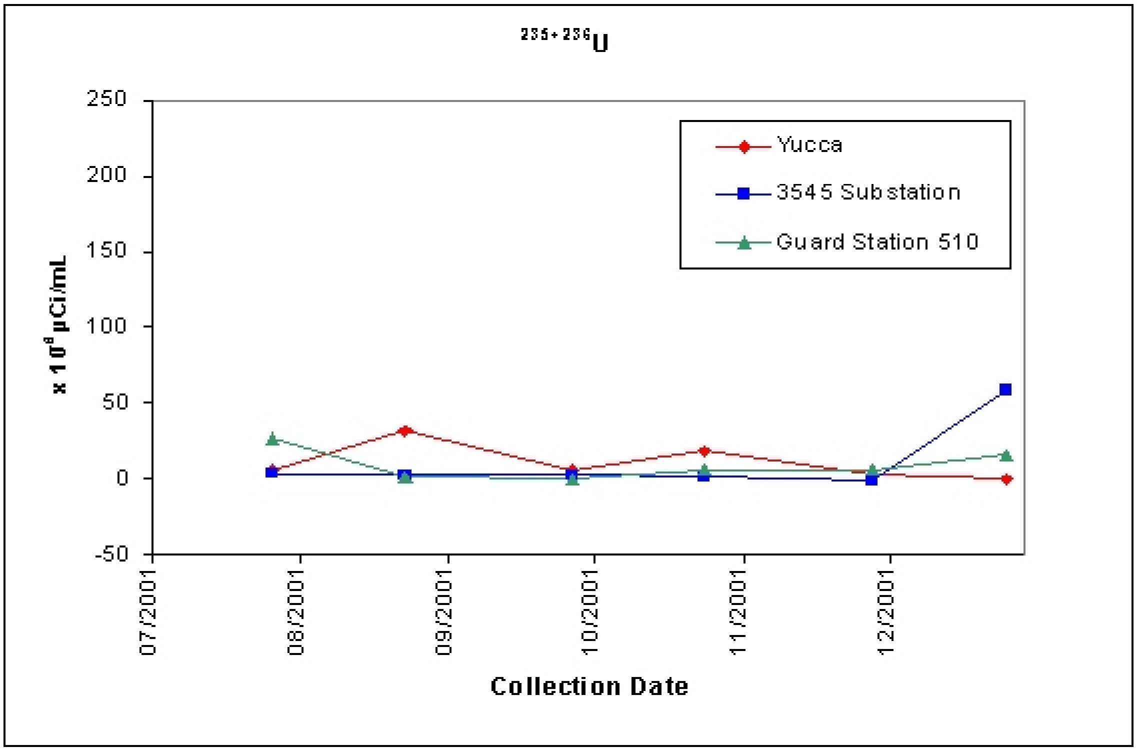


Figure 5.9 Time Series Plot of $^{235+236}U$

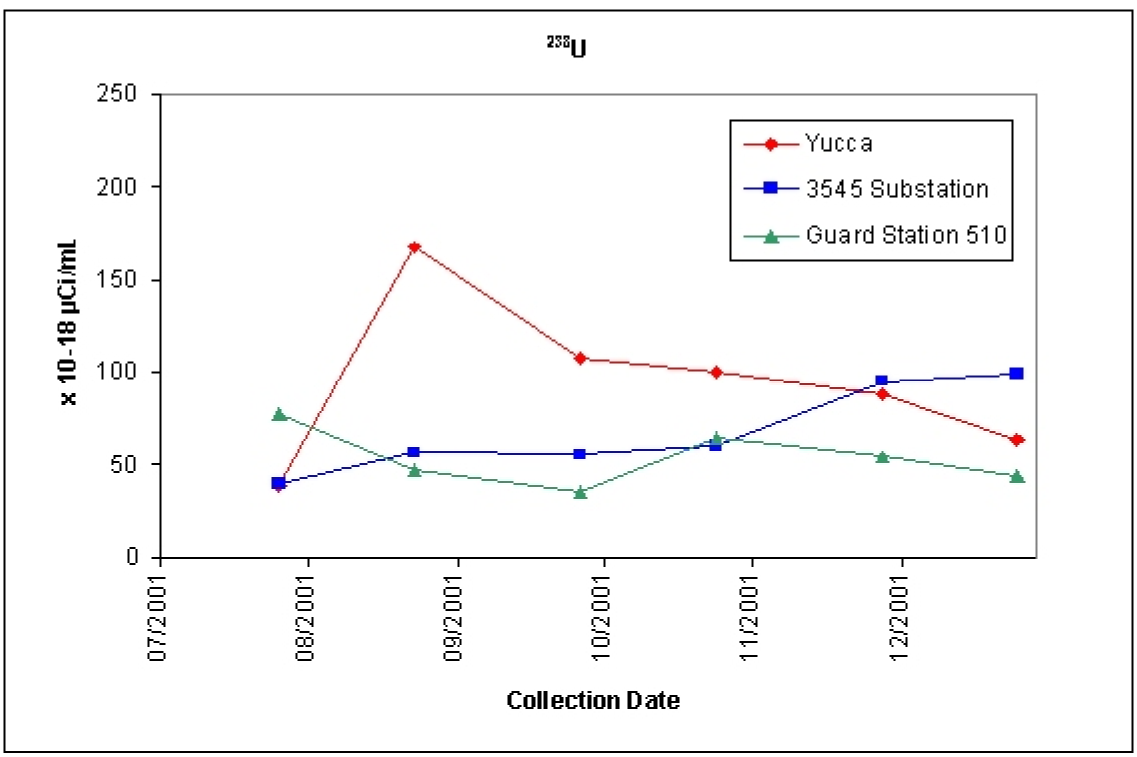


Figure 5.10 Times Series Plot of ^{238}U

Gamma-Emitting Radionuclides

^{137}Cs was the only man-made radionuclide detected in air particulate samples by gamma spectroscopy. Its descriptive statistics are given in Table 5.7. Only 1 percent of measurements exceeded their MDCs, slightly less than in 2000. The only locations at which concentrations were above the MDCs of the measurements were U-3ah/at N, Bunker T-4, and E-MAD N. The highest annual mean concentration was at Bunker T-4 (3.9 x 10^{-16} µCi/mL or 0.14 µBq/m^3), which was <0.01 percent of the DCG.

The gamma spectroscopy analyses also detected naturally occurring ^{7}Be in air at concentrations (annual mean, all locations, 1.2 x 10^{-13} µCi/mL or 4.4 mBq/m^3) which were at comparable or somewhat lower levels than in 2000 (1.5 x 10^{-13} µCi/mL or 5.6 mBq/m^3). Differences in concentrations between locations were minor and far from statistically significant. There were some week-to-week differences. The biggest differences appear to be larger reported MDCs during the first half of the year, which accounted for only 78 percent of all analyses being above the MDC, whereas virtually 100 percent of the ^{7}Be observations exceeded their MDC during 2000.

TRITIUM IN AIR

Tritiated water vapor in the form of $^{3}H^{3}HO$ or ^{3}HHO (HTO) was monitored at 19 onsite locations. The samplers were operated at a constant flow rate of 0.6 L/min (1.25 ft^3/hr) by microprocessors, which summed the total volume sampled (about 11 m^3 over a two-week sampling period). At E Tunnel Pond 2 where grid electrical power was not available, a sampler without constant flow capability that summed the air volume sampled with a dry-gas meter had to be used because of the limited power provided by a solar photovoltaic system.

With either sampler, the HTO vapor 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 columns and analyzed for tritium by liquid scintillation counting.

Tritium in Air Results

Overall 52 percent of HTO measurements exceeded their MDCs, up slightly from 49 percent in 2000. The proportion of those exceeding varied from 0 to 100 percent; locations exceeding by 100 percent were Bunker 9-300, SEDAN North, and SCHOONER and EPA FARM (Table 5.8). The proportion exceeding MDC was similar in 2001 and 2000 at most locations, except that the proportion at BJY increased from 16 to 60 percent. Measurement levels at SCHOONER (mean 4.0 x 10^{-4} pCi/mL or 15 Bq/m^3) far exceeded those at other locations (means from 7.3 x 10^{-8} to 1.3 x 10^{-5} pCi/mL or 2.7 mBq/m^3 to 0.48 Bq/m^3).

Where HTO is present, concentrations increased during the spring months and decreased during the fall (Figure 5.11). As in 2000, this pattern is correlated with temperature (Figure 5.12). Also as in 2000, a dip in airborne tritium levels is observed at SCHOONER following major precipitation events (Figure 5.13).

The mean concentration at SCHOONER was much higher than all other locations primarily because the air sampler was only 269 m from the crater created by the test. The annual mean concentration at SCHOONER was 4.0 percent of the DCG; however, the nearest member of the general public is at Tolicha Peak, which is 20 mi (32 km) west-southwest from the SCHOONER air sampler.

The historical trend in HTO concentrations, shown in Figure 5.14, illustrates the impact of selection of sampling locations and equipment on annual average and maximum concentrations. The most significant recent increase in both maximum and average

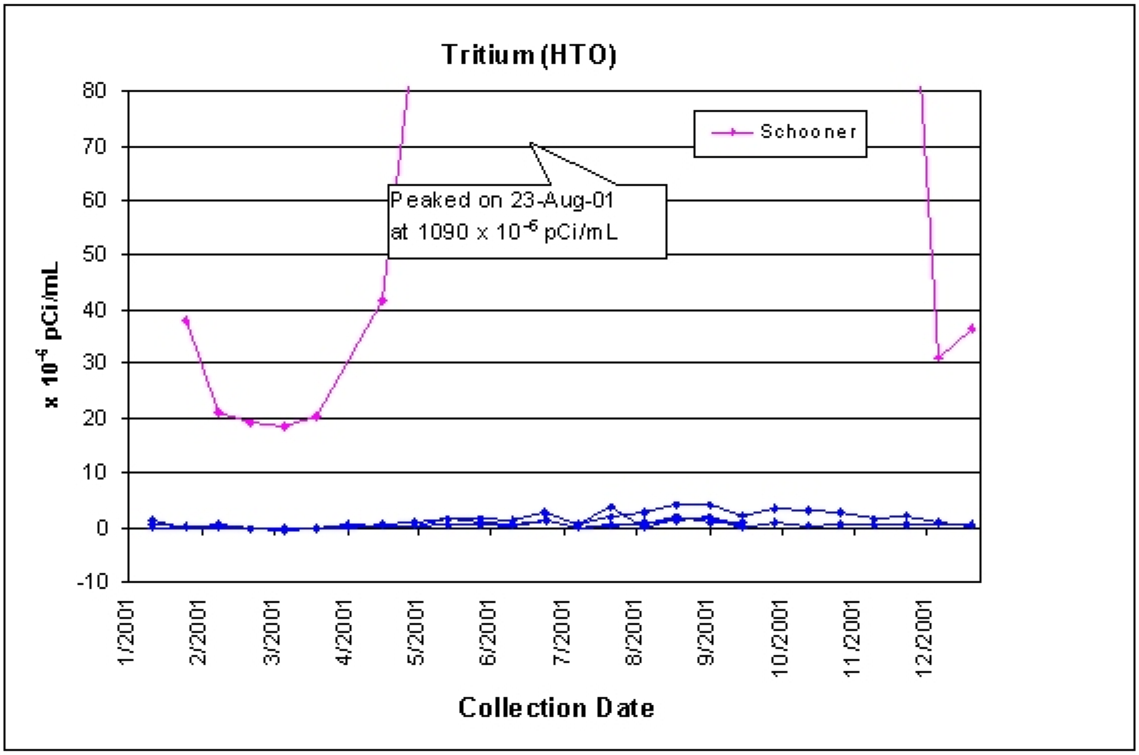


Figure 5.11 Time Series Plot of Tritium in Air - 2001

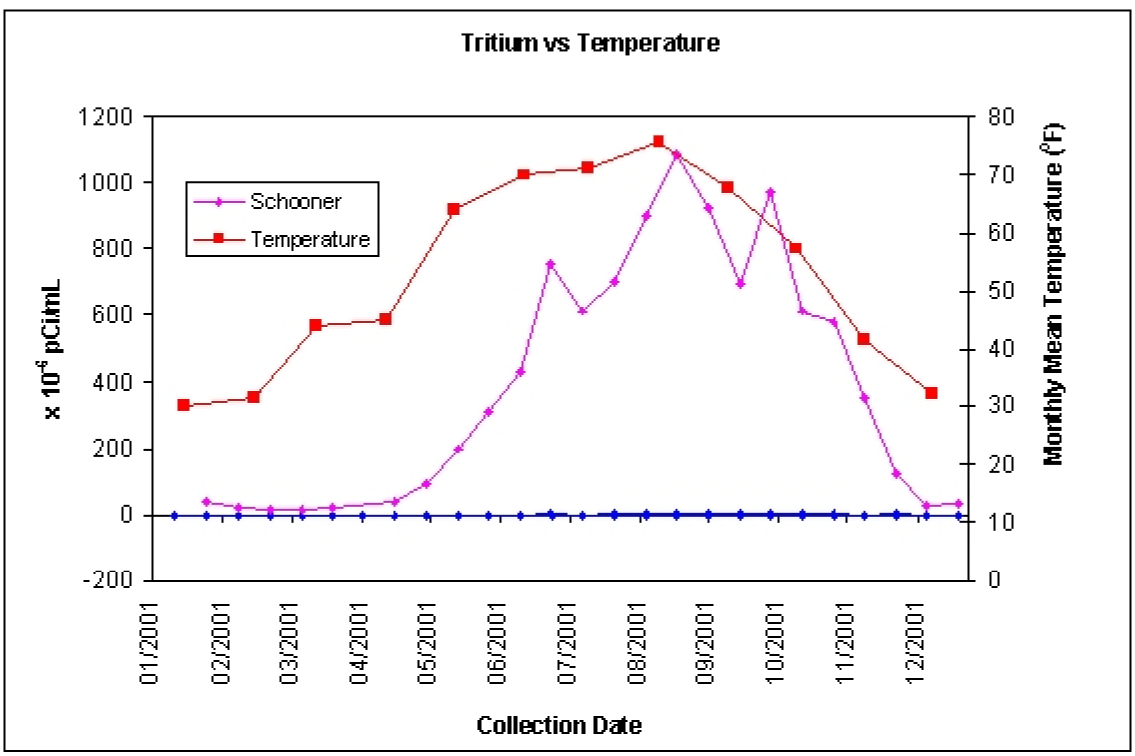


Figure 5.12 Time Series Plot of HTO vs Temperature

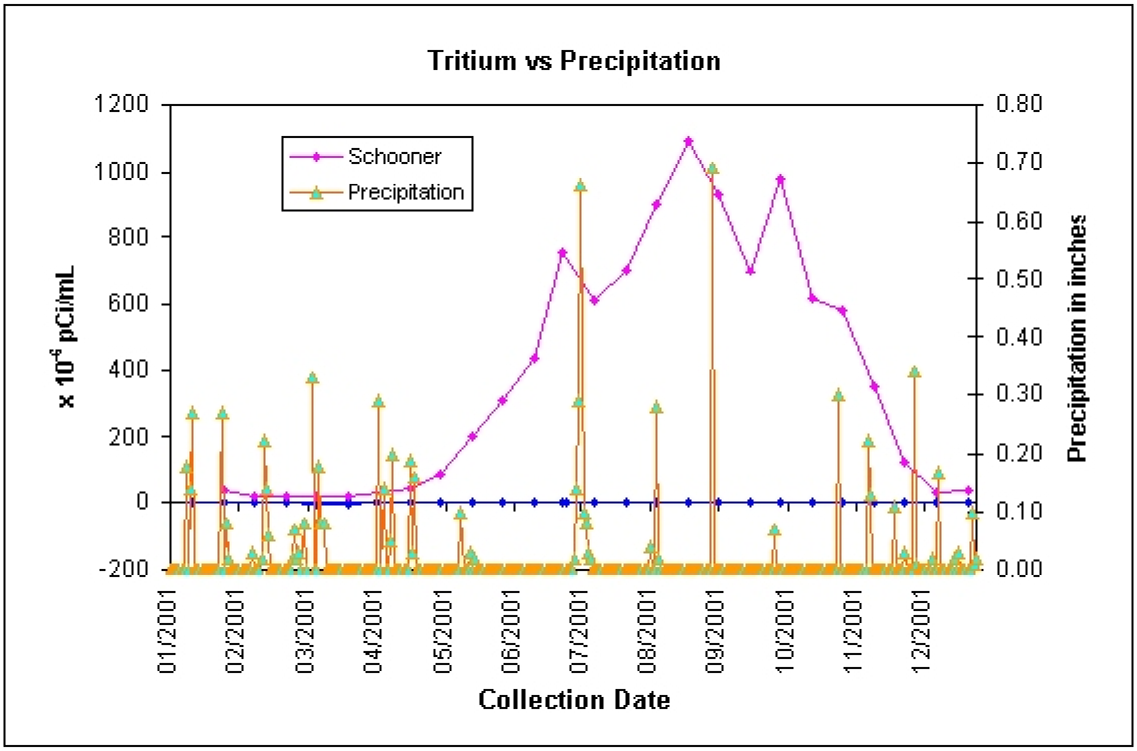


Figure 5.13 Time Series Plot of HTO vs Precipitation

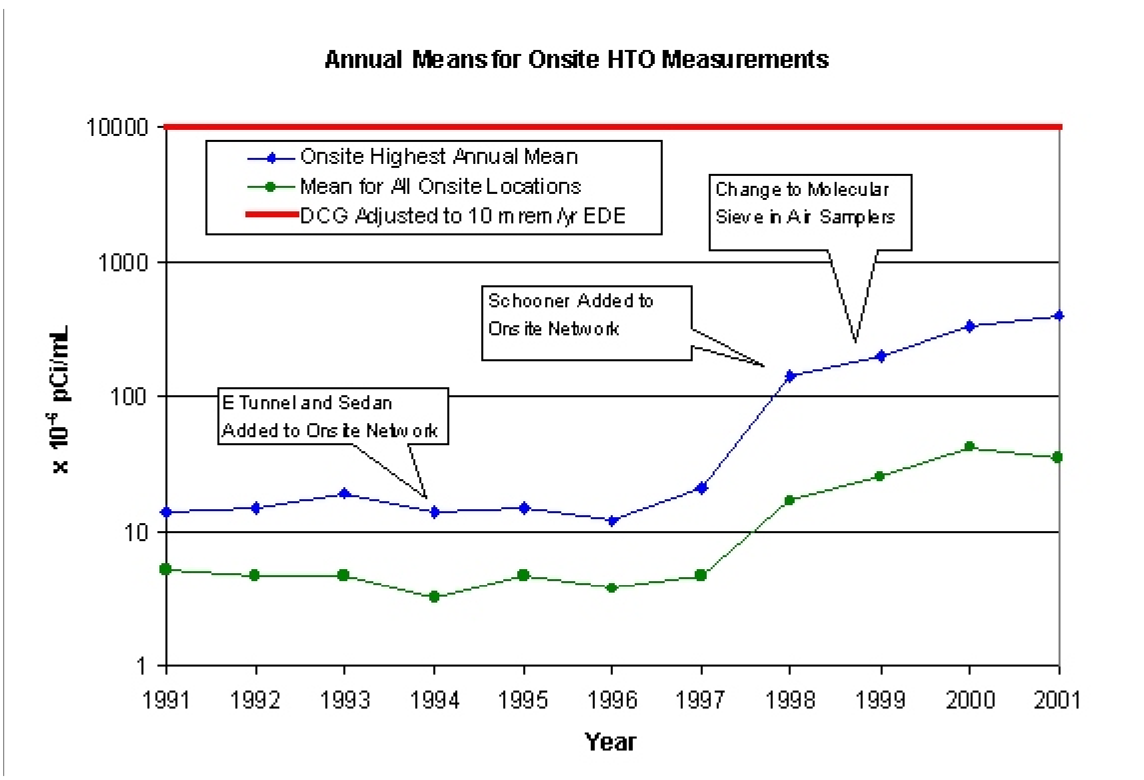


Figure 5.14 Trend in Annual Averages for HTO Concentrations Onsite

concentrations occurred in 1998, when an air sampler was installed near the SCHOONER crater. A contrasting view of historical trends is provided in Figure 5.15, which tracks the median of the means of five locations that have been in continuous service since 1982, when tritium in air data first appeared in NTS annual reports. The trend line (linear regression of log HTO on year) shows that the median concentration decreases by 50 percent in around four years (the radioactive half-life is 12 years).

5.2 ENVIRONMENTAL DOSIMETRY

AMBIENT GAMMA MONITORING

Thermoluminescent dosimeters (TLDs) are used to measure ionizing radiation exposure. The TLDs measure ionizing radiation from all sources, including natural radioactivity from cosmic or terrestrial sources and from human-produced radioactive sources. At the end of 2001, there were a total of 79 active TLD locations (Figure 5.2). The TLD used was 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 and three calcium sulfate elements are used to measure penetrating gamma radiation. Two TLDs were deployed at each location, placed about one meter above the ground. All TLDs were exchanged quarterly.

TLD locations are classified into four categories: environmental, background, historical, and waste operations (Table 5.9). Background locations are close to the perimeter of the NTS and are known to be relatively free of man-made radionuclides. Operational locations are adjacent to stored materials in Areas 3 and 5 and in the inactive Decontamination Facility locations. The remaining TLDs are in the environmental class, with a few designated as historical because of their extended data history.

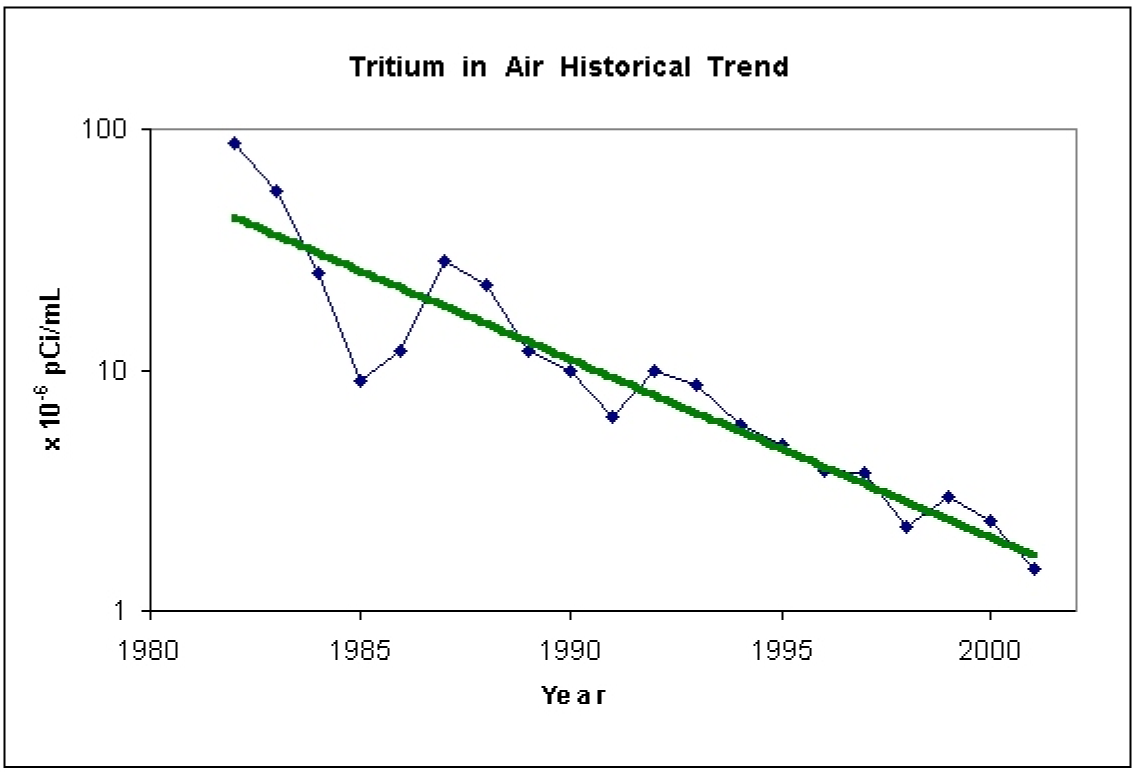


Figure 5.15 Time Series Plot for Tritium in Air on the NTS

THERMOLUMINESCENT DOSIMETER MONITORING DATA

Descriptive statistics for exposure rates at each TLD location are listed in Table 5.9. Statistical analyses were performed using log (TLD) data, since the data variation appeared proportional to mean level, making the log the appropriate variance-stabilizing transformation. Statistically significant differences were found among both locations and quarters, although the quarter-to-quarter variation was much less pronounced than the location-to-location variation. As in 2000, three locations associated (Table 5.10) with atmospheric tests in Yucca Flat (Stake A-9 in Area 4, Stake N-8 in Area 2, and RWMS South in Area 3) were identified as having mean exposure rates distinctly higher than the remaining locations. An additional four locations (SEDAN west in Area 10, Bunker 7-300 in Area 7, T Tunnel #2 Pond in Area 12, and U-3co North in Area 3) had means somewhat higher than the remaining locations. These locations were also in Yucca Flat and associated with surface tests except for T Tunnel #2 Pond in Area 12 which was associated with an underground, tunnel test. Statistically significant differences remain among the other locations, reflecting the high spatial variability of gamma radiation on the NTS.

The location-to-location differences are predominant in these data. To see if there were differences among TLD classes, a nested analysis of variance was performed. The conclusion was that statistically significant differences among classes did exist, even when the top three or all seven atypical locations were excluded. When those locations were included, the apparent location-to-location variation within classes was inflated, masking the class-to-class variation that is observed when those locations are omitted.

After adjusting for location-to-location differences, differences among quarters remained; however, these were smaller than those observed in 2000, with only a 2.3 percent difference between the lowest (second) and highest (third) quarters.

The historical trend for environmental, background, and historical locations is shown in Figure 5.16. The data are annual means for each location. For each year the bottom, middle, and top lines of the box represent the first quartile (twenty-fifth percentile), median, and third quartile, respectively. Lines extend to the lowest and highest values not categorized as outliers. Outliers are denoted by an asterisk (the seven atypical locations were excluded from the figure).

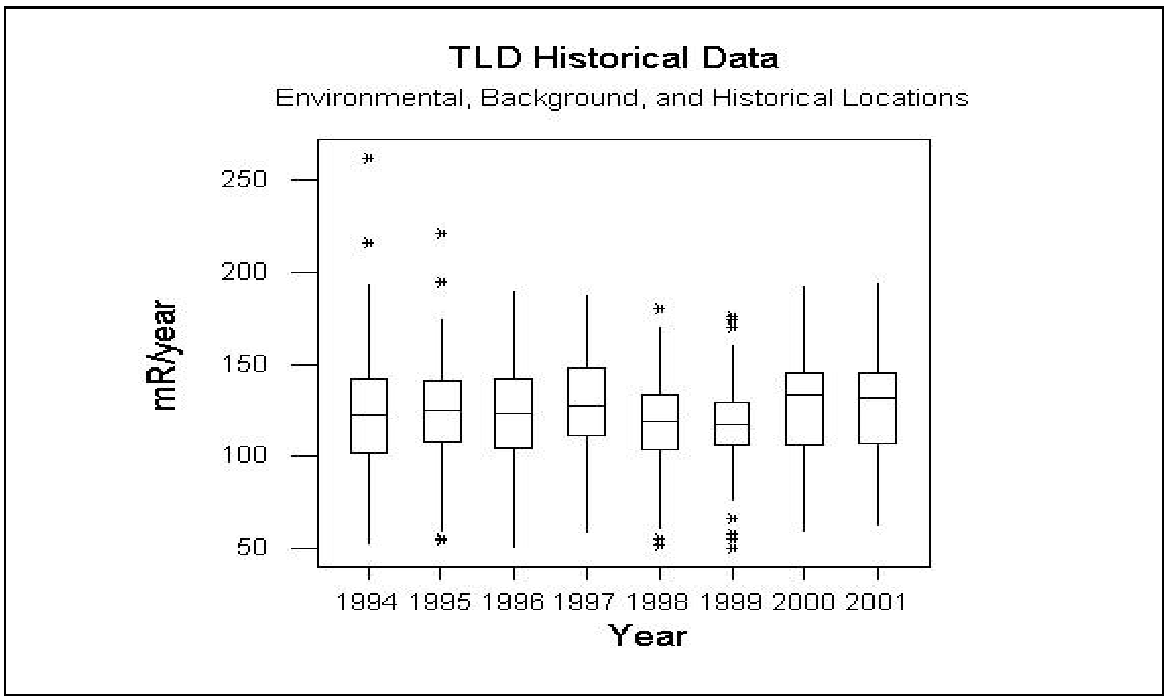


Figure 5.16 Historical Time Series of Boxplots of TLD Exposures

The boxplots for 2000 and 2001 are nearly identical, with median exposure rates slightly higher than in previous years, due to the reduction of TLD locations at relatively lower exposure rate areas.

5.3 WATER SURVEILLANCE ACTIVITIES

The surface waters that exist on the NTS are natural springs, containment ponds, and sewage lagoons. Water samples were collected only from the containment ponds and sewage lagoons. The onsite springs were not sampled because they are fed by locally derived groundwater that is not hydrologically connected to any of the aquifers that may be impacted by underground nuclear tests. Figure 5.17 shows the locations of all the containment ponds and sewage lagoons. No samples were collected from the Area 12 Sewage Lagoon or from the Area 25 Central Sewage Lagoon due to a lack of water.

CONTAINMENT PONDS

Grab samples were collected quarterly from the two containment ponds and once from the Area 12 E Tunnel ponds sediment. The descriptive statistics of the results are given in Table 5.11. As there was little difference between the results from the ponds and the effluent, the results from the different sources were combined. Due to the levels of ^{3}H, ^{90}Sr, ^{137}Cs, ^{238}Pu, $^{239+240}Pu$, and ^{241}Am in the water, the containment ponds are fenced and posted with radiological warning signs. Given that the ponds are readily available to wildlife, plants and animals are sampled to better understand environmental impact. These results are discussed in the following section.

SEWAGE LAGOONS

Each of the sewage lagoons is part of a closed system used for the evaporative treatment of sanitary sewage. Water samples collected quarterly from the lagoons were analyzed by liquid scintillation counting techniques for tritium and by gamma spectroscopy for other test-related radioactivity. No test-related radioactivity was detected in any of the samples. Only the naturally occurring radionuclides ^{40}K, ^{212}Pb, ^{214}Pb, ^{234}Th, and ^{238}U were detected in a few samples at concentrations near the MDCs of the measurements.

5.4 BIOTA SURVEILLANCE ACTIVITIES

ROUTINE SAMPLING OF NTS BIOTA

Biota sampling was conducted during 1999 and 2000 and is described fully in the Routine Radiological Environmental Monitoring Plan (RREMP). Draft sampling procedures for vegetation and animals were developed to guide field sampling (ASL LID L-E10.6.P). Five sites were selected for sampling over the next five years. These sites are E Tunnel Ponds, Palanquin, SEDAN, T2, and Plutonium Valley. These sites are considered the most contaminated sites in each of five contamination types on the NTS as described in the RREMP (DOE 1998a). Plants and animals at each site will be sampled once each five years to confirm low radionuclide levels (sites will be sampled more frequently and intensely if levels are found to be higher than action levels).

Monitoring continued in FY 2001 and was conducted at one contaminated location, E Tunnel Ponds, and a control site, Tippipah Spring (Figure 5.18). Collection of samples for the routine radiological monitoring of biota at the NTS commenced on July 12, 2001, and continued

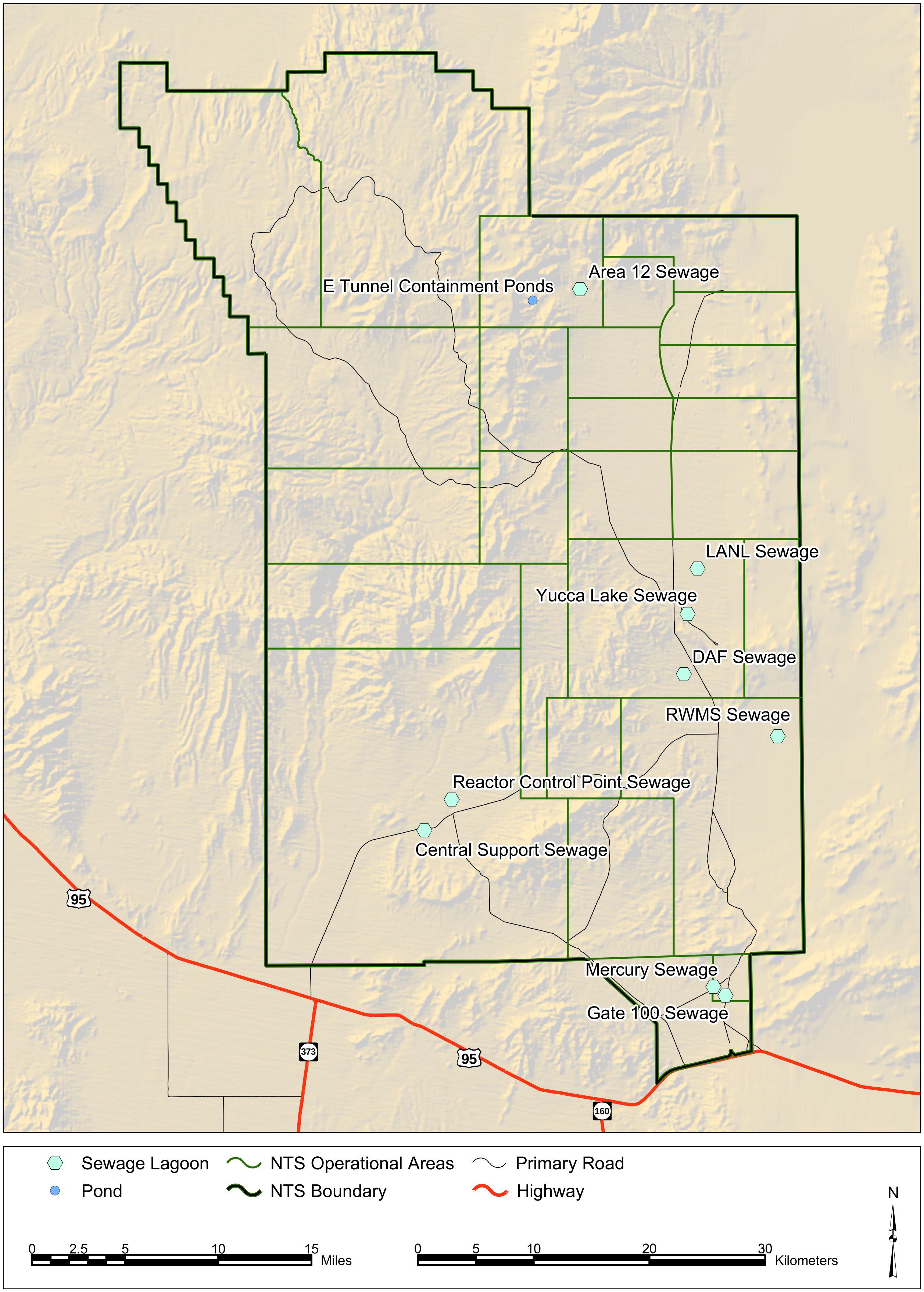


Figure 5.17 Surface Water Sampling Locations on the NTS - 2001

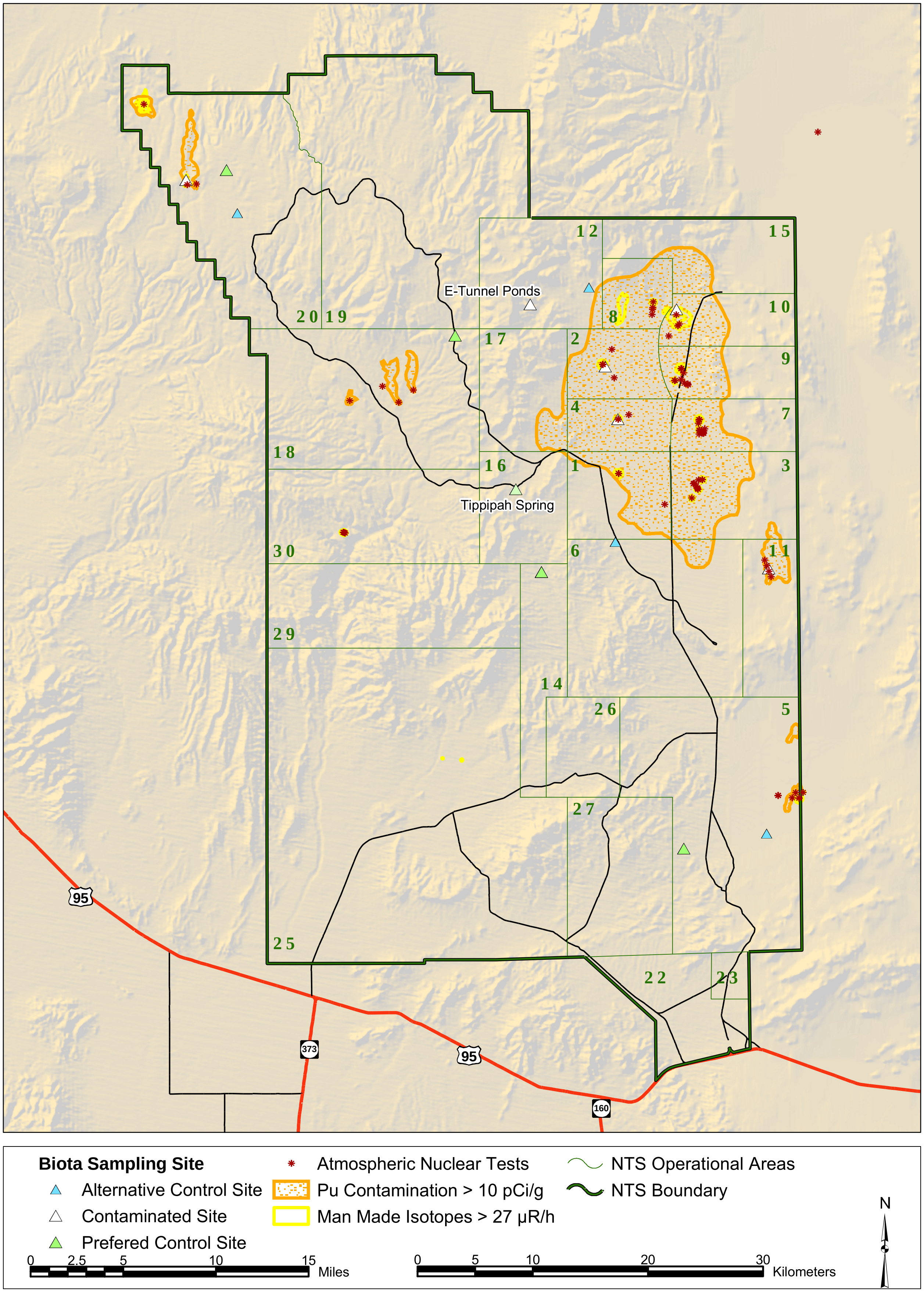


Figure 5.18 NTS Onsite Surface Biota Radiological Monitoring Sites - 2001

through October 1, 2001. A late summer to early fall sampling period corresponded to times of the year when tritium levels have been seasonally highest on the NTS (Hunter and Kinnison, 1998). This appears to be due to reduced precipitation and increased evapotranspiration, which results in a higher fraction of residual tritium in soil water than during winter or spring, when there is greater non-tritiated water in the soil from precipitation.

E Tunnel Pond (1,829 meters elevation, 6,000 feet elevation), located in Area 12 in the northern part of the NTS was selected for monitoring because of its historically high levels of contaminated water and soils (DOE 1998a). Bird trapping was conducted again at E Tunnel pond in FY 2001 as in FY 2000 in an attempt to provide additional animal samples. Tippipah spring was sampled as a control site during FY 2001(1,585 meters elevation; 5,200 feet elevation). Whiterock Spring had been previously used as a control site, but results of limited sampling in FY 2000 suggested that this site may have test related radionuclides. Vegetation at the Tippipah Spring was previously described by Hansen and others (1997).

In addition, to ensure that radioactive concentrations in large game animals that may migrate off the NTS do not pose a significant risk to humans potentially consuming them, regular biota sampling at contaminated sites was supplemented with additional samples of large animals (e.g., antelope) killed accidentally on NTS roads.

VEGETATION SAMPLING

Woody vegetation was primarily selected for sampling because it has been reported to have deeper-penetrating roots with higher concentrations of tritium (Hunter and Kinnison, 1998). Additionally, this vegetation serves as a major source of browse for wildlife game animals that might eat such vegetation and migrate offsite. Grasses and forbs were sampled where species of woody plants were limited.

About 300 to 500 grams (10.6 to 17.6 ounces) of fresh-weight, green-leaf plant material were collected from the current year's growth. All plant samples consisted of a composite of material from many plants in the area sampled. Plastic gloves were used by samplers and changed between each sample collected. Green-leaf plant materials from shrubs and forbs were hand-plucked and stored in air-tight plastic bags. Grasses were sampled by cutting off plant material with a clean utility knife blade. Samples were labeled and stored in an ice chest until delivered to the laboratory (within two hours of collection). Plant samples were delivered to the laboratory under standard chain of custody procedures and frozen until analyzed (DOE 1998a).

Plant samples were taken only at Tippipah Spring during FY 2001(Figure 5.19). Samples were taken on October 1, 2001, and included representatives of the dominant annuals, grasses, and shrubs. Samples included wetland species, as well as upland species. Wetland species sampled included Baltic rush (*Juncus balticus*) and one dominant forb, hairy willowherb, (*Epilobium ciliatum*). Upland Species included two woody shrubs, rubber rabbitbrush (*Ericameria nauseosa*), four-wing saltbush (*Atriplex canescens*), Stansbury cliffrose (*Purshia stansburiana*), and big sagebrush (*Artemesia tridentata*). No trees were present at Tippipah Spring. Approximate location of plant samples at Tippipah Spring was UTM Zone 11, 570810 Easting, 4099723 Northing.

Figure 5.19 Tippipah Spring Site Sampled for Biota - 2001

ANIMAL SAMPLING

State and federal permits were secured to take rabbits, Gambel's quail, chukar, and mourning doves during FY 2001. Animal trapping in FY 2001 consisted of about 20 trapping days. Trapping efforts were directed to mourning doves (*Zenaida macroura*), chukar (Alectoris chukar), Gambel's quail (*Callipepla gambelii*), cottontail rabbits (*Sylvilagus audubonii*), and jackrabbits (*Lepus californicus*). Mourning doves are one of the few game animals that forage on the NTS and migrate offsite; thereby providing a possible pathway of radionuclides in food to man. The ecology of mourning doves is described elsewhere (Baskett, 1993).

Traps were placed at two sites in FY 2001 to catch birds and rabbits. These sites included Tippipah Spring, and E Tunnel Pond (Figures 5.19 and 5.20). At each site, a minimum of two traps were set to different openings to allow rabbits or birds such as chukar, dove, or quail to enter the traps. Trap locations were pre-baited from three to five days prior to setting traps, to attract animals to each site. Pre-baiting consists of applying a large quantity of bait in the area outside of traps to allow animals to consume bait and become adjusted to the presence of traps. Dead shrubs and trees were also used to camouflage and cover the traps to provide shade. Trapping was conducted throughout the month of July when birds were most abundant and before numbers tapered off in early August when migration was in full swing.

Mourning doves and quail were trapped at Tippipah Spring at the same location where plants were collected. Two chukars were collected at the E Tunnel Pond site (Figure 5.20). Trapping location was UTM Zone 11, Easting 571740, Northing 4116080. No quail or doves were observed at E Tunnel pond during trapping efforts in FY 2001. No rabbits were sampled at either site.

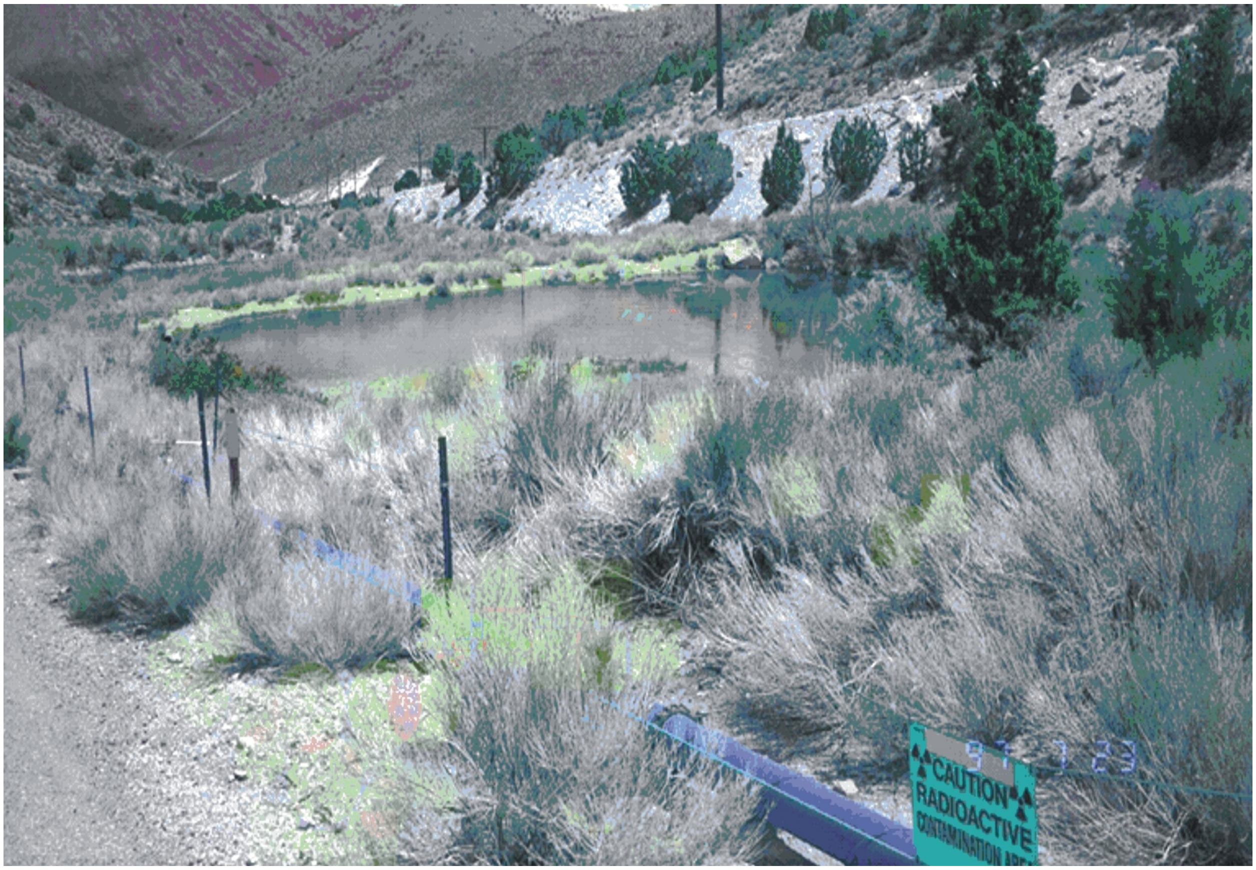


Figure 5.20 E Tunnel Pond Site where Gamebirds were Collected - 2001

Animals trapped were removed from traps by hand, killed, and carefully skinned before a meat sample (e.g. breast meat of birds) was collected. Efforts were made to prevent dust on the fur from getting onto the exposed meat during skinning of any animal. All meat samples were taken by hand or with a scalpel while wearing clean plastic gloves. Gloves were changed between samples to prevent any cross contamination. Meat samples were placed in a plastic bag, labeled, and put on ice for transport to the laboratory for storage until analyzed. Bird samples were typically small (30-50 grams). Meat samples of large mammals collected were greater than 500 grams.

Opportunistic sampling of one pronghorn antelope (*Antilocapra americana*) roadkill occurred on March 13, 2001, on the Mercury Highway (UTM Location-Easting 588220, Northing 4080380) approximately one mile north of the Cane Spring Road intersection in Frenchman Basin.

Field observations indicate doves arrive on the NTS during the month of April, and numbers increase until about mid August, after which numbers begin to decline. It is reported that a majority of mourning doves in Nevada migrate to south central Arizona during the winter (Baskett 1993). Chukar and quail are considered permanent residents of the NTS region. It is not likely that chukar or quail migrate off the NTS in their lifetime because they are a short-lived species. Most quail that were radio-marked near Yucca Mountain did not live longer than 15 months (TRW 1999).

RESULTS

Plant Samples

Radionuclide activities detected in NTS Biota Samples in FY 2001 are shown in Table 5.12. Strontium-90 was detected in only one sample of vegetation (fourwing saltbush) at Tippipah Spring. The detected ^{90}Sr activity was low and was 0.147 $\pm$ 0.0579 pCi/g, with detection limits of 0.0825 pCi/g.

Tritium was detectable in only one vegetation sample (Stanburys cliffrose) at Tippipah Spring, with very low activity levels of 319 $\pm$185 x 10^{-9} µCi/mL (MDC of 301 pCi/L). Tippipah Spring appears to be relatively free of radioactivity and is a good control site for biota sampling for aquatic sites.

Animal Samples

Two mourning doves and two Gambel's quail were collected from Tippipah Spring. Only one sample from an adult dove (#2) had detectable quantities of man-made radionuclides in the breast meat. The ^{238}Pu activity from this individual dove was 0.0587 $\pm$ 0.016 pCi/g with a detection limit of 0.00936 pCi/g. This bird probably foraged in areas away from Tippipah Spring where low levels of plutonium are known to be present in plants, soil, or water. Romney et al., (1970) found only trace amounts of Pu^{239} from the muscle tissue of small mammals and jackrabbits sampled from plutonium contaminated areas on the NTS. The highest amounts of Pu^{239} were found in the gastrointestinal tract, followed by the bone, and lungs of animals.

Two Chukars were collected for analyses at E Tunnel Ponds during FY2001. Both Chukars had detectable quantities of ^{137}Cs and tritium, while one additionally had ^{90}Sr and ^{238}Pu (Table 5.12). The ^{238}U concentration reported for the second chukar (Table 5.12) is reported for informational purposes but is questionable because it was determined by gamma spectroscopy, which is not as reliable for low uranium concentrations as alpha spectroscopy methods. Also, samples of water and sediment from the E Tunnel Ponds taken in 2001 (Table 5.11), as well as historically, have shown ^{238}U to be at background levels and isotopic ratios not different from natural sources and are therefore, considered to be natural uranium. The ^{137}Cs concentrations were 0.125 + 0.060 and 0.384 $\pm$ 0.0748 pCi/g of wet tissue (MDC of 0.069 and 0.0587, respectively). Tritium concentrations in water extracted from the muscle tissue were 247,000 ± 6500 x 10^{-9} and 213,000 ± 5620 x 10^{-9} µCi/mL of extracted water (MDC'S of 889 and 823 pCi/L, respectively). For comparison, the average concentration of tritium in water, for calendar year 2001, in the E Tunnel Ponds was 819,608 x 10^{-9} µCi/mL (Table 5.11). Given the quantity of tritium found in the chukars sampled, it is clear that the birds were using the E Tunnel Ponds as a water source.

The ^{90}Sr concentration measured in one chukar was 0.261 $\pm$ 0.078 pCi/g (MDC of 0.0528). The ^{238}Pu concentration was 0.00293 $\pm$ 0.00329 pCi/g (MDC of 0.00293). E Tunnel Ponds water samples taken during 2001 did not have detectable levels of ^{90}Sr, and ^{238}Pu was not measured but for comparison, the average concentrations of ^{90}Sr and ^{238}Pu found in the E Tunnel Ponds water sampled in 2000 were 0.96 ± 0.46 and 0.35 ± 0.22 pCi/L, respectively (BN 2001c).

The pronghorn antelope road-kill sampled from Frenchman Flat during March 2001 had no detectable man-made isotopes in the meat (Table 5.12).

5.5 RADIOLOGICAL DOSE ASSESSMENT

To assure that the general public and the environment do not receive radiation doses above the limits specified in federal and state regulations or international recommendations, the following radiological dose assessment for offsite residents and onsite biota is provided. This assessment is based upon the pathways by which radionuclides on the NTS can reach and deliver a dose to offsite residents, an estimate of the airborne emissions, the concentrations of radioactivity measured in air and surface water samples (Section 5.1), and radiation dose conversion factors specified by federal and international authorities. The pathways by which radioactive emissions and effluents from the NTS can result in radiation doses to offsite residents are:

- Inhalation of resuspended surface soil radioactively contaminated by past nuclear testing at NTS and transported offsite by the winds.

- Inhalation of tritiated atmospheric moisture transported offsite by the winds from the evaporation of the water discharged into containment ponds or ditches and the diffuse transpiration of soil or vegetation moisture at the SEDAN site, the SCHOONER site and the Area 5 Waste Management Facility.

- Ingestion of meat from migratory wild game animals which drink from surface waters and eat vegetation containing test-related radioactivity while residing on the NTS.

- Ingestion of water potentially contaminated by underground deposits of radioactivity created by past nuclear tests.

Since the migration of radioactivity in ground water has not been detected in the past nor in the year 2001 (see Chapter 8.0), the pathways by which offsite residents could receive a radiation dose from past or current activities on the NTS are limited to the first three pathways. The radiation doses assessed herein are estimates based upon measurements of radioactivity in surface water, air, and wildlife tissue and mathematical models that estimate emissions from the resuspension of surface soils and relate the emissions to potential offsite radiation doses. The following sections identify the potential sources of onsite airborne emissions and liquid effluents containing radioactivity, the estimated quantities released, and the atmospheric diffusion model that is used for calculating the radiation effective dose equivalents (EDEs) received by hypothetical offsite receptors. Although Federal regulations are for the EDE received during the year, all dose factors used in the calculation of EDEs are for committed effective doses; the calculated internal doses received up to 50 years depending upon the biological half-life of the particular radionuclide delivering the dose. Also included is an update of the assessment of radiation doses to terrestrial and aquatic biota that was begun in 2000.

RADIOACTIVE EMISSIONS

Known and potential sources of airborne emissions and liquid effluents containing radioactivity are identified and listed in Table 5.13. All sources are on the NTS or Nellis Air Force Range (NAFR) except for Building A-1, which is in North Las Vegas. A brief description of the methods used for estimating the emissions is given below. More details about the sources and methods used is reported separately (Grossman 2002).

Laboratory Sources

The emissions for the laboratory sources reported in the past were based on the total quantities found on inventory and assumed released into the air, although they were not. This year only actual emissions are reported such as the 5.6 Ci of tritium gas that was consumed while calibrating analytical equipment at Area 6 CP-50.

The tritium emission for Building A-1 was estimated from tritiated atmospheric moisture samples collected during the months of February and December and the rate by which air was exhausted from the rooms. The assumed source of the tritium was the result of an accidental release of ^{3}H in July 1995 at a fixed radiation source range in the basement of Building A-1, where residual contamination has persisted despite considerable efforts to remove it.

Area Sources

The area sources in Table 5.13 are a summation of the estimated radionuclide emissions from the individual areas on the NTS and from several contaminated sites on the NAFR (near offsite). The major sources of tritium as HTO are attributed to the events SCHOONER (Area 20) and SEDAN (Area 10), the E Tunnel ponds (Area 12), a low-level waste burial pit in Area 5 RWMS, and water pumped from Wells U-3cn PS#2 and ER-20-5 #3.

The emissions of HTO from SCHOONER, SEDAN, and Area 5 RWMS were estimated from the annual average concentration of HTO at the nearest air sampling location and by back-calculating with CAP88-PC software (DOE 1997b) to determine what emission rate would be required to produce the concentration average from the air sampling measurement. The emission of HTO from the E Tunnel ponds was determined by multiplying the quarterly measurements of HTO concentrations in the E Tunnel effluent by the water volume discharged assuming that all the pond water evaporated. The emission from the two wells was estimated from the concentration of HTO measured in the well water and the volume of water discharged; all water was conservatively assumed to evaporate into the air.

The emissions of ^{241}Am and $^{239+240}$Pu were estimated for each NTS area for which an inventory was assessed by past in situ gamma spectroscopy measurements and soil sampling (DOE 1991b). The inventoried amount on the ground surface in curies was used as input to a resuspension model (NRC 1983) to estimate the emission rate.

OFFSITE RADIOLOGICAL DOSE ESTIMATES

Dose from Airborne Emissions

The radiation doses to offsite residents from airborne emissions were estimated with CAP88-PC software (Version 2.0), in accordance with Title 10 CFR, Part 61. The estimates are described in detail in a report (Grossman 2002) to the Environmental Protection Agency. The software required the following input:

- The annual emission rates calculated for each point/grouped source (Table 5.13).

- 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, 30, and 52 [NLVF]) (for brevity, total emissions are summed for all areas in Table 5.13).

- Wind files that were constructed for Mercury, Area 12, Area 20, Yucca Flat, and Area 5 from wind rose and stability array data collected over a 10-year period.

- Location of populated areas within 80 km of the NTS sources of emissions.

The EDEs from each computer run for each emission source were summed for each populated offsite location. The location at which a hypothetical receptor received the highest offsite dose was Springdale, Nevada, where the CEDE was 0.17 mrem/yr.

Dose from Consumption of Wild Game

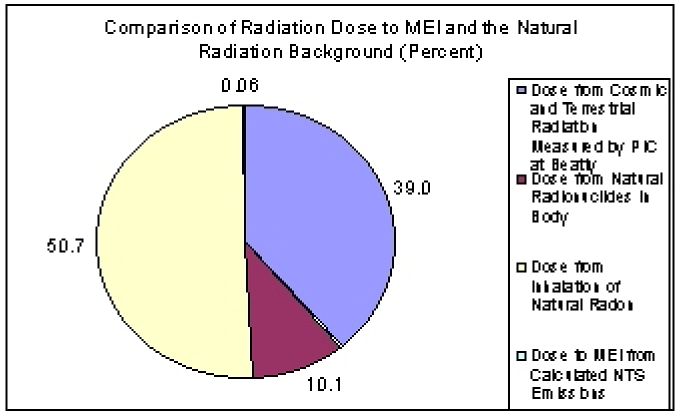
Although hunting is prohibited on the NTS, there is the remote possibility that animals drinking water and feeding on the NTS could migrate offsite where hunters could harvest them. No human-made radionuclides were detected in the one pronghorn sampled on the NTS during 2001. Muscle tissue from the two chukars sampled during 2001 had detected tritium and ^{137}Cs with ^{90}Sr detected in one sample (see section 5.4). Because the uranium source is natural, the concentrations reported for U-238 in the chukar (Table 5.12) will not be used on dose assessments.

From hunting bag limits set by the state of Nevada 6 chukar per day with no more than 12 chukar in a hunter's possession at any one time), and observed radionuclide concentrations, an estimate of the Committed EDE (CEDE) to a hunter consuming 12 chukar was made. It was assumed that the average weight of the sampled chukar breast tissue (100.9 g) was representative for each of the 12 chukar consumed and that the measured moisture content of the tissue (76 percent) was also representative. The CEDE was calculated using dose conversion factors (DOE 1988) and the total activity consumed for each of the detected radionuclides. The sum of the estimated CEDE (Table 5.14) for each radionuclide was 0.07 mrem (7.0×10^{-4} mSv).

Total Offsite Dose to Maximally Exposed Individual (MEI)

A summary of the NTS radiological doses for calendar year 2001 can be found in Chapter 1.0, Table 1.2. Based upon the estimated airborne emissions of radioactivity from the NTS for all possible sources, the maximally exposed individual (MEI) was calculated to be at Springdale, Nevada, 58 km (36 mi) west-northwest of CP-1. The EDE to a hypothetical receptor at this location was calculated to be 0.17 mrem/yr (1.7×10^{-3} mSv/yr), which is 0.17 percent of the 10 mrem/yr limit required by NESHAPs (CFR 1989). If the receptor at Springdale was the hunter harvesting and ingesting the chuckars mentioned in the previous section, the person would have received an additional 0.07 mrem/yr for a total EDE of 0.24 mrem/yr, which is 0.24 percent of the dose limit (DOE 1990b) to the general public.

The Springdale dose is small compared to the gamma radiation background (154 mR/yr) measured with a pressurized ion chamber (PIC) at Beatty (see Table 5.15) by the offsite CEMP (section 5.6). This radiation exposure in air measured by the PIC is approximately equivalent to 154 mrem/yr in tissue, but includes only the cosmic and terrestrial components of the natural environmental background. The additional components of the background are the radiation doses from the natural radionuclides within the composition of our body, primarily from ^{40}K, and the radiation dose that we receive from the inhalation of naturally occurring radon gas (NCRP 1996). When all components of the natural environmental background are included in the total radiation dose that a Springdale resident could receive, the EDE from the calculated NTS emissions is insignificant as shown in the diagram.



Collective Population Dose

The collective population dose, the product of a radiation dose and the estimated population receiving it, was reported previously (Grossman 2002) for the estimated NTS emissions as 0.44 person-rem/yr within 80 km of the NTS points of emission. This dose is insignificant compared to the population dose (13,940 person-rem/yr) for the same area from the natural environmental background. The latter dose was estimated from the average of the annual gamma exposures from cosmic and terrestrial radiations (123 mr/hr) reported for the 24 offsite PIC stations (Table 5.15) and the dose equivalents estimated by the National Council on Radiation Protection and Measurements (NCRP 1996) for the remaining components of the natural environmental background; the dose (40 mrem/yr) from the radionuclides that are naturally part of the human body, primarily ^{40}K, and the dose (200 mrem/yr) from the inhalation of naturally occurring radon in the air we breathe. The gamma exposures in air measured by the PICs in mR/yr are approximately equivalent to dose rates in mrem/yr; therefore the total dose from environmental background was estimated as 363 mrem/yr (123 +40 + 200), which when multiplied by the population (38,403) within 80 km of the points of emission results in a collective population dose of 13,940 person-rem/yr.

Onsite Biota Doses

The interim DOE Technical Standard, "A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota" (DOE 2000a) is being applied to the NTS to determine whether DOE sponsored activities are meeting the dose limits to aquatic and terrestrial biota recommended by the DOE Biota Dose Assessment Committee (BDAC). This technical standard was derived to assist all DOE activities in complying with the dose limit to aquatic organisms specified by Order DOE 5400.5, "Radiation Protection of the Public and the Environment" and the internationally-recommended dose limits for terrestrial biota. The intent of the dose limits are to "protect the aquatic and terrestrial environment, including populations of plant and animals, within and beyond the boundaries of DOE sites from impacts of routine DOE activities" (DOE 2000a). The application of this technical standard will demonstrate whether:

- the absorbed dose to aquatic animals exceeds 1 rad/day (10mGy/day) from exposure to radiation or radioactive material.
- the absorbed dose to terrestrial plants exceed 1 rad/day (10mGy/day) from exposure to radiation or radioactive material.
- the absorbed dose to terrestrial animals will not exceed 0.1 rad/day (1mGy/day) from exposure to radiation or radioactive material.

The graded approach of this technical standard is a three-step process consisting of data assembly, a general screening phase, and, if needed, a more detailed analysis phase. The screening phase consists of determining whether the sum of the ratios of maximum radionuclide concentrations in a medium such as soil or water to conservatively set biota concentration guide (BCG) values is less than one. If it is, the absorbed dose to biota will be less than the above prescribed limit for biota. As an aid to the screening phase, a set of electronic spreadsheets (the RAD-BCG Calculator) was used with the technical standard documentation to calculate and sum the concentration ratios.

In 1999, a preliminary screening phase was completed for terrestrial biota on the NTS which showed that the location with the highest radionuclide concentrations, Area 10, had a ratio of only 0.325, based primarily upon the soil concentrations of ^{90}Sr and ^{137}Cs. Since this ratio was less than one, the dose to terrestrial biota was less than 1 rad/day (10mGy/day). Soil concentration data for this evaluation was based upon past surveys of NTS surface contamination by in situ gamma spectroscopy measurements and soil sampling and analysis (DOE 1991).

No natural rivers or streams exist on the NTS, and no natural spring-fed ponds are known to be contaminated but there is a set of tunnel drainage ponds at the Area 12 E Tunnel that have existed for many years and support some aquatic organisms. Water and sediment samples were collected from the E Tunnel ponds during 2001. Results from these (see section 5.3) were input to the RAD-BCG Calculator, developed by DOE's Biota Dose Assessment Committee, to determine whether radionuclide concentrations were below those which may result in a dose exceeding limits set to protect biota. Compliance is demonstrated by showing the ratio of measured concentrations to conservatively estimated BCG is less than one. Three runs were made with the RAD-BCG Calculator. Maximum radionuclide concentrations and a full time resident scenario were input for the first screening which gave a sum of fractions of 2.0 with ^{137}Cs in water accounting for approximately 93 percent of the total. More representative average values and a 0.7 correction factor for time were then used which gave a sum of fractions of 1.3. Again, ^{137}Cs accounted for the majority at 94 percent. Both initial runs used the default most conservative lumped parameters. A third run was made using average concentration values and the 0.7 correction factor for time and allometric parameters which gave a sum of fractions of 0.9, a level passing the screening phase.

In all RAD-BCG Calculator runs, a riparian animal was listed as the organism with the most limiting dose. At the E Tunnel ponds the only full time residents of the aquatic/riparian zone are likely aquatic/emmergant insects (e.g. those in the Order Odonata). A number of animals, however, use the ponds as an occasional or seasonal water source. These include small mammals (e.g., rock squirrels, and mice), various passerine birds, swallows, mourning doves, chukar, and mule deer. During 2001, two chukar trapped near the E Tunnel ponds contained detectable radionuclides (see Section 5.4 and Table 5.12). Assuming the whole-body concentrations were the same as those in the sampled muscle tissue, and using internal dose conversion factors recommended by the BDAC, the average internal dose to the chukars was estimated to be 0.003 rad/day (3.0×103^{-5} Gy/day) (Table 5.14). Using average water and sediment concentrations and BDAC screening-level external dose coefficients, the external dose was calculated to be 0.004 rad/d. The total dose to a chukar was estimated to be 0.007 rad/day. This value is below the dose limits specified by the technical dose standards for biota.

5.6 COMMUNITY ENVIRONMENTAL MONITORING PROGRAM

The CEMP provides communities surrounding the NTS with radiological and weather data, and is operated by the DRI of the University and Community College System of Nevada. During calendar year 2001, there were 24 CEMP stations managed by DRI (Figure 5.21). Four stations (Stone Cabin, Twin Springs, Nyala, and Garden Valley) were administered by EPA, but came under the purview of the CEMP in September of 2001.

The CEMP stations include monitoring devices for direct measurement of gamma emitters and high-energy beta particles such as TLDs and PICs, and low-volume particulate air samplers for total suspended activity and radioactive particles. The PIC data are recorded in µR/hr, but no attempt is made to equate this to a dose. The air sampler draws two cubic feet of air per minute (at STP) through a paper filter.

DRI has upgraded stations to enhance their technical capability as well as improve their service to the public. The stations (Figure 5.22) are now equipped with a full suite of meteorological equipment to measure air temperature, humidity, wind speed and direction, incident solar radiation, barometric pressure, and precipitation.

DATA COLLECTION AND DISSEMINATION

All data collected by electronic sensors at the CEMP stations are stored in a datalogger. Current data readings are displayed onsite and are updated every six seconds. Data are transmitted by telephone landline, cellular phone, or GOES satellite when the preceding options are not feasible. Data storage is designed to allow for 20 days of storage on the datalogger in the event of communication loss. Collected data are transmitted once every three hours to the Western Regional Climate Center (WRCC). The data from the stations are posted on a publicly accessible WRCC web site at http://www.wrcc.dri.edu/cemp.

COMMUNITY ENVIRONMENTAL MONITORS (CEMs)

The primary objective of the CEMP is to involve residents of the communities surrounding the NTS in offsite environmental monitoring. DRI employs local citizens, whose responsibilities include monitoring the equipment, assisting with maintenance, and posting information on the program and analytical results. The CEMs are also part of the chain of custody for the air particulate samples, and are responsible for the weekly collection of air filters and for routing them to DRI, where they are prepared for submission to an independent laboratory for analysis.

Through workshops, the CEMs are trained to independently verify the results of the environmental monitoring, and become knowledgeable spokespersons on subjects ranging from radiation detection to local environmental conditions. They become effective technical liaisons between local and federal entities, helping to identify the environmental concerns of people in their communities.

CEMP AIR SURVEILLANCE NETWORK (ASN)

The inhalation of radioactive airborne particles can be a major pathway for human exposure to radiation. The atmospheric monitoring networks are designed to detect environmental radioactivity from both NTS and non-NTS activities, as well as natural sources. Data from atmospheric monitoring can be used to determine the concentration and source of airborne radioactivity and to project the fallout patterns and durations of exposure to the general public.

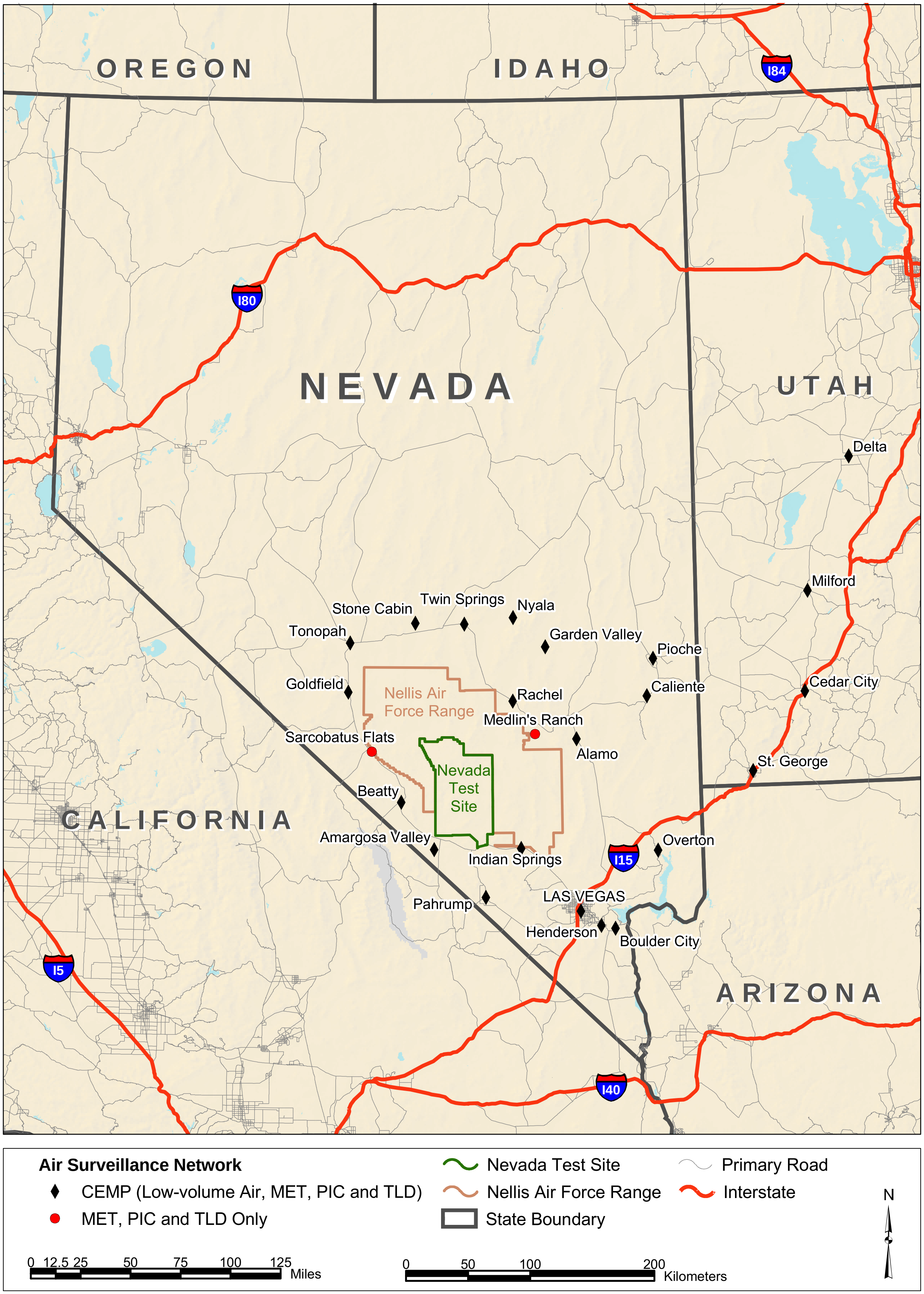


Figure 5.21 CEMP, MET, PIC and Air Sampling Sites on or near the NTS - 2001

Figure 5.22 The CEMP Station at Betty, Nevada

During calendar year 2001, the CEMP ASN consisted of 22 continuously operating low-volume air sampling locations. Four additional locations at ranch sites previously administered by EPA, came under the purview of the CEMP beginning in September 2001. Duplicate air samples are collected from two routine ASN stations each week. The duplicate samplers are operated at randomly selected stations for three months and moved to new locations.

The glass-fiber filters from the low-volume samplers are received at DRI, then prepared and sent to an independent laboratory to be analyzed for gross alpha and gross beta activity. Samples are allowed to sit for 7 to 14 days after collection to allow time for the decay of naturally occurring radon progeny. Upon completion of the gross alpha/beta analyses, the air filter samples are returned to DRI to be recompiled on a quarterly basis for gamma spectroscopy analysis.

CEMP THERMOLUMINESCENT DOSIMETRY (TLD) NETWORK

External dosimetry is another of the essential components of environmental radiological assessments. This is used to determine both individual and population exposure to ambient radiation from natural or artificial sources. In calendar year 2001, the TLD program consisted of 24 fixed environmental monitoring stations. The primary purpose of the CEMP offsite environmental dosimetry program is to establish dose estimates to populations living in the areas surrounding the NTS. For quality assurance purposes, duplicate TLDs are deployed at two randomly selected environmental stations. An average daily exposure rate was calculated for each quarterly environmental exposure period, and the average of the four values was multiplied by 365.25 to obtain the total annual exposure for each station.

CEMP PRESSURIZED ION CHAMBER (PIC) NETWORK

The PIC measures gamma radiation exposure rates, and because of its sensitivity may detect low-level exposures that go undetected by other monitoring methods. PICs are in place at all 24 stations in the CEMP network. 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 differ naturally among locations, as they may change with altitude (cosmic radiation), radioactivity in the soil (terrestrial radiation), and may vary slightly within a 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 have become much more readily apparent. These variations can be easily viewed by selecting the Time Series link from the CEMP home page http://www.wrcc.dri.edu/cemp after selecting a desired station, and then selecting the desired variables.

ANALYTICAL RESULTS

Procedures and Quality Assurance

Several methods are used by DRI to ensure that air filter sample radiological results conform to current quality assurance protocols. These methods include the use of standard operating procedures, field duplicate samples, and laboratory quality assurance procedures.

Standard Operating Procedures

DRI standard operating procedures describe the methods, materials, and equipment required for the collection and analysis of air filter samples. This includes equipment operation and calibration procedures, sample collection technique, and preparation of samples for analysis by an independent laboratory. Table 5.16 lists the types of analyses performed and methods used.

Field Quality Assurance Samples

The collection of duplicate samples in the field is an important part of quality assurance procedures. Two duplicate air samplers for the CEMP program are kept in the field at all times, and are rotated among 20 stations on a quarterly basis. This results in the collection of up to 13 duplicate air filter samples for each station. The results of these sample analyses are used to measure the repeatability of the collection and analytical technique. A summary of the results is shown in Table 5.17. The average %RSD (Relative Standard Deviation) is a measure of the precision of the analysis. This is calculated by dividing the standard deviation of the duplicate pair by the analytical mean then multiplying by 100 to obtain a percent.

Overall, the %RSD for all field duplicate analyses falls well within data quality objectives, only slightly higher than the %RSD for the laboratory duplicate results. Gross alpha results from the field duplicates individually show the most variation with about 5 percent of the duplicates exceeding or showing borderline results in terms of data quality objectives. Given the fact that equipment and field conditions are by far the most variable parameters in air sample collection, these results are acceptable. The %RSD for all gross beta and gamma spectroscopy analyses falls within data quality objectives.

Laboratory Quality Assurance Samples

Laboratory analyses were performed by Severn Trent Laboratories, St. Louis, Missouri. Quality assurance controls consisted of published laboratory techniques, method blanks, control samples, and duplicates. Method blanks consist of samples that are free of the analyte of interest, and are used to determine if the laboratory itself is contributing to the analysis. Control samples contain a known activity of the analyte and are used to assess the level of accuracy of the analysis. Duplicates in the case of air filter samples are a second analysis of an individual sample. These results indicate the repeatability of the analysis of interest. All gross alpha/beta and gamma spectroscopy analyses fell within acceptable parameters.

AIR SAMPLING RESULTS

The CEMP ASN measures the major radionuclides that could potentially be emitted from activities on the NTS, as well as naturally occurring radionuclides. The ASN represents the possible inhalation exposure pathway for the general public. All glass-filter samples were analyzed for gross alpha and gross beta activity. Upon completion, the samples were returned to DRI and compiled into quarterly composites. The quarterly composites were then analyzed by high resolution gamma spectroscopy.

Gross Alpha

Gross alpha analysis was performed on all low-volume network samples. The annual average gross alpha activity was $2.8 \pm 0.7 \times 10^{-15}$ µCi/mL ($1.0 \pm 3 \times 10^{-4}$ Bq/m^3). A summary of the results is shown in Table 5.18. As in previous years, the results exceeded the analytical MDC and overall showed similar values to previous years' data.

Gross Beta

Gross beta analysis was also performed on all low-volume network samples. As in previous years, these results also exceeded the analytical MDC. The annual average gross beta activity was 2.9 ± 0.2 x 10^{-14} µCi/mL (1.1 ± 0.1 x 10^{-3} Bq/m^3). A summary of the results is shown in Table 5.19. The results overall showed similar values to previous years' data.

Gamma Spectroscopy

Gamma spectroscopy analysis was performed on all samples from the low-volume network samples. The air-filter samples were combined by station on a quarterly basis after gross alpha/beta analysis. This results in the analysis of up to 13 air filters simultaneously for gamma activity. All samples were gamma spectrum negligible (i.e., no gamma-emitting radionuclides detected) relative to ^{137}Cs, the main calibration point.

TLD RESULTS

There were 24 offsite environmental stations monitored with TLDs in 2001. The total exposure for 2001 ranged from 71 mR (0.71 mSv) per year at Pahrump, Nevada, to 145 mR (1.45mSv) at Garden Valley, Nevada, with a mean annual exposure of 106 mR (1.06 mSv) per year for all operating locations. All results shown in Table 5.20 are consistent with recent years' results. Overall, the 2001 results remain consistent with background levels observed in the United States.

PRESSURIZED ION CHAMBER (PIC) RESULTS

The PIC data presented in this section are based on daily averages of gamma exposure rates from each station. Table 5.15 contains the maximum, minimum, and standard deviation of daily averages for the periods during 2001 when telemetry data were available. It also shows the average gamma exposure rate for each station during the year, as well as the total mR/yr. The mean ranged from 72 to 168 mR/yr. Background levels of environmental gamma exposure rates in the United States (from the 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 5.21. The annual exposure levels observed at the CEMP stations are well within these United States background levels.

Table 5.1 Descriptive Statistics for Gross Alpha in Air (x 10^{-15} µCi/mL) - 2001

Area	Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	%> MDC
1	BJY	45	7.337	6.452	3.646	-0.132	18.653	95.6
2	2-1 Substation	26	6.859	5.810	3.248	3.257	14.290	92.3
3	Bunker 3-300	26	7.171	6.504	2.980	2.785	16.639	96.2
3	U-3ah/at N	46	6.986	6.456	3.021	2.084	17.081	95.7
3	U-3ah/at S	46	8.171	5.907	9.818	2.572	69.414	96.7
3	U-3bh N	45	6.586	5.979	2.841	2.330	15.011	91.1
3	U-3bh South	46	6.416	5.383	3.084	1.774	14.550	91.3
3	Well ER 3-1	25	6.443	5.825	2.621	2.485	13.273	92.0
4	Bunker T-4	24	6.255	5.808	3.254	0.864	15.612	87.5
5	DOD	45	6.497	5.806	3.076	2.127	14.659	90.0
5	RWMS 4 Northeast	33	6.515	5.968	2.505	3.375	13.567	100.0
5	RWMS 7 West	32	6.376	5.847	2.750	2.419	14.808	96.9
5	WEF Northeast	33	6.149	5.461	2.202	2.043	10.313	97.0
5	WEF Southwest	33	5.847	5.562	2.262	2.576	11.394	93.9
5	Sugar Bunker North	43	7.028	6.400	3.377	2.213	16.931	95.4
6	Yucca	26	7.285	6.158	3.705	2.206	19.210	92.3
7	UE7nS	46	7.004	6.806	3.104	1.291	15.617	94.6
9	Bunker 9-300	44	6.750	6.412	3.328	1.635	14.260	88.6
10	SEDAN North	24	6.685	5.648	3.077	1.483	13.677	91.7
10	Gate 700 South	43	6.043	5.160	3.247	1.382	14.316	90.7
15	EPA Farm	23	5.920	5.532	3.509	0.215	18.184	91.3
16	3545 Substation	41	5.761	5.032	2.847	1.602	15.110	92.7
18	Little Feller 2 N	26	6.700	6.634	3.339	1.510	16.100	92.3
20	CABRIOLET	20	5.628	4.446	3.005	1.801	11.570	85.0
20	SCHOONER	20	5.516	4.757	3.269	1.217	13.873	80.0
23	Mercury Track	20	5.360	4.826	3.876	0.120	15.736	75.0
25	E-MAD N	19	6.148	4.316	3.984	2.529	15.601	84.2
25	Guard Station 510	12	8.119	6.872	3.997	3.443	15.393	100.0
All Onsite Locations		**912**	**6.605**	**5.847**	**3.769**	**-0.132**	**69.414**	**92.4**

Table 5.2 Descriptive Statistics for Gross Beta in Air (x 10^{-14} µCi/mL) - 2001

Area	Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	%> MDC
1	BJY	45	1.927	1.628	0.949	-0.291	4.084	93.3
2	2-1 Substation	26	1.598	1.511	0.719	0.518	4.099	100.0
3	Bunker 3-300	26	1.576	1.382	0.701	0.628	3.983	100.0
3	U-3ah/at N	46	1.901	1.686	0.843	0.765	3.970	100.0
3	U-3ah/at S	46	1.985	1.693	0.954	0.823	5.192	100.0
3	U-3bh N	45	1.856	1.698	0.752	0.850	3.951	100.0
3	U-3bh South	46	1.855	1.668	0.824	0.713	3.971	100.0
3	Well Er 3-1	25	1.583	1.523	0.762	0.415	4.306	96.0
4	Bunker T-4	24	1.444	1.492	0.628	-0.138	2.705	95.8
5	DOD	45	2.014	1.837	0.896	0.644	4.177	100.0
5	RWMS 4 Northeast	33	1.829	1.786	0.815	0.771	4.347	100.0
5	RWMS 7 West	32	1.835	1.695	0.853	0.451	4.334	96.9
5	WEF Northeast	33	1.809	1.610	0.799	0.809	3.882	100.0
5	WEF Southwest	33	1.816	1.608	0.836	0.832	3.985	100.0
5	Sugar Bunker North	43	2.110	1.915	0.989	0.583	4.708	100.0
6	Yucca	26	1.581	1.542	0.751	0.546	3.939	100.0
7	UE7nS	46	1.898	1.776	0.868	0.604	4.245	100.0
9	Bunker 9-300	44	1.938	1.698	0.782	0.997	3.927	100.0
10	SEDAN North	24	1.540	1.360	0.719	0.530	3.835	100.0
10	Gate 700 South	43	1.642	1.414	0.758	0.425	3.991	95.4
15	EPA Farm	23	1.345	1.383	0.640	-0.010	3.479	95.7
16	3545 Substation	41	1.768	1.717	0.750	0.480	4.019	100.0
18	LITTLE FELLER 2 N	26	1.562	1.484	0.702	0.328	3.694	100.0
20	CABRIOLET	20	2.264	2.165	0.764	1.433	3.749	100.0
20	SCHOONER	20	2.153	2.059	0.818	1.141	3.980	100.0
23	Mercury Track	20	2.338	1.974	1.213	0.154	5.411	95.0
25	E-MAD N	19	2.672	2.325	0.832	1.400	4.072	100.0
25	Guard Station 510	12	2.494	2.405	0.813	1.476	3.674	100.0
All Onsite Locations		**912**	**1.856**	**1.692**	**0.853**	**-0.291**	**5.411**	**98.9**

Table 5.3 Descriptive Statistics for ^{238}Pu in Air (x 10^{-18} μCi/mL) - 2001

Area	Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	%> MDC
1	BJY	12	2.76	2.30	4.28	-4.43	11.20	16.7
2	2-1 Substation	6	1.95	2.30	2.40	-1.29	5.54	0.0
3	Bunker 3-300	6	1.36	0.64	3.81	-2.38	8.47	16.7
3	U-3ah/at N	12	1.30	1.44	2.10	-1.42	4.59	8.3
3	U-3ah/at S	12	5.59	2.57	10.35	-0.78	37.04	12.5
3	U-3bh N	12	0.86	1.12	1.83	-2.74	3.41	0.0
3	U-3bh South	12	0.45	1.19	2.84	-4.18	4.70	0.0
3	Well ER 3-1	6	2.28	0.00	4.01	-1.01	8.53	0.0
4	Bunker T-4	6	13.67	7.34	16.35	1.43	46.15	33.3
5	DOD	12	0.71	0.30	1.60	-1.65	4.17	0.0
5	RWMS 4 Northeast	9	2.08	1.31	4.51	-2.99	12.29	11.1
5	RWMS 7 West	9	0.61	0.84	3.05	-3.30	5.25	11.1
5	WEF Northeast	9	1.07	1.60	1.98	-2.63	3.84	0.0
5	WEF Southwest	9	2.04	1.62	2.00	-0.52	6.40	0.0
5	Sugar Bunker North	3	1.83	3.75	3.35	-2.04	3.78	0.0
6	Yucca	12	1.29	0.55	3.18	-3.86	9.15	8.3
7	UE7nS	6	0.24	-0.38	2.51	-2.62	4.78	0.0
9	Bunker 9-300	12	3.02	2.08	3.23	-1.39	8.36	25.0
10	Sedan North	12	5.44	3.93	5.49	0.00	16.79	41.7
10	Gate 700 South	6	3.14	1.94	4.07	0.00	11.29	0.0
15	EPA Farm	6	0.90	0.94	3.80	-2.89	7.59	0.0
16	3545 Substation	6	0.60	0.70	1.01	-0.88	2.12	0.0
18	LITTLE FELLER 2 N	12	1.64	1.06	3.11	-1.39	10.90	8.3
20	CABRIOLET	6	2.37	1.81	3.12	-0.49	8.18	16.7
20	SCHOONER	12	1.27	0.71	1.95	0.00	6.98	0.0
23	Mercury Track	6	0.39	0.33	1.41	-1.38	2.58	0.0
25	E-MAD N	6	0.80	0.70	2.16	-1.75	4.24	8.3
25	Guard Station 510	6	1.16	0.00	2.28	-0.70	5.30	0.0
All Onsite Locations		**243**	**2.15**	**1.28**	**4.87**	**-4.43**	**46.15**	**8.6**

Table 5.4 Descriptive Statistics for $^{239+240}Pu$ in Air (x 10^{-18} μCi/mL) - 2001

Area	Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	%> MDC
1	BJY	12	83.56	18.84	144.56	0.95	454.40	58.3
2	2-1 Substation	6	5.07	6.07	5.25	-1.85	12.49	16.7
3	Bunker 3-300	6	36.15	22.46	36.98	2.87	84.66	50.0
3	U-3ah/at N	12	71.71	84.32	43.40	14.44	134.80	100.0
3	U-3ah/at S	12	302.29	39.01	753.61	5.03	2659.31	91.7
3	U-3bh N	12	44.40	22.02	81.46	1.04	298.36	75.0
3	U-3bh South	12	38.65	23.80	45.18	9.74	172.68	83.3
3	Well ER 3-1	6	5.22	4.96	5.08	0.00	13.36	33.3
4	Bunker T-4	6	49.98	17.83	70.17	6.14	186.91	66.7
5	DOD	12	1.66	1.16	2.21	-0.83	5.87	0.0
5	RWMS 4 Northeast	9	2.96	4.28	4.03	-3.08	9.32	11.1
5	RWMS 7 West	9	7.85	2.19	13.89	-1.21	41.73	22.2
5	WEF Northeast	9	3.12	2.39	2.69	0.00	9.11	33.3
5	WEF Southwest	9	7.41	5.22	12.81	-2.18	39.96	33.3
5	Sugar Bunker North	3	103.39	8.14	173.72	-1.87	303.89	66.7
6	Yucca	12	15.78	8.54	26.28	-1.14	96.44	29.2
7	UE7nS	6	6.29	4.06	6.12	1.30	16.97	16.7
9	Bunker 9-300	12	156.48	108.15	158.73	-2.63	503.94	83.3
10	Sedan North	12	173.45	27.71	350.98	5.49	1176.31	91.7
10	Gate 700 South	6	5.23	6.08	3.28	0.00	8.45	33.3
15	EPA Farm	6	6.05	5.17	4.79	1.44	14.01	0.0
16	3545 Substation	6	2.11	2.90	6.81	-10.57	9.55	0.0
18	LITTLE FELLER 2 N	12	4.31	3.05	5.70	-1.45	17.21	16.7
20	CABRIOLET	6	1.63	1.31	4.33	-3.88	8.48	0.0
20	SCHOONER	12	3.71	3.77	2.29	0.00	6.65	16.7
23	Mercury Track	6	-1.12	-0.61	2.74	-6.19	2.03	0.0
25	E-MAD N	6	2.73	2.95	1.96	0.00	4.67	8.3
25	Guard Station 510	6	1.89	2.99	2.71	-2.74	4.20	0.0
All Onsite Locations		**243**	**49.31**	**6.45**	**200.59**	**-10.57**	**2659.31**	**42**

Table 5.5 Descriptive Statistics for ^{241}Am in Air (x 10^{-18} μCi/mL) - 2001

Area	Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	%> MDC
1	BJY	12	21.71	7.24	28.69	0.00	87.57	66.7
2	2-1 Substation	6	9.51	8.81	6.06	3.21	20.53	33.3
3	Bunker 3-300	6	14.58	10.67	12.81	2.02	38.88	83.3
3	U-3ah/at N	12	16.98	17.37	8.94	2.17	29.55	70.8
3	U-3ah/at S	12	57.00	21.34	114.66	4.61	415.95	91.7
3	U-3bh N	12	12.46	8.56	15.59	0.80	60.22	75.0
3	U-3bh South	12	13.90	9.48	13.66	2.15	53.70	83.3
3	Well ER 3-1	6	9.94	6.82	8.46	4.21	26.72	50.0
4	Bunker T-4	6	18.92	13.87	19.16	3.34	56.23	83.3
5	DOD	12	6.22	4.88	4.89	0.00	17.07	41.7
5	RWMS 4 Northeast	9	6.12	6.61	2.60	2.46	10.04	66.7
5	RWMS 7 West	9	7.81	7.10	4.95	2.86	19.08	44.4
5	WEF Northeast	9	7.39	7.35	2.75	4.06	10.93	66.7
5	WEF Southwest	9	8.63	5.58	7.63	2.41	25.62	55.6
5	Sugar Bunker North	3	51.33	51.27	17.63	33.74	68.99	100.0
6	Yucca	12	17.91	13.35	20.48	1.48	80.59	79.2
7	UE7nS	6	7.38	5.91	3.93	4.43	14.66	66.7
9	Bunker 9-300	12	32.92	26.45	24.53	6.57	75.98	100.0
10	SEDAN North	12	40.81	13.05	59.40	3.44	206.00	75.0
10	Gate 700 South	6	15.20	7.73	20.99	3.68	57.77	100.0
15	EPA Farm	6	9.53	7.82	6.01	2.33	17.01	50.0
16	3545 Substation	6	11.98	5.40	18.36	0.79	49.27	83.3
18	LITTLE FELLER 2 N	12	14.33	4.83	30.18	2.58	109.71	25.0
20	CABRIOLET	6	7.66	8.76	4.72	1.94	13.76	50.0
20	SCHOONER	12	10.34	6.85	9.56	3.12	35.58	66.7
23	Mercury Track	6	9.08	5.26	11.71	1.17	32.57	33.3
25	E-MAD N	6	9.07	7.55	5.62	4.23	18.47	33.3
25	Guard Station 510	6	7.03	4.88	4.86	3.39	16.18	83.3
All Onsite Locations		**243**	**17.03**	**8.27**	**33.56**	**0.00**	**415.95**	**66.7**

Table 5.6 Descriptive Statistics for $^{233+234, 235+236, 238}U$ in Air (x10^{-18} µCi/mL)

Area	Location	Mean	Median	Standard Deviation	Minimum	Maximum	% > MDC
	Uranium-233,234						
6	Yucca	122.4	117.2	44.8	62.6	194.8	91.7
16	3545 Substation	62.5	67.6	20.5	22.5	79.2	66.7
25	Guard Station 510	61.9	59.9	17.5	36.3	89.3	100.0
	Uranium-235,236						
6	Yucca	11.1	6.4	11.8	-0.1	31.6	0.0
16	3545 Substation	11.4	2.6	23.0	-0.8	58.3	0.0
25	Guard Station 510	9.2	5.8	10.3	-0.1	26.8	16.7[a]
	Uranium-238						
6	Yucca	94.2	94.1	43.8	38.6	167.0	91.7
16	3545 Substation	67.9	58.5	23.9	39.9	99.3	83.3
25	Guard Station 510	53.9	50.6	15.2	35.8	77.5	100.0

(a) One out of six analyses was above the MDC; however, this sample was considered a false positive due to an uncertainty of ±90 percent in the measurement.

Table 5.7 Descriptive Statistics for ^{137}Cs in Air (x 10^{-16} µCi/mL) - 2001

Area	Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	%> MDC
1	BJY	12	0.16	1.13	4.18	-11.10	3.49	0.0
2	2-1 Substation	6	4.60	3.64	5.36	-1.50	14.07	0.0
3	Bunker 3-300	6	-1.20	0.03	3.49	-7.42	1.57	0.0
3	U-3ah/at N	12	0.71	0.60	3.60	-4.73	8.21	0.0
3	U-3ah/at S	12	1.08	-0.16	4.27	-2.89	12.76	0.0
3	U-3bh N	12	1.94	-0.11	4.70	-2.25	14.22	8.3
3	U-3bh South	12	0.58	0.52	2.92	-4.12	6.33	0.0
3	Well ER 3-1	6	0.63	0.65	1.72	-1.78	3.01	0.0
4	Bunker T-4	6	3.94	3.81	9.31	-5.37	20.71	16.7
5	DOD	12	0.23	0.28	1.96	-2.96	3.28	0.0
5	RWMS 4 Northeast	9	0.66	-0.03	2.19	-2.25	4.57	0.0
5	RWMS 7 West	9	-0.29	0.33	3.55	-6.17	5.02	0.0
5	WEF Northeast	9	0.86	0.00	3.38	-2.87	7.95	0.0
5	WEF Southwest	9	0.48	0.42	3.21	-4.49	6.94	0.0
5	Sugar Bunker North	3	-1.51	-1.30	0.44	-2.02	-1.23	0.0
6	Yucca	12	0.72	1.18	1.85	-2.44	3.31	0.0
7	UE7nS	6	-0.50	0.35	2.62	-5.36	2.14	0.0
9	Bunker 9-300	12	0.60	0.69	2.07	-1.79	4.45	0.0
10	SEDAN North	12	1.42	1.65	3.03	-1.78	8.00	0.0
10	Gate 700 South	6	-0.65	-0.74	1.10	-1.79	1.31	0.0
15	EPA Farm	6	1.95	1.58	5.34	-6.15	10.07	0.0
16	3545 Substation	6	0.02	0.06	1.86	-1.86	3.23	0.0
18	LITTLE FELLER 2 N	12	-0.17	0.00	2.05	-4.53	2.65	0.0
20	CABRIOLET	6	1.56	1.47	2.30	-1.10	5.29	0.0
20	SCHOONER	12	1.27	1.58	2.51	-2.84	6.89	0.0
23	Mercury Track	6	-0.27	0.19	2.08	-2.73	2.90	0.0
25	E-MAD N	6	1.91	2.10	1.59	-0.79	3.56	8.3
25	Guard Station 510	6	-0.58	-0.74	1.78	-2.27	1.75	0.0
All Onsite Locations		**243**	**0.75**	**0.42**	**3.38**	**-11.10**	**20.71**	**1.0**

Table 5.8 Descriptive Statistics for Airborne Tritium Concentrations - 2001

^{3}H Concentration (x 10^{-6} pCi/mL)								
Area	Location	Number of Sample	Mean	Median	Standard Deviation	Minimum	Maximum	%> MDC
Onsite Locations								
1	BJY	26	1.48	1.35	1.38	-0.33	4.2	59.6
5	DOD	12	0.98	0.64	1.03	0	3.78	16.7
5	RWMS 4 Northeast	25	6.52	3.61	6.97	-0.12	21.86	76
5	RWMS 7 West	17	1.93	0.75	3.05	-0.48	11.81	35.3
5	RWMS 9 South	19	0.66	0.58	0.59	-0.27	1. 91	26.3
5	WEF Northeast	19	0.49	0.44	0.59	-0.45	1.8	5.3
5	Well 5B	11	-0.14	-0.28	0.34	-0.61	0.46	0
5	Sugar Bunker North	6	0.53	0.51	0.21	0.33	0.91	0
6	YUCCA	11	1.64	1.45	1.74	-0.01	6.16	54.6
9	Bunker 9-300	12	6.22	7.52	2.8	0.76	10.08	100
10	SEDAN North	22	13.07	8.33	12.23	1.62	42.29	100
10	Gate 700 South	13	0.89	0.99	0.53	0.06	1.85	46.2
12	E Tunnel Pond No. 2	26	10.71	6.74	9.29	0.41	24.99	84.6
15	EPA Farm	12	2.54	2.63	0.79	1.29	3.77	100
16	3545 Substation	13	0.92	0.39	1.73	-0.38	5.3	15.4
18	Little Feller 2N	12	0.3	0.6	0.53	-0.3	1.31	8.3
20	SCHOONER	24	399.39	330.62	366.53	18.68	1089.95	100
23	Mercury Track	13	0.07	-0.01	0.42	-0.86	0.71	0
25	Guard Station 510	13	0.86	0.27	1.65	-0.05	6.05	19.2
All Onsite Locations		**306**	**34.58**	**1.16**	**146.74**	**-0.86**	**1089.95**	**51.6**

Table 5.9 Descriptive Statistics for TLD Annual Exposures, (mR/yr) - 2001

Area	Location	Sample Type	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum
1	BJY	(a)	3	102	102	1	101	103
1	Bunker 1-300	(a)	4	130	130	2	128	133
1	Sandbag Storage Hut	(a)	4	119	119	3	116	122
1	Stake C-2	(a)	4	123	124	4	119	127
2	Stake L-9	(a)	4	189	188	8	180	200
2	Stake M-140	(a)	4	141	140	4	136	145
2	Stake N-8	(a)	4	716	710	24	694	749
2	Stake Th-58	(a)	4	99	99	2	96	101
3	A3 RWMS Center	(d)	4	172	172	5	166	177
3	LANL Trailers	(a)	4	126	127	4	121	130
3	RWMS East	(d)	4	156	156	1	156	158
3	RWMS North	(d)	4	133	132	2	131	136
3	RWMS South	(d)	4	499	504	13	480	508
3	RWMS West	(d)	4	134	134	1	133	134
3	Stake A-6.5	(a)	4	155	156	3	150	157
3	Stake OB-11.5	(a)	4	135	135	2	134	137
3	Stake OB-20	(a)	4	93	93	2	91	96
3	U-3co North	(a)	4	235	234	3	233	240
3	U-3co South	(a)	4	173	172	2	171	175
3	Well ER 3-1	(a)	4	135	136	5	130	141
4	Stake A-9	(a)	4	843	835	19	830	870
4	Stake TH-41	(a)	4	117	117	3	114	119
4	Stake TH-48	(a)	4	131	128	7	126	142
5	3.3 Mi SE of Aggr. Pit	(b)	4	80	65	30	63	125
5	Bldg 5-31	(a)	4	126	126	3	124	130
5	RWMS East Gate	(d)	4	170	169	3	168	175
5	RWMS Expansion NE*	(d)	1	152	152	.	152	152
5	RWMS Expansion NW*	(d)	1	158	158	.	158	158
5	RWMS NE Corner	(d)	4	126	126	0	126	127
5	RWMS NW Corner	(d)	4	140	140	5	136	145
5	RWMS South Gate	(d)	4	123	123	1	122	123
5	RWMS SW Corner	(d)	4	132	132	1	131	132
5	Water Well 5B	(c)	4	123	122	2	120	126
5	WEF East	(d)	4	132	132	1	131	133
5	WEF North	(d)	4	127	127	2	125	129
5	WEF South	(d)	4	133	133	2	131	135
5	WEF West	(d)	4	143	142	2	141	145
6	CP-6	(c)	4	75	75	2	73	77
6	DAF East	(a)	4	98	99	4	93	102
6	DAF West	(a)	4	89	89	3	87	92
6	Decon Facility NW	(a)	4	125	124	3	122	129

(a) Environmental Locations.
(b) Background Locations.
(c) Historical Locations.
(d) Waste Operations.
* Discontinued TLD measurements at this location after first quarter 2001.

Table 5.9 (Descriptive Statistics for TLD Annual Exposures, [mR/yr] - 2001, cont.)

Area	Location	Sample Type	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum
6	Decon Facility SE	(a)	4	132	132	3	128	134
6	Yucca Oil Storage	(a)	4	104	104	2	102	107
7	Bunker 7-300	(a)	4	286	286	6	280	294
7	Reitmann Seep	(a)	4	132	133	3	127	134
7	Stake H-8	(a)	4	141	141	1	140	142
8	Road 8-02	(a)	4	136	136	3	134	139
8	Stake K-25	(a)	4	109	109	1	109	110
8	Stake M-152	(a)	4	177	177	3	174	181
9	Bunker 9-300	(a)	4	131	132	2	128	133
9	Papoose Lake Road	(c)	4	85	86	2	83	87
9	U-9cw South	(a)	4	110	110	5	105	115
9	V&G Road Junction	(a)	4	120	120	2	119	123
10	Circle & L Roads	(a)	4	125	125	2	123	127
10	Gate 700 South	(c)	4	141	140	3	139	146
10	Sedan East Visitor Box	(a)	4	144	143	4	141	150
10	Sedan West	(a)	4	289	287	5	285	296
11	Stake A-21	(a)	4	137	136	3	134	140
12	Gold Meadows Spring*	(b)	1	125	125	.	125	125
12	T-Tunnel #2 Pond	(a)	4	252	254	11	236	263
12	Upper Haines Lake	(a)	4	118	116	4	116	125
12	Upper N Pond	(a)	4	135	135	4	132	139
15	EPA Farm	(a)	4	119	118	2	118	121
15	U-15e Substation	(b)	4	101	101	1	100	102
18	Stake A-83	(a)	4	152	151	6	147	161
18	Stake F-11	(a)	4	160	158	9	152	172
19	Gate 19-3P*	(b)	1	153	153	.	153	153
19	Stake C-27*	(b)	1	152	152	.	152	152
19	Stake P-41	(a)	4	178	177	4	174	182
19	Stake P-77*	(a)	1	154	154	.	154	154
19	Stake R-26*	(b)	1	164	164	.	164	164
20	Stake A-118	(b)	4	161	160	7	153	170
20	Stake J-31	(a)	4	195	198	8	183	202
20	Stake J-41	(a)	4	145	145	5	141	151
20	Stake LC-4*	(b)	1	161	161	.	161	161
22	Army #1 Water Well	(b)	4	86	86	1	85	88
23	Building 650 Dosimetry	(c)	4	62	62	3	58	65
23	Building 650 Roof*	(c)	1	65	65	.	65	65
23	Mercury Fitness Track	(a)	4	84	84	2	82	87
23	Post Office*	(c)	1	78	78	.	78	78

(a) Environmental Locations.
(b) Background Locations.
(c) Historical Locations.
(d) Waste Operations
* Discontinued TLD measurements at this location after 1st Quarter 2001.

Table 5.9 (Descriptive Statistics for TLD Annual Exposures, [mR/yr] - 2001, cont.)

Area	Location	Sample Type	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum
25	Gate 25-4-P	(b)	4	144	144	1	143	145
25	Guard Station 510	(b)	4	141	139	8	134	151
25	Henre	(c)	4	137	137	4	133	140
25	Jckass Flats & A-27 Rds	(b)	4	87	87	2	84	90
25	NRDS Warehouse	(c)	4	132	132	4	128	136
25	Yucca Mountain	(b)	4	146	146	4	140	150
27	Cafeteria	(c)	4	144	144	2	142	145
30	Jct Cat Cnyon/Buggy Rd*	(b)	1	193	193	.	193	193
	Summary by Sample Type							
Environmental		(a)	188	171	134	137	82	870
Background		(b)	38	124	138	34	63	193
Historical		(c)	34	110	125	32	58	146
Waste Operations		(d)	58	165	134	93	122	508
All Locations			**318**	**158**	**134**	**116**	**58**	**870**

(a) Environmental Locations.
(b) Background Locations.
(c) Historical Locations.
(d) Waste Operations
* Discontinued TLD measurements at this location after 1st Quarter 2001.

Table 5.10 Listing of Atypical TLD Data Values - 2001

Area	Location	Location Mean	Mean for Other Locations in Area
4	Stake A-9 [(a)]	843	124
2	Stake N-8 [(a)]	716	143
3	RWMS South [(d)]	499	138
10	SEDAN West [(a)]	289	137
7	Bunker 7-300 [(a)]	286	137
12	T-Tunnel No. 2 Pond [(a)]	252	126
3	U-3co North [(a)]	235	138

(a) Environmental Locations.
(b) Background Locations.
(c) Historical Locations.
(d) Waste Operations.

Table 5.11 Descriptive Statistics for Detected Radioactivity in E Tunnel Pond Water and Sediment - 2001

Media	Radionuclide	Mean	Median	Standard Deviation	Min.	Max.	%> MDC
Water	^{3}H	818422	823430	13574	803780	824750	100
(x10^{-9} µCi/mL)	^{137}Cs	73.46	74	17.84	66.9	80.6	100
(N = 5)	^{234}U	3.23	3.2	0.54	3.08	3.36	100
	^{235}U	0.07	0.07	0.09	0.03	0.13	100
	^{238}U	1.28	1.26	0.25	1.24	1.33	100
	$^{239+240}Pu$	3	2.98	0.5	2.77	3.3	100
	^{241}Am	0.19	0.2	0.06	0.18	0.2	100
Sediment	^{90}Sr	3.27	0.84	5.03	0.65	8.31	67
(x10^{-9} µCi/g)	^{137}Cs	137.87	72.8	127.59	71.8	269	100
(N = 3)	^{234}U	3.05	2.12	2.2	2.09	4.94	100
	^{235}U	0.12	0.14	0.22	0.01	0.2	33
	^{238}U	1.73	1.66	0.82	1.35	2.18	100
	$^{239+240}Pu$	7.04	3.31	8.06	2.92	14.9	100
	^{241}Am	0.62	0.24	1.04	0.11	1.52	67

Table 5.12 Radionuclide Activities in NTS Biota Samples - 2001

Location	Common Name	Scientific Name[(a)] Genus	Species	$\%H_20$ (%)	Concentration x 10^{-9} µCi/mL Tritium[(b)]	Concentration, pCi/g ^{137}Cs	^{90}Sr[(b)]
PLANT SAMPLES							
Tippipah Springs							
1	Hairy willowherb	*Epilobium*	*ciliatum*	73.4	-73.5 ± 163(c)	-0.0108 ± 0.101(c)	0.00355 ± 0.0427(c)
2	Hairy willowherb	*Epilobium*	*ciliatum*	73.5	-128 ± 164(c)	0.0294 ± 0.0982(c)	0.0365 ± 0.0476(c)
1	Big sagebrush	*Artemisia*	*tridentata*	36.7	-101 ± 165(c)	0.148 ± 0.161(c)	0.0463 ± 0.0455(c)
2	*Big sagebrush*	*Artemisia*	*tridentata*	50.6	109 ± 186(c)	0.0149 ± 0.0547(c)	0.0254 ± 0.0315(c)
1	Fourwing saltbush	*Atriplex*	*canescens*	43.1	22.7 ± 175(c)	0.00137 ± 0.0513(c)	0.00634 ± 0.0267(c)
2	Fourwing saltbush	*Atriplex*	*canescens*	38.3	-70.4 ± 168(c)	0.0107 ± 0.04(c)	0.147 ± 0.0759
1	Rubber rabbitbrush	*Ericameria*	*nauseosa*	54.2	-94.2 ± 178(c)	0.0205 ± 0.0665(c)	0.0223 ± 0.0229(c)
2	Rubber rabbitbrush	*Ericameria*	*nauseosa*	59.4	-1.9 ± 175(c)	0(c)	0.00654 ± 0.0264(c)
1	Baltic rush	*Juncus*	*balticus*	67.5	-97.5 ± 166(c)	0.116 ± 0.164(c)	0.0129 ± 0.0296(c)
2	Baltic rush	*Juncus*	*balticus*	55.9	25.9 ± 171(c)	0(c)	-0.00591 ± 0.0366(c)
1	Stansbury cliffrose	*Purshia*	*stansburiana*	41.1	-24 ± 169(c)	0.0102 ± 0.0569(c)	0.00925 ± 0.0278(c)
2	Stansbury cliffrose	*Purshia*	*stansburiana*	43.8	319 ± 185	-0.0273 ± 0.0386(c)	0.0394 ± 0.0315(c)
ANIMAL SAMPLES							
Tippipah Springs							
1	Mourning dove	*Zenaida*	*macroura*	69.6	-114 ± 169(c)	0.121 ± 0.0817(c)	-0.0179 ± 0.0533(c)
2	Mourning dove	*Zenaida*	*macroura*	69.7	-20.3 ± 169(c)	-0.0392 ± 0.112(c)	0.038 ± 0.0431(c)
1	Gambel's quail	*Callipepla*	*gambelii*	71.5	-28.7 ± 164(c)	-0.0243 ± 0.0708(c)	0.0234 ± 0.0283(c)
2	Gambel's quail	*Callipepla*	*gambelii*	(d)	-29.7 ± 170(c)	-0.0131 ± 0.054(c)	0.0177 ± 0.0251(c)
E Tunnel Ponds							
1	Chukar	*Alectoris*	*chukar*	74.3	213,000 ± 5,620	0.125 ± 0.0602	0.0234 ± 0.0408(c)
2	Chukar	*Alectoris*	*chukar*	76.9	247,000 ± 6,500	0.334 ± 0.0748	0.261 ± 0.078
Roadkill Sample							
Area 5 Mercury Highway	Antelope	*Antilocapra*	*americana*	72.3	-601 ± 240(c)	0.00981 ± 0.0129(c)	0.0634 ± 0.0391(c)

± Error is the 2.0 Sigma Error, % H_20 is the approximate percent water of sample on a dry weight basis, ^{40}K is a naturally occurring radioisotope.

(a) U. S. Department of Agriculture. 1996. The PLANTS database. National Plant Data Center, Baton Rouge, LA 70874-4490 USA.

(b) Activity levels result from subtracting background levels and may occasionally yield negative values.

(c) Value was less than Minimum Detectable Activity.

(d) Missing Data.

Table 5.12 (Radionuclide Activities in NTS Biota Samples - 2001, cont.)

Location	Common Name	Scientific Name[a] Genus	Species	%H_20 (%)	Concentration, pCi/g $^{238}Pu^{(b)}$	$^{239+240}Pu^{(b)}$	$^{241}Am^{(b)}$	^{235}U	^{238}U
PLANT SAMPLES									
Tippipah Springs									
1	Hairy willowherb	*Epilobium*	*ciliatum*	73.4	0.00394 ± 0.00472(c)	0(c)	-0.339 ± 0.325(c)	0(c)	0(c)
2	Hairy willowherb	*Epilobium*	*ciliatum*	73.5	-0.00127 ± 0.00248(c)	-0.00127 ± 0.00557(c)	0.0815 ± 0.491(c)	0.396 ± 0.0575(c)	0(c)
1	Big sagebrush	*Artemisia*	*tridentata*	36.7	0(c)	0.00273 ± 0.00536(c)	0.0243 ± 0.172(c)	0(c)	0(c)
2	Big sagebrush	*Artemisia*	*tridentata*	50.6	0.00168 ± 0.00232(c)	-0.00168 ± 0.00402(c)	-0.127 ± 0.21(c)	0.0564 ± 0.527(c)	0(c)
1	Fourwing saltbush	*Atriplex*	*canescens*	43.1	0(c)	0.00084 ± 0.00366(c)	0.0516 ± 0.0443(c)	-0.0283 ± 0.243(c)	0(c)
2	Fourwing saltbush	*Atriplex*	*canescens*	38.3	0.00184 ± 0.0108(c)	0.00551 ± 0.00807(c)	-0.0599 ± 0.141(c)	0.225 ± 0.202(c)	0(c)
1	Rubber rabbitbrush	*Ericameria*	*nauseosa*	54.2	0.00081 ± 0.00158(c)	0(c)	-0.0514 ± 0.196(c)	0.267 ± 0.359(c)	0(c)
2	Rubber rabbitbrush	*Ericameria*	*nauseosa*	59.4	0.0018 ± 0.00497(c)	0(c)	0.171 ± 0.341(c)	0.248 ± 0.295(c)	0(c)
1	Baltic rush	*Juncus*	*balticus*	67.5	0.00362 ± 0.0114(c)	0(c)	-0.497 ± 0.606(c)	0 (c)	0(c)
2	Baltic rush	*Juncus*	*balticus*	55.9	0.00272 ± 0.00841(c)	-0.00271 ± 0.00842(c)	0.274 ± 0.289(c)	0 (c)	0(c)
1	Stansbury cliffrose	*Purshia*	*stansburiana*	41.1	0.0025 ± 0.00712(c)	0(c)	-1.32 ± 0.179(c)	0.081 ± 0.378(c)	0(c)
2	Stansbury cliffrose	*Purshia*	*stansburiana*	43.8	-0.0048 ± 0.00727(c)	0.00192 ± 0.00376(c)	-0.0721 ± 0.138(c)	0.174 ± 0.229(c)	0(c)
ANIMAL SAMPLES									
Tippipah Springs									
1	Mourning dove	*Zenaida*	*macroura*	69.6	-0.00241 ± 0.00414(c)	0(c)	-0.0426 ± 0.313(c)	0.129 ± 0.651(c)	0(c)
2	Mourning dove	*Zenaida*	*macroura*	69.7	0.0587 ± 0.016	0.00487 ± 0.00576(c)	0.245 ± 0.36(c)	0.293 ± 0.523(c)	3.23 ± 5.73(c)
1	Gambel's quail	*Callipepla*	*gambelii*	71.5	0(c)	0(c)	0.0811 ± 0.212(c)	0.451 ± 0.325(c)	0(c)
2	Gambel's quail	*Callipepla*	*gambelii*	(d)	0.00176 ± 0.00343(c)	0.00963 ± 0.00794(c)	0.0435 ± 0.181(c)	0.141 ± 0.44(c)	0.443 ± 2.53(c)
E Tunnel Ponds									
1	Chukar	*Alectoris*	*chukar*	74.3	-0.000733 ± 0.00428(c)	0.00146 ± 0.00454(c)	-0.0199 ± 0.119(c)	0.0256 ± 0.2(c)	0.301 ± 2.24(c)
2	Chukar	*Alectoris*	*chukar*	76.9	0.00293 ± 0.00329	-0.00194 ± 0.00381(c)	0.206 ± 0.198(c)	0.262 ± 0.363(c)	4.25 ± 3.19
Roadkill Sample									
Area 5 Mercury Highway	Antelope	*Antilocapra*	*americana*	72.3	0.00156 ± 0.00305(c)	0(c)	-0.0507 ± 0.0431(c)	0.0216 ± 0.114(c)	0(c)

± Error is the 2.0 Sigma Error, % H_20 is the approximate percent water of sample on a dry weight basis, ^{40}K is a naturally occurring radioisotope.

(a) U. S. Department of Agriculture. 1996. The PLANTS database. National Plant Data Center, Baton Rouge, LA 70874-4490 USA.

(b) Activity levels result from subtracting background levels and may occasionally yield negative values.

(c) Value was less than Minimum Detectable Activity.

(d) Missing Data.

Table 5.13 Summary of Annual Radionuclide Emissions by Source [(a)] (Multiply Ci by 37 to obtain Gbq) - 2001

Location	Source Type	Radionuclide	Half-Life (years)	Quantity (Ci)
Area 6, CP-50 Laboratory	Point	^{3}H	12.35	5.6
Area 52, Building A-1, North Las Vegas	Point	^{3}H	12.35	0.2
Onsite	Area	^{3}H [(b)]	12.35	558
Total ^{3}H				**564**
Onsite	Area	$^{239+240}Pu$ [(c)]	24065	2.9×10^{-1}
Near Offsite, NAFR	Area	$^{239+240}Pu$ [(c)]	24065	3.2×10^{-2}
Total $^{239+240}Pu$				**3.2×10^{-1}**
Onsite	Area	^{241}Am [(c)]	432.2	4.7×10^{-2}
Near Offsite, NAFR	Area	^{241}Am [(c)]	432.2	2.0×10^{-3}
Total ^{241}Am				**4.9×10^{-2}**

(a) All locations on or near the NTS except Building A-1, which is in North Las Vegas.
(b) Emissions based on environmental air sampling data at (RWMS-5, SCHOONER and SEDAN), tritiated water discharged from the E Tunnel and tritiated water pumped from Wells U-3cn PS #2 and ER-20-5 #3.
(c) Emission based upon resuspension model (DOE 1992).

Table 5.14 Hypothetical Dose for a Human Consuming Chukar from the E Tunnel Ponds and Estimates for Dose to Chukar at E Tunnel Ponds - 2001

Media	Radionuclide	Average Concentration (pCi/g - wet)	CEDE Factors (mrem per pCi consumed)[(a)]	Dose (mrem)
Chukar Breast Tissue	^{3}H	230[(b)]	6.3×10^{-8}	0.018
	^{137}Cs	0.23	5.0×10^{-5}	0.019
	^{90}Sr	0.14	1.3×10^{-4}	0.029
Total Dose to Human Consuming 12 Chukar				**0.07**
Media	**Radionuclide**	**Average Concentration (pCi/g)**	**Dose Factors/Coefficients[(c)] (rad/d per pCi/g)**	**Dose (rad/day)**
Chukar Breast Tissue[(d)]	^{3}H	175	1.07×10^{-5}	0.0019
	^{137}Cs	0.23	1.59×10^{-3}	0.0004
	^{90}Sr	0.14	2.15×10^{-3}	0.0003
Total Internal Dose to Chukar				**0.003**
Pond Water	^{3}H	819.6	1.5×10^{-7}	1.2×10^{-4}
	^{137}Cs	7.2×10^{-2}	2.0×10^{-5}	1.4×10^{-6}
	$^{239/240}Pu$	3.0×10^{-3}	2.5×10^{-7}	7.6×10^{-10}
	^{241}Am	2.0×10^{-4}	1.5×10^{-6}	3.0×10^{-10}
Sediment	^{90}Sr	4.74	2.9×10^{-5}	1.4×10^{-4}
	^{137}Cs	170.65	2.0×10^{-5}	3.4×10^{-3}
	$^{239/240}Pu$	8.43	2.5×10^{-7}	2.1×10^{-6}
	^{241}Am	0.86	1.5×10^{-6}	1.3×10^{-6}
Total External Dose to Chukar				**0.004**
Total Dose to Chukar				**0.007**

(a) Dose Factors for human ingestion from DOE/EH-0071. It was assumed that a person ate 134 grams of muscle tissue from each of 12 chukars.
(b) Concentration of tritium in water (pCi/mL) extracted from chukar tissue by vacuum distillation. Average muscle tissue water content, by weight, was 76 percent.
(c) Dose factors or coefficients for dose to chukar recommended by DOE's Biota Dose Assessment Committee.
(d) Concentration in sampled breast meat (wet) assumed the same as whole chukar.

Table 5.15 Summary of Gamma Exposure Rates (µR/hr) as Measured by PIC - 2001

Sampling Location	Maximum	Minimum	Standard Deviation	Average	mR/Year
Alamo	18	12.6	1.02	14.6	128
Amargosa Center	15.9	11.7	0.23	12.4	108
Beatty	22.3	16	0.44	17.6	154
Boulder City	18.9	12.4	0.29	13.9	122
Caliente	21.2	11.2	0.43	16.7	146
Cedar City	15.9	8.6	0.51	10.1	88
Delta	16	10	0.35	11.8	104
Garden Valley	20.6	13.2	0.54	15.9	139
Henderson	19.7	8.6	0.38	15	131
Goldfield	19.6	12.1	0.62	14.9	130
Indian Springs	30.6	8.9	0.93	10.7	93
Las Vegas	14	10.6	0.22	11.2	98
Medlins Ranch	23.3	14.3	0.32	15.5	136
Milford	22.4	14.8	0.61	17.3	151
Nyala	16.3	11.5	0.52	12.9	113
Overton	16.9	7.6	0.38	10.6	93
Pahrump	11.9	6.8	0.26	8.2	72
Pioche	17.2	8.5	0.4	15.1	133
Rachel	19.4	9.2	0.42	15.1	133
St. George	12.6	7.2	0.59	8.5	75
Sarcobatus Flats	20.9	14.8	0.77	17.1	150
Stone Cabin	26.1	14.9	0.76	17	150
Tonopah	24.9	14.4	0.55	16.9	148
Twin Springs	43.3	17.4	0.78	19.2	168

Table 5.16 Air Filter Analyses and Techniques

Analyte	**Collection Time**	**Minimum Holding Time**	**Method**
Gross Alpha	168 hours	168 hours	DOE RP-710 mod
Gross Beta	168 hours	168 hours	DOE RP-710 mod
Gamma Spectroscopy	Quarterly Composite	None	EPA 901.1 mod

Table 5.17 Results of Field and Laboratory Quality Assurance Samples - 2001

Analyte	**Number of Field Duplicates**	**Average %RSD**	**Number of Laboratory Duplicates**	**Average %RSD**
Gross Alpha	102	13.5	119	10.7
Gross Beta	102	4.5	119	2..8
Gamma ^{7}Be	8	10.3	8	9.2
Gamma ^{210}Pb	8	4.2	8	0

Table 5.18 Gross Alpha Results for the Offsite Air Surveillance Network - 2001

Concentration (10^{-15} μCi/mL [37 μBq/m^3])					
Sampling Location	**Number**	**Maximum**	**Minimum**	**Mean**	**Standard Deviation**
Alamo	52	7.4	1.4	3.7	1.6
Amargosa Center	52	7.9	1	3.5	1.9
Beatty	52	8.2	0.8	3.2	1.6
Boulder City	52	8.2	0.7	3.3	1.6
Caliente	52	5.8	1	2.7	0.9
Cedar City	52	7.6	1.1	4.1	1.8
Delta	50	5.1	1	2.2	0.8
Garden Valley	17	3.2	1	2	0.7
Goldfield	52	5.1	0.9	2.4	0.9
Henderson	52	6.8	0.4	2.8	1.4
Indian Springs	51	4.7	0.5	2.2	0.9
Las Vegas	52	8.4	1.4	3.5	0.9
Milford	52	5.8	1	2.6	0.9
Nyala	17	3.1	0.8	1.7	0.6
Overton	50	6.6	1	3	1.3
Pahrump	52	5.3	0.8	2.6	1.2
Pioche	52	4.3	1	2.2	0.8
Rachel	33	8.7	0.5	2.8	1.8
St. George	52	4.6	0.8	2.4	0.9
Stone Cabin	18	5.8	1.8	3.5	1.1
Tonopah	50	5.5	0.8	2.5	1.1
Twin Springs	17	3.6	1.1	2	0.7
Mean MDC = 6.8 x 10^{-16} μCi/mL			**Standard Deviation of Mean MDC = 1.5 x 10^{-16} μCi/mL**		

Table 5.19 Gross Beta Results for the Offsite Air Surveillance Network - 2001

Concentration (10^{-14} µCi/mL [0.37 mBq/m^3])					
Sampling Location	**Number**	**Maximum**	**Minimum**	**Mean**	**Standard Deviation**
Alamo	52	7.6	1.4	2.9	1
Amargosa Center	52	5.3	1.1	2.8	0.8
Beatty	52	4.9	1	2.7	0.7
Boulder City	52	5	1	2.8	0.8
Caliente	52	5.1	1.3	3	0.9
Cedar City	52	4.7	1.5	2.8	0.7
Delta	50	6	1.1	2.8	0.9
Garden Valley	17	4.2	1.6	3.2	0.7
Goldfield	52	5.5	1.2	2.7	0.8
Henderson	52	4.8	1.1	2.7	0.8
Indian Springs	51	4.4	1	2.6	0.8
Las Vegas	52	5.1	1.3	2.8	0.8
Milford	52	7.5	1.4	3.1	1.1
Nyala	17	3.9	1.9	2.7	0.6
Overton	50	4.8	1.3	2.9	0.8
Pahrump	52	5.2	1.1	2.6	0.8
Pioche	52	4.4	1	2.6	0.7
Rachel	33	4.8	0.6	2.9	0.9
St. George	51	5	1.4	2.9	0.9
Stone Cabin	18	5.2	1.7	3	0.9
Tonopah	50	4.9	1.2	2.7	0.8
Twin Springs	16	5.4	2.3	3.5	0.8
Mean MDC = 1.24 x 10^{-15} µCi/mL			**Standard Deviation of Mean MDC = 0.11 x 10^{-15} µCi/mL**		

Table 5.20 TLD Monitoring Results for Offsite Stations - 2001

Sampling Location	Days	Daily Exposure (mR) Minimum	Maximum	Mean	Total (mR) Exposure
Alamo	365	0.26	0.3	0.28	103
Amargosa Center	366	0.24	0.29	0.26	94
Beatty	365	0.33	0.43	0.38	138
Boulder City	366	0.24	0.28	0.26	94
Caliente	280	0.29	0.33	0.32	115
Cedar City	366	0.19	0.25	0.23	84
Delta	365	0.21	0.29	0.26	93
Goldfield	365	0.29	0.33	0.31	113
Garden Valley	98	N/A	N/A	0.4	145
Henderson	366	0.27	0.3	0.29	107
Indian Springs	366	0.21	0.26	0.24	86
Las Vegas	366	0.18	0.23	0.21	77
Medlins Ranch	369	0.32	0.36	0.34	125
Milford	365	0.33	0.36	0.35	126
Nyala	100	N/A	N/A	0.25	91
Overton	366	0.19	0.24	0.22	81
Pahrump	366	0.16	0.23	0.2	71
Pioche	365	0.2	0.29	0.26	94
Rachel	365	0.3	0.36	0.33	120
Sarcobatus Flats	370	0.35	0.37	0.36	133
St. George	365	0.17	0.22	0.21	76
Stone Cabin	99	N/A	N/A	0.32	118
Tonopah	365	0.34	0.37	0.35	128
Twin Springs	98	N/A	N/A	0.37	134

Table 5.21 Average Natural Background Radiation for Selected U.S. Cities (Excluding Radon)

City	Radiation (mrem/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

Note: From http://www.wrcc.dri.edu/cemp/Radiation.html (“Radiation in Perspective,” August 1990).

Frenchman Flat in the Spring (No Date Provided)

6.0 NONRADIOLOGICAL ENVIRONMENTAL PROGRAMS

The 2001 nonradiological monitoring program for the Nevada Test Site (NTS) included onsite sampling of various environmental media and substances for compliance with federal and state regulations or permits and for ecological studies. The Ecological Monitoring and Compliance (EMAC) program performed biological surveys at proposed construction sites, ecosystem mapping/data management, monitoring of sensitive species and unique habitats, and reviews of Hazardous Materials Spill center (HSC) test plans. In 2001, nonradiological monitoring was performed for six series of test involving 24 chemicals that were at the HSC.

6.1 WATER SURVEILLANCE

SAFE DRINKING WATER ACT (SDWA)

Four public water system permits were maintained on the NTS (see Table 3.4) until October 1, 2001. At that time, the permit for the Area 1 public water system was dropped because of the lack of active service connections. The two community water systems were converted to non-community water systems at that time to reflect changes in the use of facilities at the NTS. The NTS also operates two permitted water hauling trucks. All other water systems on the NTS are considered private water systems and are operated outside of the scope of state and federal regulations.

In 2001, water sampling was conducted for analysis of coliform bacteria, volatile organic compounds, inorganic chemicals, lead, copper, nitrates, and fluoride as required by the SDWA, state of Nevada regulations, and the NTS Contaminant Monitoring Waivers. Samples were collected from supply wells for nitrates, fluoride, volatile organic compounds, and inorganic chemicals. Samples were also collected from taps within the drinking water distribution systems for coliform bacteria, lead, and copper. All samples were collected in accordance with accepted practices, and the analyses were performed by state-approved laboratories. Approved analytical methods listed in Nevada Administrative Code (NAC) 445A (NAC 1996) and Title 40 Code of Federal Regulations (CFR) 141 were used.

Bacteriological Sampling

All water distribution systems were tested either monthly or quarterly for coliform bacteria, with the number of people being served determining the number of samples collected and the frequency (see Table 6.1). If coliform bacteria are present, confirmation samples are collected, and the source of contamination is determined by the water system operator. The NV000360 systems tested positive for coliform bacteria in June and July 2001, and positive for *E. coli* in July 2001. All confirmation and repeat samples were negative. Investigation revealed sample handling at the subcontracted laboratory to be the source of contamination. The laboratory invalidated the samples, and the distribution systems did not exceed the Maximum contaminant Level (MCL).

Samples from permitted water hauling trucks were analyzed monthly for coliform bacteria. The sample from one truck tested positive for coliform bacteria in April, May, June, and July, while the other truck tested positive in July. After each incident, the trucks were disinfected and flushed. Repeat samples were all negative. It was determined that improper sample handling after collection caused the positive results. The July samples were invalidated by the subcontracted laboratory as explained above.

Organic Compound Analysis

In accordance with the monitoring waivers issued in 1996, the National Nuclear Security Administration, Nevada Operations Office (NNSA/NV) collected Volatile Organic Compound (VOC) samples in 2001. No VOCs were detected in NTS water supply wells.

Metal Analysis

Samples were collected from taps in the Area 12 public water system (NY-4099-12C) in the third quarter and analyzed for lead and copper. All results were below the action level of 1.3 mg/L for copper. Lead results, however, exceeded the 0.015 mg/L action level. The samples were collected from the Miners' Change House (Building 12-43), the Teamster Building (Building 12-12), and from a hose connection outside Building 12-43. Lead solder is the cause of the high concentration of lead. The NNSA/NV is in the process of determining a remedy for this situation, but in the interim, the water is only being used for non-consumption purposes. Water for drinking is supplied from a lead-free source.

Reduced monitoring for lead and copper is in effect in the other two water systems (NY-0360-12C and NY-4098-12NTNC).

Other Inorganic Chemical Analysis

To comply with a 1991 variance to the Area 25 water system permit, fluoride samples are collected annually from the two wells in Area 25 (NY-4098-12NTNC) before July 31 to confirm that the fluoride concentration is less than four parts per million. Samples taken from Area 25 Wells J-12 and J-13 in the first quarter of 2001 confirmed that the fluoride concentrations were acceptable.

During the first quarter of 2001, samples were collected from each supply well and analyzed for nitrates and Phase V Inorganic Chemicals. All results were within acceptable limits.

The results of inorganic analyses are shown in Tables 6.2 and 6.3 respectively.

Inspections

The Nevada Bureau of Health Protection Services performed a formal inspection of the permitted water hauling trucks and reported no findings or discrepancies.

6.2 AIR SURVEILLANCE

Air quality monitoring for the criteria pollutants is not required for the NTS. With the exception of the air permit for the HSC, the permits issued by the state of Nevada require opacity and material throughput measurements. The HSC received a waiver by the state from adhering to opacity limits, due to the nature of its operations. Nonradiological monitoring is required by the HSC's air permit, and was conducted for six series of tests conducted at the HSC in 2001.

MONITORING OF NTS OPERATIONS

Routine nonradiological environmental monitoring on the NTS in 2001 was limited to the HSC air permit requirements and asbestos sampling in conjunction with asbestos removal and renovation projects, in accordance with occupational safety and National Emission Standards for Hazardous Air Pollutants compliance.

The HSC was established in Frenchman Flat in Area 5 as a basic research tool for studying the dynamics of accidental releases of various hazardous materials and the effectiveness of mitigation procedures. In addition to the state of Nevada air permit monitoring requirements, offsite monitoring of HSC tests may be required by the U.S. Environmental Protection Agency (EPA). Prior to each HSC test series, and, at other tests in the series depending on projected need, the documentation describing the tests are reviewed by the EPA to determine whether appropriate air sampling equipment should be deployed downwind of the test at the NTS boundary to measure chemical concentrations that may have reached the offsite area. During 2001, no monitoring was required.

6.3 ECOLOGICAL MONITORING

The EMAC program is designed to ensure compliance with applicable laws and regulations, delineate and define NTS ecosystems, and provide ecological information that can be used to predict and evaluate the potential impacts of proposed projects and programs on those ecosystems. EMAC tasks conducted in 2001 included biological surveys for sensitive species at proposed project locations, ecosystem mapping/data management, sensitive species and habitat monitoring, and reviews of HSC test plans.

BIOLOGICAL SURVEYS

Biological surveys are performed at proposed project sites where land disturbance will occur. The goal is to minimize adverse effects of land disturbance on sensitive plant and animal species, their associated habitat, and important biological resources. Sensitive species include those protected under state or federal regulations which are known or suspected to occur on the NTS (Table 6.4). Important biological resources include such things as cover sites, nest or burrow sites, roost sites, or water sources important to sensitive species. Survey reports are written to document species and resources found and to provide mitigation recommendations.

Biological surveys for 26 projects were conducted in 2001 on or near the NTS (Figure 6.1, Table 6.5). For some of the projects, multiple sites were surveyed. A total of 901.4 acres was surveyed for the projects (Table 6.5).

Fifteen of the projects had sites within the range of the threatened desert tortoise (*Gopherus agassizii*) (Figure 6.1). Sensitive species (or their sign) and important biological resources found within proposed project boundaries included nesting barn owls, sensitive plant populations, potential tortoise burrows, kit fox dens, predator burrows, Joshua trees, and cacti (Table 6.5). A pair of breeding barn owls was found in each of two buildings scheduled for demolition (Projects 01-06 and 01-18). A known population of Clokey's eggvetch (*Astragalus oophorus* var. *clokeyanus*) in Area 12 occurs within a proposed disturbance area for the U12v

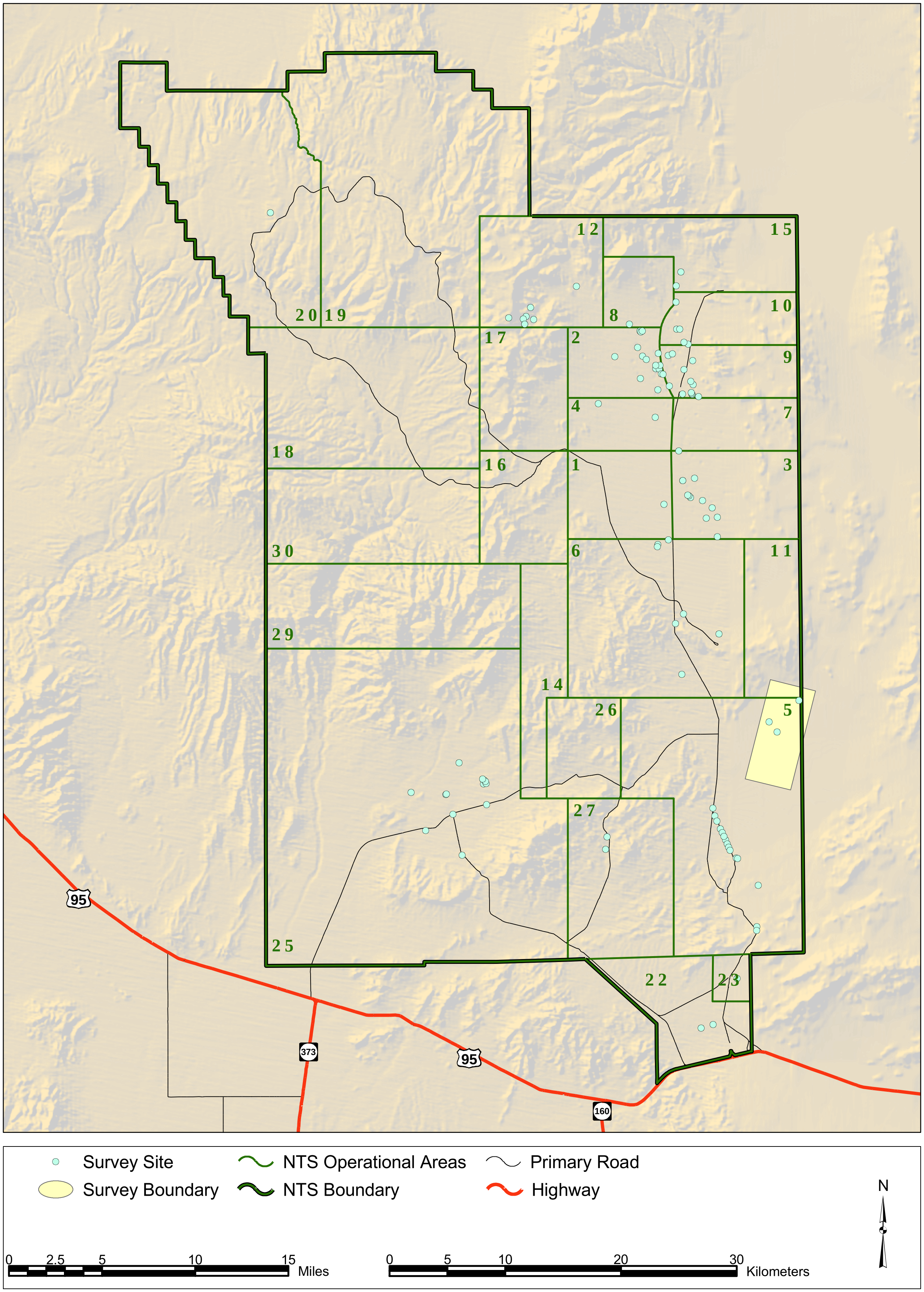


Figure 6.1 Biological Surveys Conducted on the NTS - 2001

Tunnel Seismic Lines project (Project 01-23). A new population of Pahute Mesa beard tongue (*Penstemon pahutensis*) was found in Area 12 on Rainier Mesa during surveys for the same project. The most extensive surveys conducted were transect surveys along approximately 160 miles of staked lines over an 8,700-acre area in Frenchman Flat where geo-seismic studies were conducted (Project 01-21). Off-road driving will occur along these lines by trucks creating seismic vibrations and by equipment trucks needed to place and retrieve geophones. Active predator and kit fox burrows were the only significant resources found during these extensive transect surveys.

HABITAT MAPPING

In fiscal year (FY) 1996, efforts began to map wildlife and plant habitats of the NTS. Field data were collected, analyzed, and preliminary maps created to show basic habitat features. Databases were developed and linked to geographic information system (GIS) maps to facilitate creation of habitat-physical feature maps. Emphasis during 2001 was on publication of the report describing the classification of vegetation on the NTS and on the compilation of historical species-specific wildlife collection and sighting data from the NTS.

The topical report “Classification of Vegetation on the Nevada Test Site” (Ostler et al., 2001) was published and distributed in 2001. Ten vegetation alliances and twenty associations were recognized as occurring on the NTS. Two major vegetation groups or ecoregions, Mojave Desert and Great Basin Desert, are identified along with the broad Transition Zone between these two ecoregions. Analysis of species diversity (richness or the number of species) of perennial trees and shrubs is presented. Species richness of woody species was greatest in the Great Basin Desert compared to associations in the Transition Zone and the Mojave Desert. Similar species diversity patterns were also observed for all combined perennial species on the NTS. Several appendices are presented that provide details of vegetation on the NTS, including lists of all species that have been recorded on the NTS and the vegetation alliances where they are commonly found, relative abundance and frequency values for species in vegetation alliances and associations, and species names and codes.

This year, work started on entering location coordinates into the Ecological GIS (EGIS) fauna database for historical animal sighting and specimen collection sites on the NTS. The data will be used to link animal distribution data to the vegetation classification data gathered from Ecological Landform Units (ELUs). A review of all published vertebrate and invertebrate inventories and research performed on the NTS was conducted to identify geographical information. Other sources searched included field notes from past and present researchers on the NTS and collection records for vertebrate specimens maintained at the Brigham Young University museum in Provo, Utah. Wildlife observations made by Bechtel Nevada (BN) biologists or reported to Ecological Services by NTS workers are also maintained in the EGIS animal database, and new wildlife observations were entered into the EGIS database as well. To date, thousands of data entries have been made. This work will continue next FY and faunal distribution maps will begin to be produced.

In support of the habitat mapping and general ecological monitoring tasks of EMAC, all ecology-related reports and publications from current and historical work conducted on the NTS were compiled and published in CY 2001 as “Ecology of the Nevada Test: An Annotated Bibliography With Narrative Summary, Keyword Index, and Species List,” (Wills and Ostler 2001). This keystone document is an update of “The Ecology of the Nevada Test Site: A Narrative Summary and Annotated Bibliography,” published over 25 years ago (O’Farrell and Emery 1976). The original 1976 document summarized all readily-available publications and reports through 1975 and provided a necessary focal point for the collection and integration of NTS ecological information. Over the past 25 years, the need arose to update this original annotated bibliography.

SENSITIVE SPECIES MONITORING

There are 26 species which occur on the NTS that are considered sensitive because they are either (1) candidates for listing under the Endangered Species Act (ESA), (2) considered species of concern by the U.S. Fish and Wildlife Service (USFWS), (3) protected by other federal acts, or (4) state-managed species of public interest. The goal of sensitive species monitoring is to ensure their continued presence on the NTS by protecting them from significant impacts due to actions of the NNSA/NV. A secondary goal is to gather sufficient information on these species' distribution and abundance on the NTS to determine if further protection under state or federal law is necessary.

SENSITIVE PLANTS

Thirteen sensitive plant species are known to occur on or near the NTS (Table 6.4). The NNSA/NV has funded efforts to collect data on the status of these plants and produced documents reporting their occurrence, distribution, and susceptibility to threats on the NTS (Anderson et al., 1998; Blomquist et al., 1995;). In 1998, NNSA/NV prepared a Resource Management Plan (RMP) which commits to protect and conserve these sensitive plant species and to minimize cumulative impacts to them (DOE 1998d). In 2001, BN published and distributed the "Adaptive Management Plan for Sensitive Plant Species on the Nevada Test Site" (BN 2001b). This document presents the procedures of a long-term adaptive management plan which will ensure that the RMP goals are met. It identifies the parameters that are measured for all sensitive plant populations during long-term monitoring and the adaptive management actions which may be taken if significant threats to these populations are detected.

The management plan was implemented in 2001. A known population of the sensitive plant *Astragalus oophorus* var. *clokeyanus* was visited on June 6, 2001. Ten plants were found, most of which were, in a vegetative state although some had older fruits still attached. The health of the plants looked good but a dirt road went through the population and appeared to be getting increased use. This same population was found within the proposed project area for the U12v Tunnel Seismic Lines project (Project 01-23) on June 26. Recommendations were made to reroute a portion of the seismic line to avoid the population.

The type population *Astragalus beatleyae*, on Pahute Mesa, was observed this year in June. Plants had already completed flowering and many had set seed, although on closer analysis most of the seed had been eaten by insects. Plants looked healthy, and there was no evidence of any human disturbance or loss of the habitat.

An area along Orange Blossom road, that had a population of *Camissonia megalantha* in previous years, was visited in July of 2001. No plants of this species were observed. This is most likely a result of the low rainfall that occurred in 2001 and not because of any NNSA/NV activities. The road had very little use for the past several years and there was no evidence of new disturbances. It is common for annuals not to germinate in poor rainfall years such as 2001. No other populations of sensitive plants were monitored in 2001.

WESTERN BURROWING OWL

The western burrowing owl (*Speotyto cunicularia*) is a species of concern which breeds on the NTS. This owl occurs in all three eco-regions of the NTS: the Great Basin Desert, Transition Zone, and the Mojave Desert. It occupies the burrows of predators (e.g., coyote, kit fox, badger) and desert tortoises, as well as man-made structures such as buried pipes. Collection of baseline data continued in calendar year 2001. Owl monitoring included visiting known burrows monthly to detect owl activity, using still cameras at burrows to detect reproductive activity, disturbance monitoring, and pellet analysis to determine the prey base.

Eight new burrow sites were found in 2001. Figure 6.2 shows the distribution of 77 known owl burrow sites. Fifty burrows are in disturbed habitat and 27 are in undisturbed habitat. It should be noted that there may be one or more burrows or burrow entrances at any given burrow site. Sixty-nine burrows were monitored at least once a month in 2001. As in previous years, some owls were present year round on the NTS. An increase in active owl burrows was observed from mid March to early April. The number of active and inactive burrows is highest within the Transition ecoregions of the NTS. The number of active burrows was highest in this region from late February through late July. The number of active burrows dropped by half the amount during late July to August. Changes in burrow use within this ecoregions this year suggest that immigration occurred in late February to mid March and emigration occurred during late July to August.

A total of 55 juvenile owls were detected from 11 breeding pairs (Table 6.6). The number of young detected on the NTS in 2001 (55) was 28 percent higher than the number detected in 2000 (43). An average of 5.0 young per breeding pair was observed in 2001, compared to 3.4 and 5.6 young per pair observed during 1999 and 2000, respectively.

To develop reasonable mitigation recommendations for land-disturbing projects in burrowing owl habitat, it is important to know the level of disturbance owls tolerate without causing nest abandonment. Two methods were used this year to continue to determine this disturbance tolerance. One method involved setting traffic counters near active burrow nest sites and recording the number of vehicle passes and the distance from the nest burrow to the road. The second was measuring the distance at which owls flushed from observers as they approached the owl by foot and in a vehicle.

Data collected show that owls can breed successfully with several vehicles per day passing within 10 to 269 m of a nest burrow. No correlation is evident between the number of vehicles per day or distance to road and the number of young detected. The average flushing distance, while an observer was approaching a burrow on foot, was 20 m (range 4 m to 70 m; [n=49]). The average flushing distance, while an observer was approaching or stopped near a burrow in a vehicle, was 24 m (range 5 m to 80 m; [n=41]). These data suggest that burrowing owls are fairly tolerant of human presence.

Analysis of burrowing owl pellets was completed in 2001. Approximately 314 samples representing 1,800 pellets were analyzed by Oregon State University. Invertebrates (predominately Orthopterans, Coleopterans, Solifugids, and scorpions) were the dominant prey found within pellets sampled across all ecoregions of the NTS. Kangaroo rats (*Dipodomys*) were the dominant rodent eaten.

Differences among ecoregions are also evident. Percent frequency of scorpions, Hemipterans, other rodents, *Peromyscus*, and *Reithrodontomys* tends to be highest in the Great Basin Desert ecoregions; whereas percent frequency of Perognathinae and *Dipodomys* was highest in the Mojave Desert and transition ecoregions, respectively.

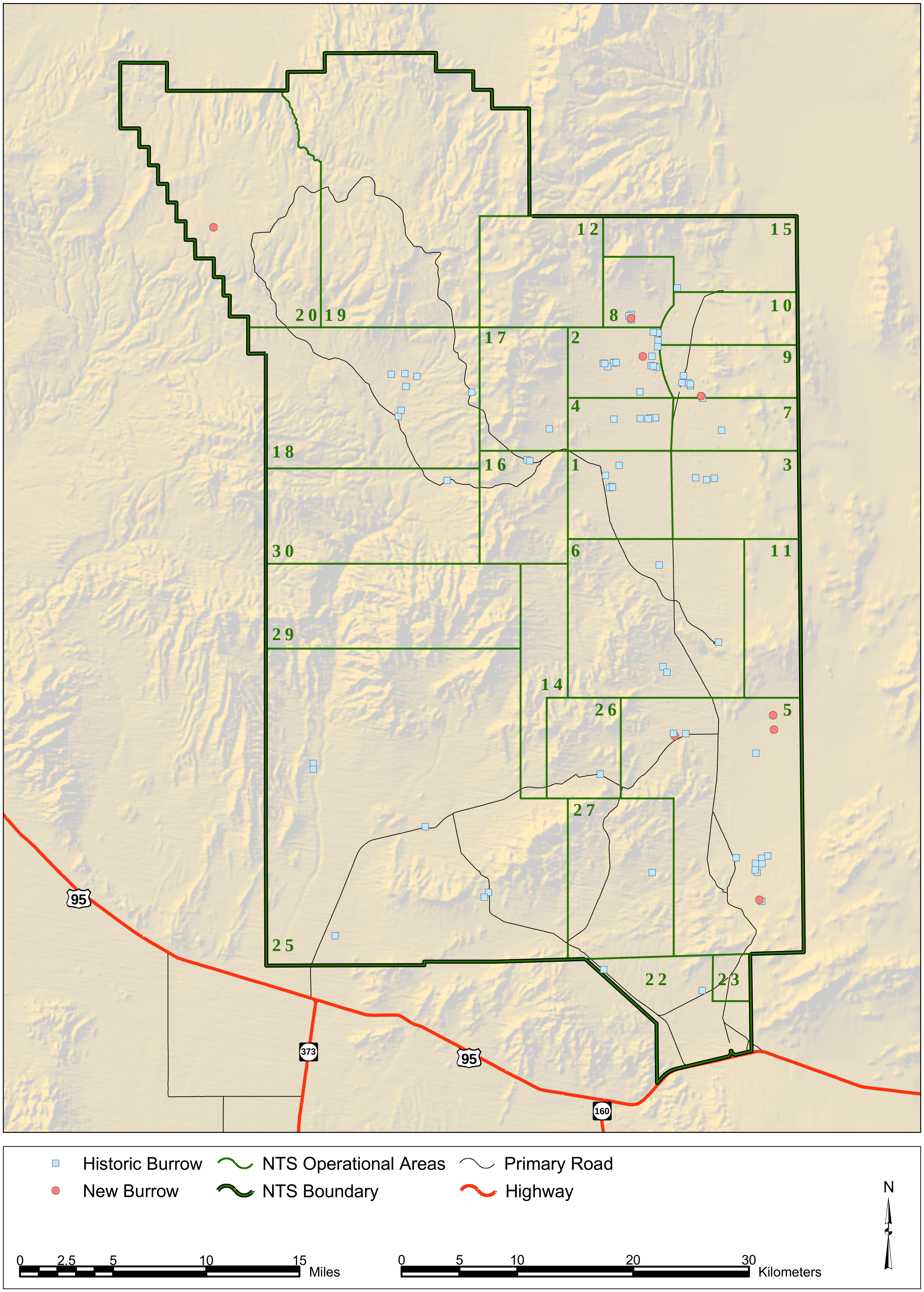


Figure 6.2 Known Owl Burrows on the NTS - 2001

The percent frequency of Orthopterans, Coleopterans, Solifugids, and scorpions in the sampled owl pellets decreased from fall to winter, whereas the percent frequency of rodents increased from fall to winter. These data suggest that a seasonal shift in prey from invertebrates to rodents from fall to winter occurs. Also, reptiles, pocket gophers (*Thomomys*), sagebrush voles (*Lemmiscus*), and shrews (Soricidae) were only detected in pellets during spring and summer.

BAT SPECIES OF CONCERN

To date, a total of 14 bat species has been documented on the NTS, of which 7 are species of concern. They are the Townsend's big-eared bat (*Corynorhinus townsendii*), spotted bat (*Euderma maculatum*), small-footed myotis (*Myotis ciliolabrum*), long-eared myotis (*Myotis evotis*), fringed myotis (*Myotis thysanodes*), the long-legged myotis (*Myotis volans*), and the big free-tailed bat (*Nyctinomops macrotis*). Monitoring to identify the distribution of these species of concern continued in 2001 at 31 individual water sources including natural springs, sewage lagoons, and man-made wells and sumps between April and September. Eleven water sources were in the Great Basin Desert ecoregions, eight in the Transition ecoregions, and twelve in the Mojave Desert ecoregions.

A total of 292 bats representing 10 of the 16 species known to occur on the NTS were captured. Of these, 78 bats representing six bat species of concern were trapped. Only the Yuma myotis was not trapped or detected. Audible calls of the spotted bat were documented at three sites. The majority (68) of the 78 bat species of concern were captured or detected in the Great Basin ecoregions.

Mines and tunnels are important or even critical habitats for some bat species. These man-made excavations can be used as day and night roosts, maternity colonies, and hibernacula. To determine which NTS mines and tunnels are being used by which bat species, the Anabat II device (Titley Electronics, Ballina, Australia) was again used in 2001. Only one survey was conducted in 2001 at G Tunnel. Very little bat activity was detected. No bats were captured, and only eight computer files were recorded with the Anabat system. A few bats were also detected with the NightSight™ camera flying around the portal entrance. Preliminary results indicate that only the small-footed myotis was detected at G Tunnel.

Recorded ultrasonic vocalizations of bats collected over previous years continued to be analyzed in 2001. Based on the analyses, the red bat (*Lasiurus blossevillii*) was detected at Gold Meadows Spring during June of 1999 and 2000. Very few records of this species have been documented in Nevada, so this is a significant finding.

WILD HORSES

Cattle and other livestock were removed from the NTS prior to testing of nuclear weapons in 1951, but a small herd of horses was not removed (Greger and Romney, 1994). There were no efforts to monitor the size of that herd from 1951 through the 1970s, although O'Farrell and Emory (1976) reported that "A band of about 20 mustangs is located in the vicinity of Rainier Mesa…. Their numbers have not increased markedly over the last few years." Wild horses (*Equus caballus*) occur on the NTS, and ongoing monitoring of this species was conducted in 2001. Wild horses are protected on public lands under the Wild Free-Roaming Horse and Burro Act of 1971. This act calls for the management and protection of wild horses and burros in a manner that is designed to achieve and maintain a thriving natural ecological balance. Although the NTS is on land withdrawn from public use, the NNSA/NV is committed to this same management goal on the NTS. In 1997, the DOE/NV signed a Five-Party Cooperative Agreement with Nellis Air Force Range (NAFR), USFWS, U.S. Bureau of Land Management, and the state of Nevada Clearinghouse. The goal of the agreement is to enhance management of the natural resources within ecosystems on the NAFR, the NTS, and the Desert National Wildlife Range. This agreement facilitates an ecosystem-based approach in the management of free-roaming animals with large home ranges, such as wild horses.

In 1989, a program was initiated to estimate the abundance of horses on the NTS annually by identifying and photographing all horses seen during systematic surveys. That monitoring has continued through 2001 and has provided excellent information on the abundance, recruitment (i.e., survival of horses to reproductive age), and distribution of the horse population on the NTS. Information on abundance and recruitment during 1990-1998 is summarized in Greger and Romney (1999). In 2001, BN biologists determined horse abundance and recorded horse sign along roads. Also, selected natural and man-made water sources were visited in the summer to determine their influence on horse distribution and movements and to determine the impact horses are having on NTS wetlands.

The direct population count in FY 2001 was 37 horses (Table 6.7), and does not include foals. Eleven foals were observed with their mares, of which two were missing by the end of the summer, and one was removed from the NTS by the Bureau of Land Management after its mother was found dead of unknown causes. All four foals observed in 2000 survived to yearlings. Two adult males (> 3 years old) that were observed on the NTS in FY 2000 were not observed in FY 2001. One adult female horse with a foal died of unknown causes in May.

From 1995 to 1998, the feral horse population declined 31 percent, from 54 to 37 adult horses (Table 6.7). The population currently appears to be stable. Six of the 16 foals observed in 1999 and 2000 survived to yearlings during the past two years. This resulted in stabilizing the horse population decline from the previous five years (1995-99). The addition of younger horses increases the herd's viability. The past population decline appeared to be the result of (1) low recruitment due to very poor foaling rates and foal survival and (2) moderate adult mortality. Over the past ten years, the causes of mortality among adults have included predation (four observed), collisions with vehicles (two observed), and drownings (one observed). An additional four adult horses have been found dead from unknown causes.

Horse sign data collected during the road surveys and horse use at natural and man-made water sources indicate that the 2001 NTS horse range includes Kawich Canyon, Gold Meadows, Yucca Flat, southwest foothills of the Eleana Range, and southeast Pahute Mesa (Figure 6.3). Overall, the annual horse range appears not to have changed greatly from last year. During the summer, horses are dependent on Captain Jack Spring, the only known water source in the Eleana Range (Figure 6.3). Man-made water sources on Yucca Flat have been removed in past years, and the increased distances horses must travel back and forth to Captain Jack Spring probably limits the herd's grazing range to the north.

As in previous years, the NTS horse herd appears to consist of two components, one larger group of horses (about 25 horses) that spends summers west of the Eleana Range and one smaller group (12-13 horses) that summers east of the Eleana Range on Yucca Flat. These groups of horses probably intermix during the winter in the Eleana Range. Approximately 30 horses were observed during the winter season (December-February) in the southern Eleana Range and in lower elevation areas west of the Eleana Range in Areas 18 and 30. This strongly suggests that horses do not move off the NTS during the winter.

The NTS horse population is dependent on several natural and man-made water sources in Areas 18, 12, and 30 (Figure 6.3) during different seasons. Man-made water source availability has not changed greatly on the NTS over the last four to five years. Wildhorse and Little Wildhorse seeps, both located in Area 30, are important winter-spring water sources. Two other natural water sources (Captain Jack Spring in Area 12, Gold Meadows Spring in Area 12) and one man-made pond (Camp 17 Pond in Area 18) were used by horses this summer, as in past years. Overall, Captain Jack Spring, Gold Meadows Spring, and Camp 17 Pond were the

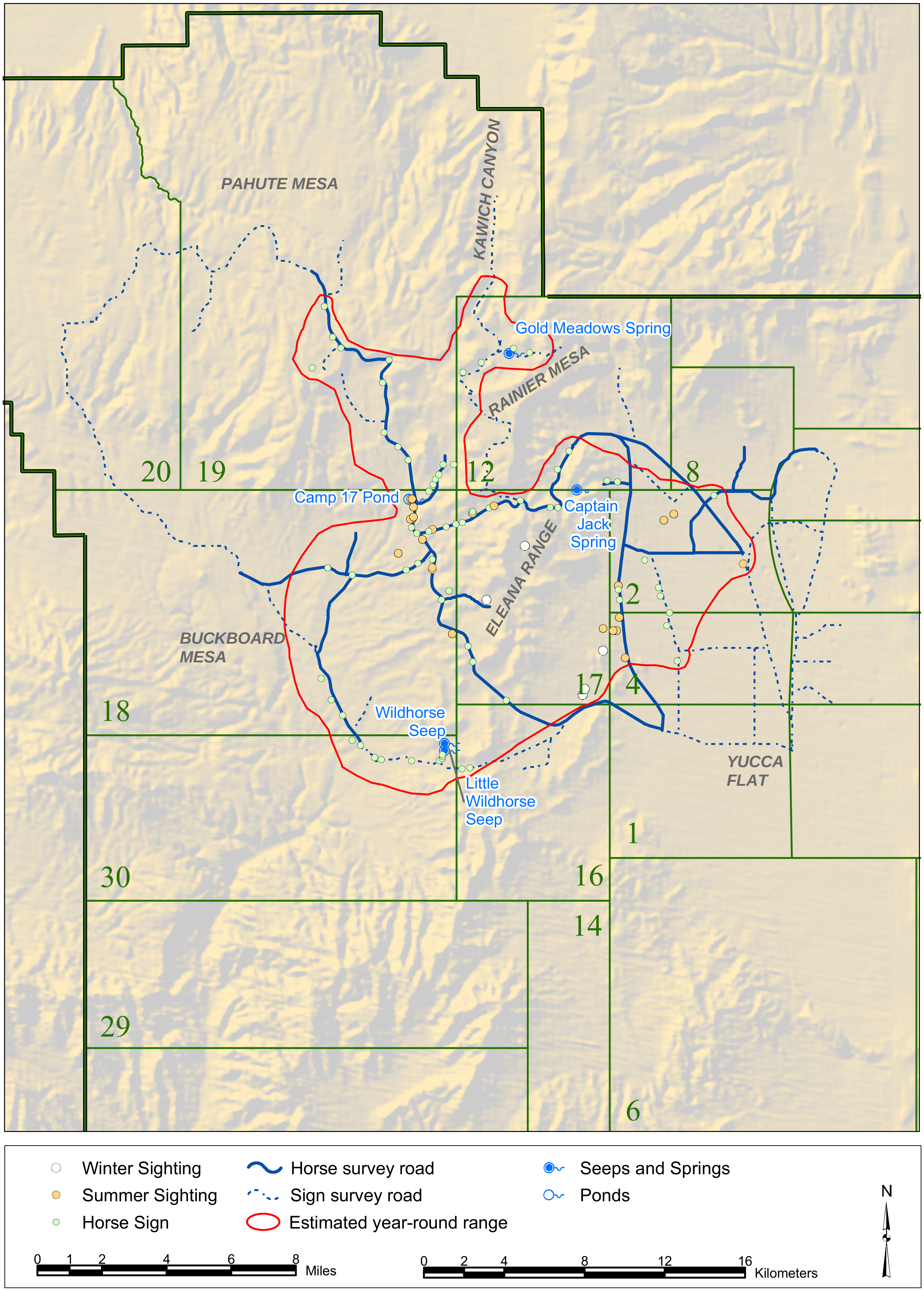


Figure 6.3 Feral Horse Sightings and Horse Sign Observed on the NTS - 2001

most important summer-fall water sources for horses based on the presence and quantity of horse sign and trampled and grazed vegetation. Horses often use ephemeral water sources in winter such as rock tanks and natural pools that collect water from rain and snowmelt. They appear to be much less dependent on man-made sources in winter.

There are presently six man-made water sources within or on the edge of the annual horse range and none of them were used by horses in 2001. Only two of these six water sources are permanent year-round: the E Tunnel Containment Ponds and Area 12 Sewage Ponds. The other water sources are semipermanent, plastic-lined sumps that occur at ER 19-1, ER 12-1, U10j, and U2gg (see Figure 6.4); they contain water only in the winter and spring. No horse sign have ever been found at the E Tunnel Containment Ponds or the Area 12 Sewage Ponds, strongly suggesting that horses do not drink from them.

RAPTORS

Several raptors occur and breed on the NTS which are not protected under the ESA and are not species of concern. They are, however, protected by the federal government under the Migratory Bird Treaty Act and by the state of Nevada. Raptors include all vultures, hawks, kites, eagles, ospreys, falcons, and owls. Because these birds occupy high trophic levels of the food chain, they are regarded as sensitive indicators of ecosystem stability and health. There are nine raptors (Table 6.8) which are known to breed on the NTS; however, only a few records exist of breeding raptors on the NTS or of their reproductive success, egg incubation periods, and fledging times (time when young leave the nest). Surveys to locate raptor nests and the number of breeding pairs of raptors began on the NTS in 1998 and were continued in 2001.

Twelve known raptor nests were visited from April through July to check for reproduction. Two of these twelve nests were active this year, and five new nests were found in buildings. Two active Great-horned owl nests were found in buildings in Yucca Flat and represent the first breeding record for this species on the NTS.

Three Barn Owl nests were found and monitored; one in Building 210 in Mercury, Area 23 and two in the R-MAD Decon Building, Area 25. In Building 210, four chicks fledged, one chick fell out of its nest and later died, and one fledged young apparently became entrapped in a small room within the abandoned building and died. At the R-MAD building, one pair of Barn Owls produced two clutches of young. Both buildings were demolished only after nests contained no eggs, all chicks were fledged, and owls were flushed from the buildings.

One active Red-tailed Hawk nest was found on the outside structure of a building at the R-MAD facility. It was reported to biologists that a Red-tailed Hawk was nesting in Area 27 on a power line pole nest which has been used for three consecutive years. One other known Joshua tree nest in southeast Yucca Flat was used again this year by a breeding pair of Red-tailed Hawks.

Few raptor mortalities have been recorded at the NTS. Wildlife observations, made opportunistically by biologists and other NTS workers, are maintained in a computerized database. Accounts of injured and dead animals are also usually reported to biologists and are stored in the same database. Over the last 11 years, from 1990-2001, 25 incidents of dead raptors have been recorded on the NTS (Table 6.9). The known causes of death include seven roadkills, three electrocutions, two suspected drownings, three predator kills, and one entrapment in a building. Also, four chicks have been found dead in or at the base of a nest.

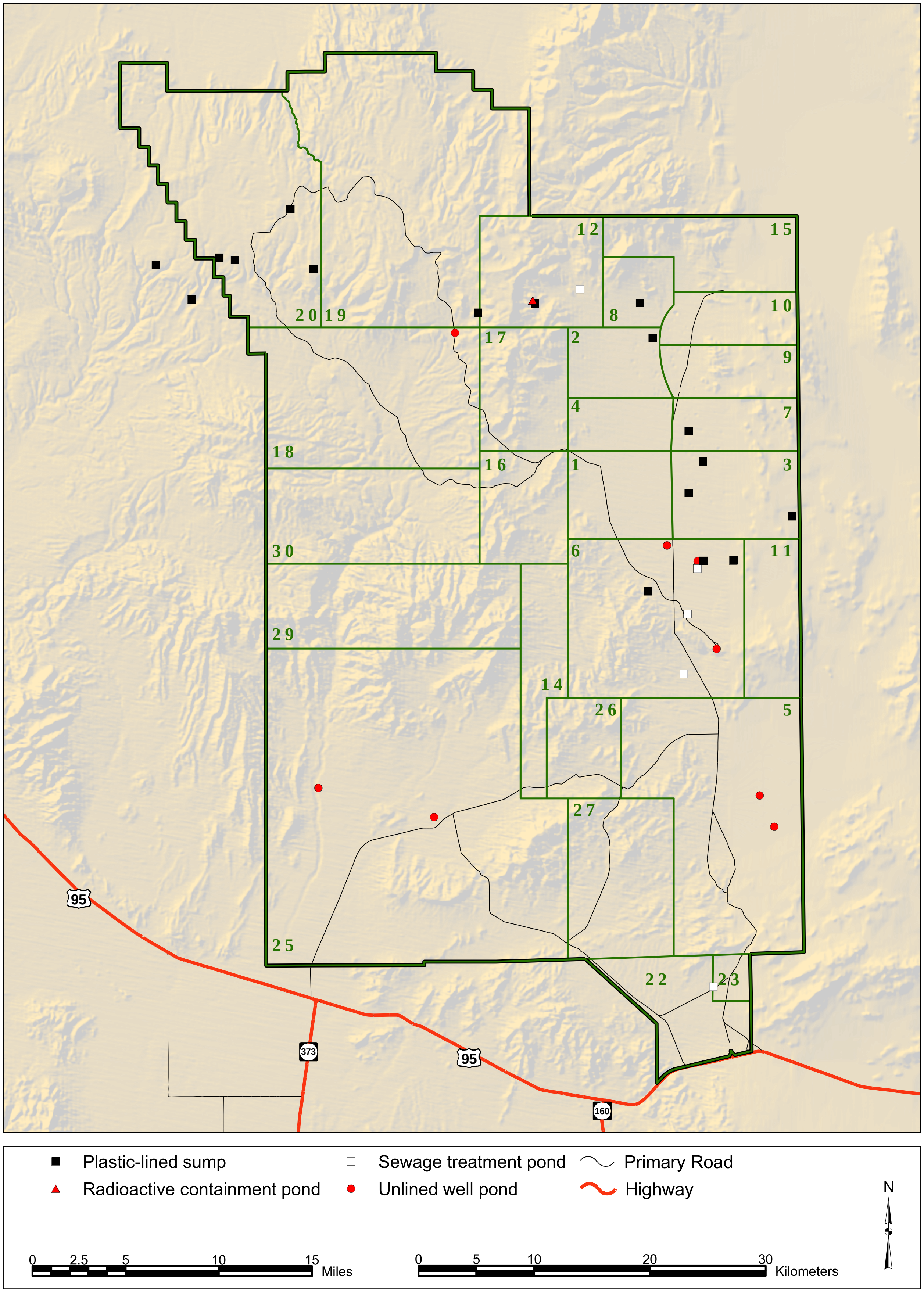


Figure 6.4 Man-made Water Sources Monitored for Wildlife Use and Mortality on the NTS - 2001

MONITORING NATURAL WATER SOURCES

Natural wetlands and man-made water sources on the NTS provide unique habitats for mesic and aquatic plants and animals and attract a variety of other wildlife. Natural NTS wetlands may qualify as jurisdictional wetlands under the Clean Water Act (CWA). Characterization of these mesic habitats to determine their status under the CWA and periodic monitoring of their hydrologic and biotic parameters are components of the Ecological Monitoring program which was started in 1997. Periodic wetlands monitoring may help identify annual fluctuations in measured parameters that are natural and unrelated to activities of the NNSA/NV. Also, if a spring classified as a jurisdictional wetland was unavoidably impacted by a NNSA/NV project, mitigation for the loss of wetland habitat would be required under the CWA. Under these circumstances, wetland hydrology, habitat quality, and wildlife usage data collected at the impacted spring over several previous years can help to develop a viable mitigation plan and demonstrate successful wetland mitigation.

Monitoring of selected NTS wetlands continued in 2001 to characterize seasonal baselines and trends in physical and biological parameters. Twelve wetlands (Figure 6.5) were visited at least once during the year to record the presence/absence of land disturbance, water flow rates, and surface area of standing water (Table 6.10). No jurisdictional or nonjurisdictional wetlands on the NTS were disturbed during 2001 and no U.S. Army Corps of Engineers 404 Permit was required.

Mule deer sign were observed at 10 of the 12 wetlands visited (wetlands are listed in Table 6.10). Deer sign were not found at Wahmonie Seeps No. 1 and 3. Mountain lions frequented three of the springs visited: Cane Spring, Tippipah Spring, and Topopah Spring. Mourning Doves were the bird species most commonly observed at the springs, followed by House Finches, Chukar, Black-throated Sparrows, and Gambel's Quail.

MONITORING MAN-MADE WATER SOURCES

Man-made water sources are located throughout the NTS (Figure 6.4) and include 35 plastic-lined sumps, 9 sewage treatment ponds, 8 unlined well ponds, and 2 radioactive containment ponds. Several ponds or sumps are located next to each other at the same project site. Many NTS animals rely on these man-made structures as sources of free water. Wildlife and migratory birds may drown in steep-sided or plastic-lined sumps as a result of entrapment, or ingest contaminants in drill-fluid sumps or evaporative ponds. Mitigation measures, required under the Mitigation Action Plan for the "Final Environmental Impact Statement for the Nevada Test Site and Offsite Locations in the State of Nevada" (DOE 1996c), include placing flag lines, fencing, or coverings over contaminated water sources to repel birds. Ponds are monitored to assess their use by wildlife and to develop and implement mitigation measures to prevent them from causing significant harm to wildlife.

During 2001, use of unlined sumps and ponds by waterfowl (ducks, shorebirds), passerine birds (ravens, horned larks, house finches), and mammals, such as coyotes and deer, was common. Only one man-made pond (Camp 17 Pond in Area 18) was used in 2001 by wild horses. Birds were observed much less at the plastic-lined sumps compared to the unlined ponds. No dead animals were recorded in any plastic-lined sumps during 2001.

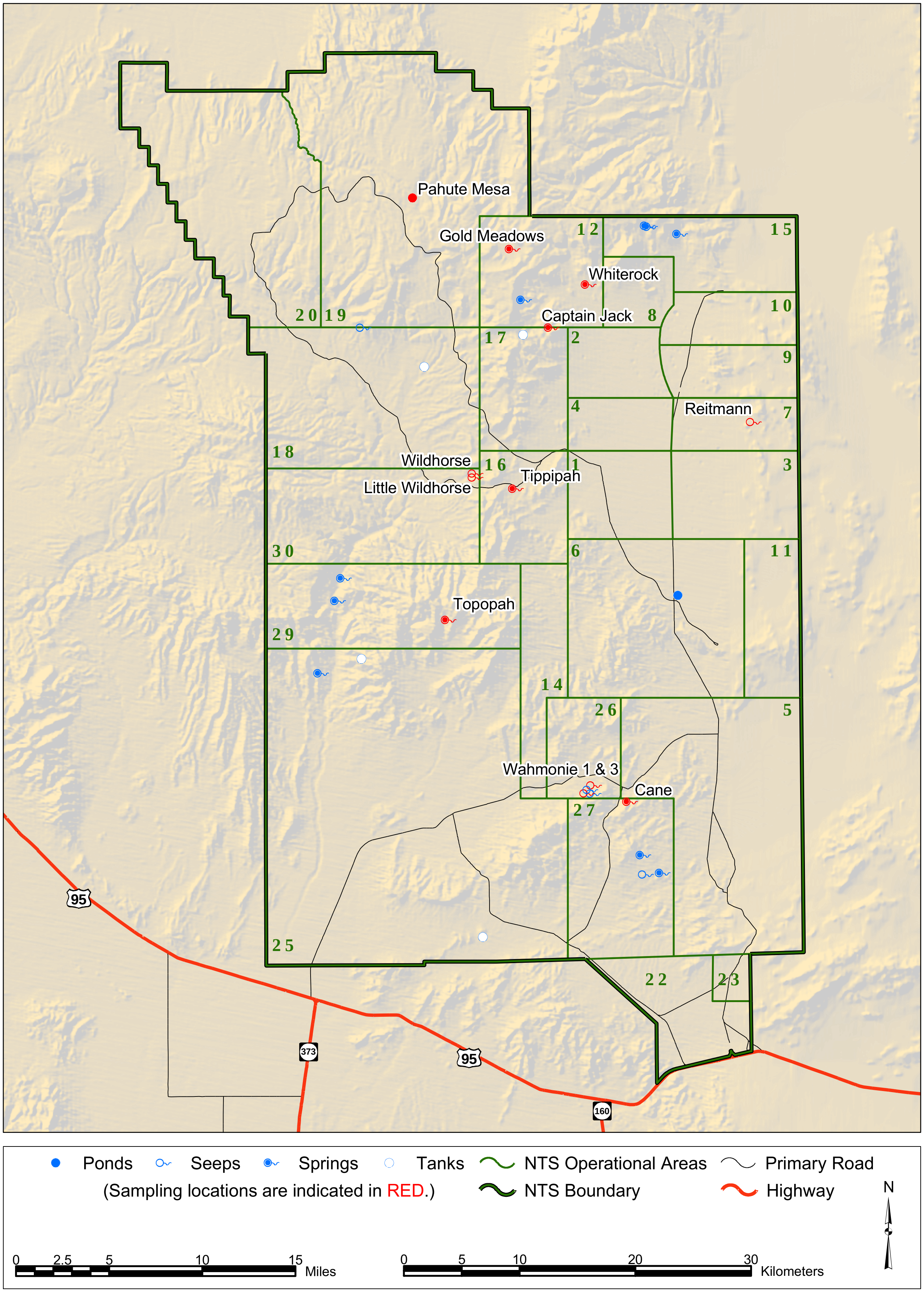


Figure 6.5 Natural Water Sources Sampled on the NTS - 2001

Table 6.1 Frequency of Coliform Bacteria Monitoring for NTS Public Water Systems

Public Water System/Permit Number	Monitoring Frequency
NV0000360/NY-0360-12C	Monthly - 3 Samples
NV0004098/NY-4098-12NTNC	Quarterly - 1 Sample
NV0004099/NY-4099-12C	Monthly - 1 Sample[(a)]
NY-5024-12NTNC[b]	Quarterly - 1 Sample
NY-0835-12H	Monthly - 1 Sample
NY-0836-12H	Monthly - 1 Sample

(a) Beginning October 2001, monitoring frequency is quarterly because of a change in status to non-community system.
(b) Permit dropped September 30, 2001.

Table 6.2 Analyses of Well Water Samples - 2001

Water System/Well	Nitrates (MCL[(c)] 10 ppm[(a)])	Fluoride (MCL 4 ppm)	Lead (action level .015
NV0000360			
Army Well	0.27		
Well 5B	3.0		
Well 5C	1.6		
Well 4	3.9		
Well 4A	4.0		
Well C-1	(b)		
NV0004098			
Well J-12	1.9	2.1	
Well J-13	2.0	2.4	
NV0004099			0.06
Well 8	1.2		
NV0005024			
Well UE16d	(b)		

(a) Parts per million.
(b) Not detected.
(c) Maximum contaminant level.

Table 6.3 Phase V Inorganic Chemicals (all results in mg/L)

Public Water System/Well	Antimony	Beryllium	Cyanide	Nickel	Thallium
NV0000360					
Army Well	(a)	(a)	(a)	(a)	(a)
Well 5b	0.0011	(a)	(a)	(a)	(a)
Well 5c	0.0012	(a)	(a)	(a)	(a)
Well 4	(a)	(a)	(a)	(a)	(a)
Well 4a	(a)	(a)	(a)	(a)	(a)
Well C-1	0.0013	(a)	(a)	(a)	(a)
NV0004098					
Well J-12	0.0013	(a)	(a)	(a)	(a)
Well J-13	(a)	(a)	(a)	(a)	(a)
NV0004099 Well 8	(a)	(a)	(a)	(a)	(a)
NV0005024 Well Ue16d	0.0024	(a)	(a)	(a)	(a)

(a) Not detected.

Table 6.4. Sensitive Species that are Protected Under State or Federal Regulations Which are Known to Occur on or Adjacent to the NTS

Plant Species	Common Names	Status [(a)]
Arctomecon merriamii	Desert bearpoppy	SOC
Astragalus beatleyae	Beatley's milkvetch	SOC
Astragalus funereus	Funeral Mountain milkvetch	SOC
Astragalus oopherus var. *clokeyanus*	Clokey's eg vetch	SOC
Camissonia megalantha	Cane Spring evening primrose	SOC
Cymopterus ripleyi var. *saniculoides*	Ripley's spring parsley	SOC
Frasera albicaulis var. *modocensis* (formerly *Frasera pahutensis*)	Modoc frasera	SOC
Galium hilendiae ssp. *kingstonense*	Kingston Mountains bedstraw	SOC
Penstemon albomarginatus	Whitemargin beard tongue	SOC
Penstemon fruticiformis var. *amargosae*	Death Valley beard tongue	SOC
Penstemon pahutensis	Paiute beard tongue	SOC
Phacelia beatleyae	Beatley's phacelia	SOC
Phacelia parishii	Parish's phacelia	SOC

(a) Status Codes:

Endangered Species Act (ESA), U.S. Fish and Wildlife Service (FWS)
LT - Listed Threatened
PT - Proposed for listing as Threatened
<LE - Former listed endangered species
SOC - Species of concern

U.S. Department of Interior
H&B - Protected under Wild Free Roaming Horses and Burros Act
EA - Protected under Bald and Golden Eagle Act

State of Nevada
NPT - Protected Threatened
G - Regulated as game
F - Regulated as fur-bearer
P - Protected bird

(b) Does not include all bird species that are protected by the Migratory Bird Treaty Act or by the state. Additionally, there are 26 birds which have been observed on the NTS, which are all protected by the state.

Table 6.4. (Sensitive Species that are Protected Under State or Federal Regulations Which are Known to Occur on or Adjacent to the NTS, cont.)

Reptile Species	Common Names	Status [(a)]
Gopherus agassizii	Desert tortoise	LT, NPT
Sauromalus obesus	Chuckwalla	SOC
Bird Species[(b)]		
Athene cunicularia hypugea	Western burrowing owl	SOC, P
Alectoris chukar	Chukar	G
Aquila chrysaetos	Golden eagle	EA, P
Buteo regalis	Ferruginous hawk	SOC, P
Callipepla gambelii	Gambel's quail	G
Charadrius montanus	Mountain plover	PT, P
Chlidonias niger	Black Tern	SOC
Empidonax wrightii	Gray flycatcher	SOC
Falco peregrinus anatum	American peregrine falcon	<LE, P
Ixobrychus exillis hesperis	Western least bittern	SOC, P
Phainopepla nitens	Phainopepla	SOC
Phasianus colchicus	Ring-necked pheasant	G
Plegadis chihi	White-faced ibis	SOC, P

(a) Status Codes:

Endangered Species Act (ESA), U.S. Fish and Wildlife Service (FWS)
LT - Listed Threatened
PT - Proposed for listing as Threatened
<LE - Former listed endangered species
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State of Nevada
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P - Protected bird

(b) Does not include all bird species that are protected by the Migratory Bird Treaty Act or by the state. Additionally, there are 26 birds which have been observed on the NTS, which are all protected by the state.

Table 6.4 (Sensitive Species that are Protected Under State or Federal Regulations Which are Known to Occur on or Adjacent to the NTS, cont.)

Mammal Species	Common Name	Status [a]
Antilocapra americana	Pronghorn antelope	G
Corynorhinus townsendii pallescens	Townsend's big-eared bat	SOC
Equus asinus	Burro	H&B
Equus caballus	Horse	H&B
Euderma maculatum	Spotted bat	SOC, NPT
Felis concolor	Mountain lion	G
Lynx rufus	Bobcat	F
Myotis ciliolabrum	Small-footed myotis	SOC
Myotis evotis	Long-eared myotis	SOC
Myotis thysanodes	Fringed myotis	SOC
Myotis volans	Long-legged myotis	SOC
Myotis yumanensis	Yuma myotis	SOC
Ovis canadensis nelsoni	Desert bighorn sheep	G
Odocoileus hemionus	Mule deer	G
Sylvilagus audubonii	Desert cottontail	G
Sylvilagus nuttallii	Mountain cottontail	G
Urocyon cinereoargenteus	Gray fox	G
Vulpes velox macrotis	Kit fox	F

(a) Status Codes:

Endangered Species Act (ESA), U.S. Fish and Wildlife Service (FWS)
LT - Listed Threatened
PT - Proposed for listing as Threatened
<LE - Former listed endangered species
SOC - Species of concern

U.S. Department of Interior
H&B - Protected under Wild Free Roaming Horses and Burros Act
EA - Protected under Bald and Golden Eagle Act

State of Nevada
NPT - Protected Threatened
G - Regulated as game
F - Regulated as fur-bearer
P - Protected bird

(b) Does not include all bird species that are protected by the Migratory Bird Treaty Act or by the state. Additionally, there are 26 birds which have been observed on the NTS, which are all protected by the state.

Table 6.5. Summary of Biological Surveys Conducted on the NTS - 2001

Project Number	Project	Important Species/ Resources Found	Area Surveyed (acres)	Proposed Project Area in Undisturbed Habitat (acres)	Conservation Recommendations
36896	Demolition of Decon Building at R-MAD Facility (CAU 254)	Nesting barn owls	0	0	Monitor chicks, postpone demolition until chicks fledge
36897	Test Cell A Leachfield Remediation (CAU 261)	None	0.2	0	None
36898	Soil Sampling at Area 22 Weather Station Fuel Storage (CAU 321)	None	0.5	0	None
36899	Remediation at Area 22 Sewage Lagoons and Desert Rock Airport Strainer Box (CAU 230/320)	Yucca, cacti	3.2	0.3	Avoid yucca and cacti
36900	U12 Tunnel Bat Survey	None	0	0	None
36901	Construction of runway and pad on Yucca Lake	None	21.7	7.9	None
36902	Reuse of Area 2 and Area 8 Borrow Pits	None	12.6	0	None
36903	Erosion Control at Area 27 Landfill	Potential tortoise burrows, quail, deer and predator signs	0.5	0.1	Avoid burrows
01-14a	G Tunnel Fungi Survey	None	0	0	Identify fungi samples taken
01-14b	RWMS Expansion	Yucca, inactive predator burrows	145.7	133	None, resources unavoidable
36905	Remediation at Area 3 Mud Plant and Camp (CAU 34)	Doves, raptor	3.7	0	Contact biologists if tamarisk trees are to be removed
36906	Plugging of Existing Boreholes	Buried pipes used by burrowing owls	12.2	0.1	None
36907	Renovation of Mercury Highway	None	0.1	0	None

Table 6.5. (Summary of Biological Surveys Conducted on the NTS - 2001, cont.)

Project Number	Project	Important Species/ Resources Found	Area Surveyed (acres)	Proposed Project Area in Undisturbed Habitat (acres)	Mitigation Recommendations
36908	Demolition of Building 210 in Mercury	Nesting barn owls	0	0	Monitor chicks, postpone demolition until chicks fledge
36909	Remediation at Area 2 Spill Site 02-99-01 (CAU 387)	Inactive predator burrows	0.01	0	None
36910	Characterization/Remediation at Area 3 Camp Injection Wells (CAU 322)	None	0.9	0	None
36911	Frenchman Flat Geo-Seismic Study	5 kit fox dens/burrow sites, 14 predato burrows	580	568	Avoid burrows
36912	Remediation at Six Spill and Surface Debris Sites (CAU 392)	None	5.1	0	None
36913	U12v Tunnel Seismic Lines	*Astragalus oophorus* var. *clokeyanus*, *Penstemon pahutensis*	33.6	9.7	Reroute line to avoid *A. oophorus* var. *clokeyanus*
37287	Characterization/Remediation at Areas 25, 26, and 27 Septic Systems (CAU 271)	Inactive tortoise burrow	9.4	1.7	
37288	Plugging of 12 Existing Boreholes	3 predator burrows	10.9	0	Avoid burrows
37289	Closure Activities at E-MAD and R-MAD (CAU 143)	3 inactive predator burrows	21.4	16.8	None
37290	Mercury Highway Culvert Repairs	None	10.5	1	None
37291	Four New Septic Tanks - Areas 5, 6, 12, and 25	Yucca, cacti	22.3	8.3	Avoid mature yucca
37292	Characterization/Remediation at Mud Pit Disposal Sites (CAU 356)	Collapsed kit fox burrow	6.1	0	None
37293	Surface Laid Cable in Area 25	None	0.8	0.8	None
Total			901.4	747.7	

Table 6.6 Summary of Burrow use by Pairs of Owls on the NTS - 2001

Eco-region	Sites Surveyed	Burrows With Non-Breeding Pairs	Burrows With Breeding Pairs	Juvenile Owls
Mojave Desert	4	0	2	6(3/burrow)
Transition	18	2	9	49 (1–8/burrow)
Great Basin Desert	1	0	0	0
Totals	**23**	**2**	**11**	**55**

Table 6.7 Number of Horse Observed on the NTS by Age Class, Gender, and Year Since 1995

Class/Age	Number of Horses Observed													
	1995		**1996**		**1997**		**1998**		**1999**		**2000**		**2001**	
Foals	1		1		3		8		5		11		11	
Yearlings	3		0		0		0		0		4		2	
Adults	**M***	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**
2 Year Olds	0	0	0	1	0	0	0	0	0	0	(2)	0	1	3
3 Year Olds	0	0	0	0	0	1	0	0	0	0	0	0	0	0
> 3 Year	22	29	21	24	19	20	16	21	11	20	13	21	11	20
Total (excluding foals)	**54**		**46**		**40**		**37**		**31**		**38**		**37**	

*M=male; F=female ** dead

Table 6.8 Raptor Species that Occur and Breed on the NTS

Raptor Species	Common Name
Aquila chrysaetos	Golden eagle
Asio otus	Long-eared owl
Bubo virginianus	Great horned owl
Buteo jamaicensis	Red-tailed hawk
Buteo swainsoni	Swainson's hawk
Falco mexicanus	Prairie falcon
Falco sparverius	American kestrel
Speotyto cuniculaia	Western burrowing owl
Tyto alba	Barn owl

Table 6.9 Summary of NTS Raptor Mortality Records from 1990 - 2001

Species	Roadkill	Electrocution	Suspected Drowning	Predation	Entrapment	Chick Mortality	Unknown	Totals
American kestrel				1			2	**3**
Barn owl	1			1	1	3	1	**7**
Golden eagle	1	1						**2**
Great-horned Owl	3	1				1		**5**
Prairie falcon				1				**1**
Red-tailed hawk	2	1	1				1	**5**
Turkey vulture							1	**1**
Western burrowing owl			1					**1**
Totals	**7**	**3**	**2**	**3**	**1**	**4**	**5**	**25**

Table 6.10 Seasonal Data from Selected Natural Water Sources on the NTS Collected - 2001

Water Source	Date	Surface Area of Water (m^2)[(a)]	Surface Flow Rate (L/Min)[(b)]	Disturbance at Spring
Cane Spring	8/12	13	1	None
Captain Jack Spring	9/13	20	1	Horse grazing and trampling vegetation
Gold Meadows Spring	7/16	240	c	Horse grazing and trampling
Gold Meadows Spring	8/28	600	c	Horse grazing and trampling
Little Wildhorse Seep	5/31	3	c	Horse grazing and trampling
Little Wildhorse Seep	8/28	0	0	Horse grazing and trampling
Pahute Mesa Pond	6/04	800	0	None
Pahute Mesa Pond	8/15	0	0	None
Reitmann Seep	8/15	0.5	0	None
Tippipah Spring	8/08	200	0.35	None
Topopah Spring	8/08	1.5	0.15	None
Wahmonie Seep	6/05	0	0	None No. 1
Wahmonie Seep	6/05	0	0	None No. 3
Whiterock Spring	8/15	10	3	None
Wildhorse Seep	5/31	15	c	Horse grazing and trampling
Wildhorse Seep	8/28	0	0	Horse grazing and trampling

(a) Square meters.
(b) Liters per minute.
(c) Not measurable due to diffused flow.

U12N Overview of All Ponds from the Top of Muck Pile (March 13, 1989)

7.0 SITE HYDROLOGY

The hydrologic character of the Nevada Test Site (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 more than 40 years (U. S. Department of Energy [DOE] 1996c), and numerous scientific reports and large databases are available. The following sections present an overview of the hydrologic setting of the NTS and vicinity, including summary descriptions of surface water and groundwater, hydrogeologic framework, and finally brief descriptions of the hydrogeology for each of the idle underground test areas on the NTS. For additional information regarding hydrogeology of the individual testing areas on the NTS, refer to Chapter 7.0 of the NTS Annual Site Environmental Report for calender year 2000 (BN 2001c).

7.1 SURFACE WATER

The NTS is located within the Great Basin, a closed hydrographic province which comprises several closed hydrographic basins (Figure 7.1). 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. Two playas (seasonally dry lakes) occur 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 locally perched groundwater systems are the only natural sources of perennial surface water in the region. There are 20 known springs or seeps on the NTS (Hansen et al., 1997) (Figure 7.2). Spring discharge rates are low, ranging from 0.014 to 2.2 liters/sec (0.22 to 35 gal/min) (International Technology [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 1998a). Surface water is not a source of drinking water on the NTS.

7.2 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 7.3).

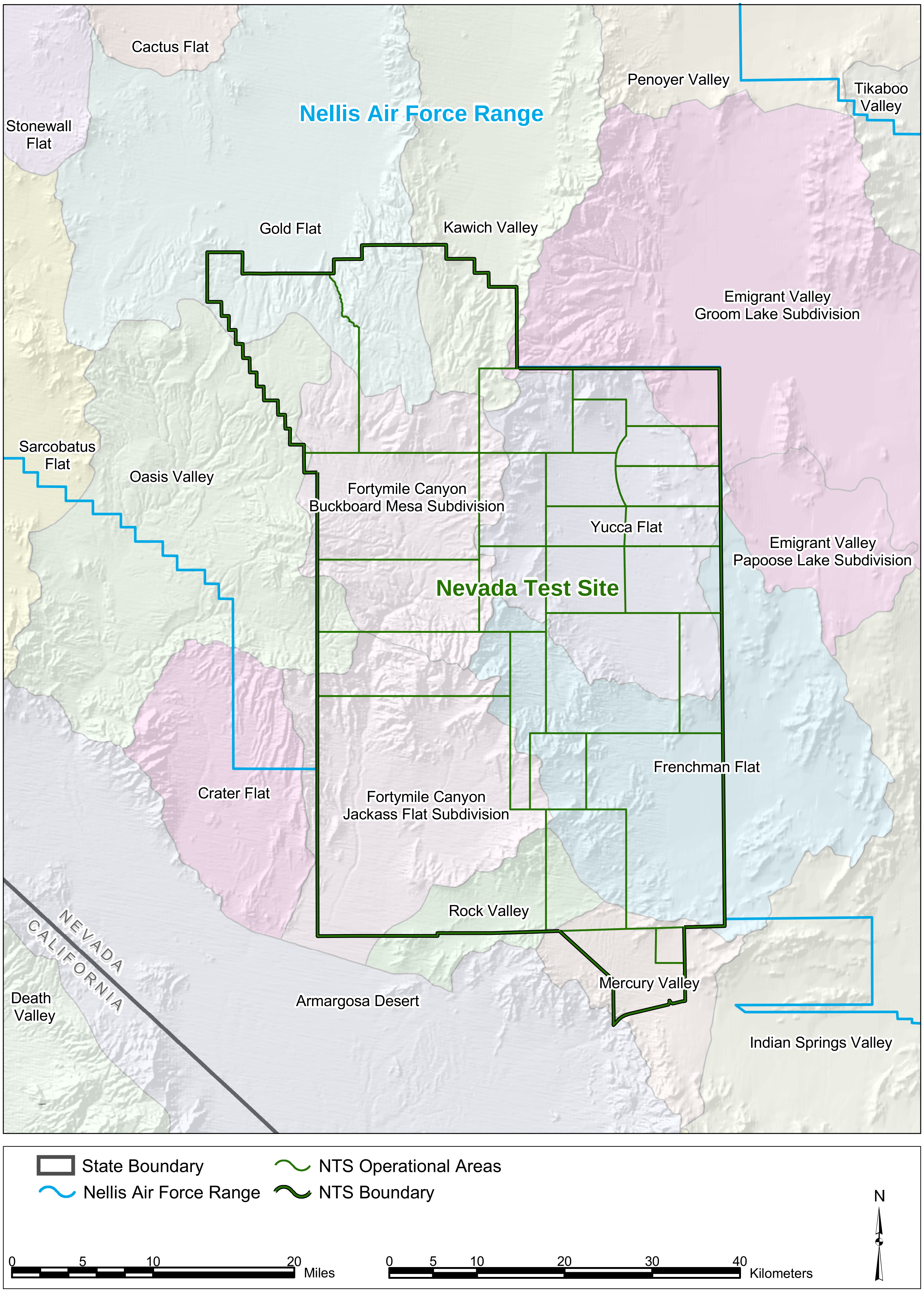


Figure 7.1 Closed Hydrobasins on the NTS

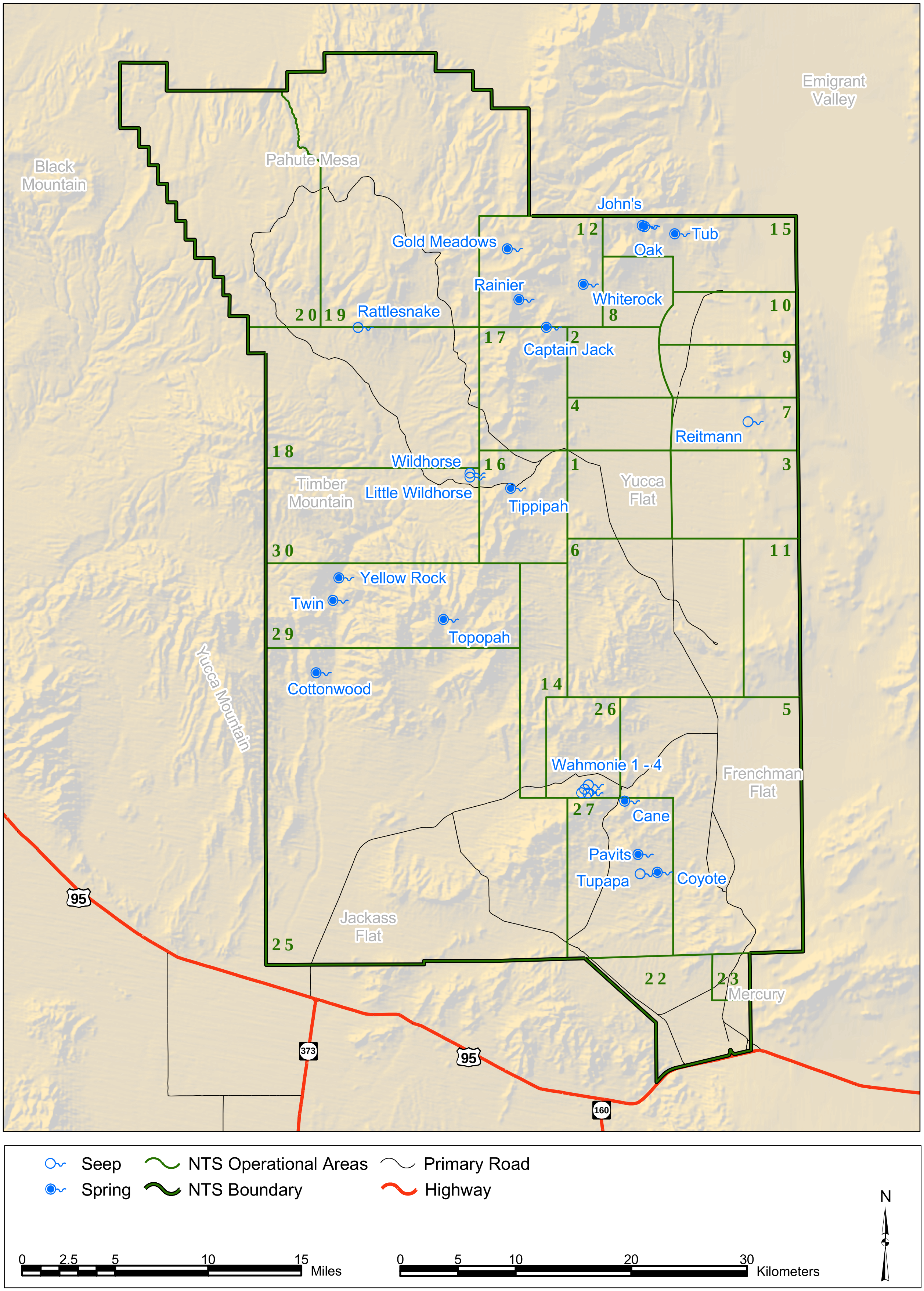


Figure 7.2 Natural Springs and Seeps on the NTS

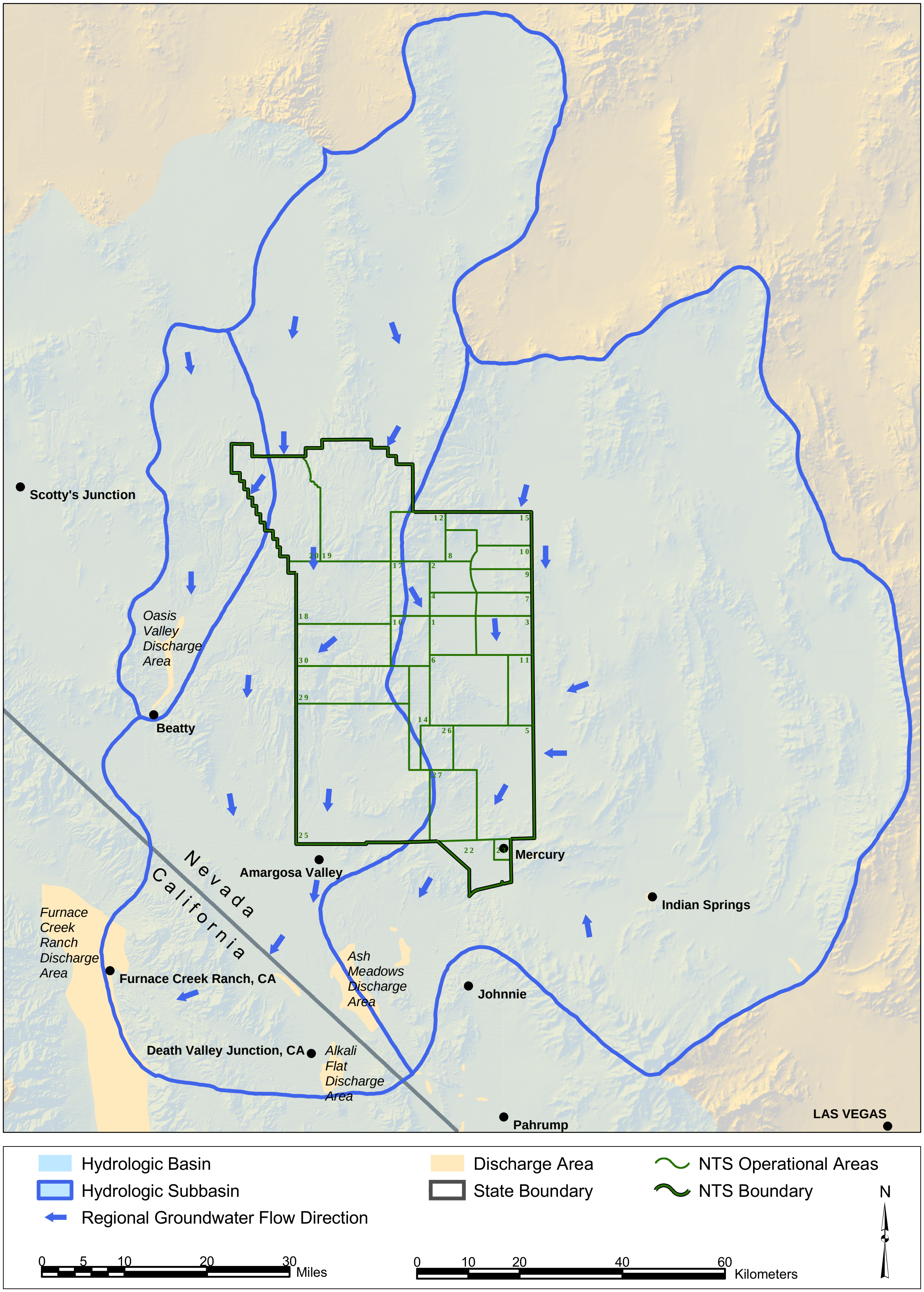


Figure 7.3 Groundwater Sub-basins of the NTS and Vicinity

The groundwater-bearing rocks at the NTS have been classified into several hydrogeologic units, of which the most important is the lower carbonate aquifer, a thick sequence of Paleozoic-age 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 (IT 1996b; Reiner 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; IT 1996b; DOE 1998a) 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 7.3).

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 ten potable water wells that make up the NTS water system and 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 the U.S. Environmental Protection Agency(EPA) drinking Water Standards (Chapman and Lyles 1993; Rose et al., 1997; Bechtel Nevada [BN] 2001c).

7.3 HYDROLOGIC MODELING

The information in this section was compiled from various sources, as referenced throughout the discussion. However, the basic approach to these discussions is based on that taken to produce groundwater models for the various idle test areas at the NTS for the Underground Test Area (UGTA) Program.

The Environmental Restoration Division of the National Nuclear Security Administration, Nevada Operation Office (NNSA/NV) initiated the UGTA project to study the effects of past underground nuclear testing in shafts and tunnels on groundwater at the NTS and surrounding areas. The multi-disciplinary UGTA investigation focuses on the geology and hydrology of the NTS to determine how contaminants are transported by groundwater flow. A regional three-dimensional computer groundwater model (IT 1996a; 1997) has already 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 one model has been built: Frenchman Flat (IT 1998b). The Pahute Mesa and Yucca Flat models are in progress. The results of the UGTA modeling efforts will be used to refine a monitoring network to ensure public health and safety.

Other hydrogeologic models for the area include those developed for the Yucca Mountain Program (YMP) (YMP 1998) and the Death Valley regional groundwater flow system (D’Agnese et al., 1997). There are also site-specific models for the Radioactive Waste Management Sites (RWMSs) in Frenchman Flat, Area 5 (Shott et al., 1998) and Yucca Flat, Area 3 (BN 1997).

7.4 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 (BILBY 1963) was designed in part to study explosion effects on groundwater and the movement in groundwater of radioactive byproducts from the explosion. 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 been developed further by the UGTA hydrogeologic modeling team (IT 1996c, 1998b; BN 2002c).

Winograd and Thordarson (1975) established a hydrogeologic framework, incorporating the work of Blankennagel and Weir (1973) who defined the first hydrogeologic units to address the complex hydraulic properties of volcanic rocks. Hydrogeologic units (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) (see Seaber [1988] for a discussion of hydrostratigraphy). 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). The following paragraphs summarize the current understanding of the hydrogeologic framework of the NTS, first addressing HGUs, then describing the main HSUs.

HYDROGEOLOGIC UNITS OF THE NTS AREA

All the rocks of the NTS and vicinity can be classified as one of nine hydrogeologic units, which include the alluvial aquifer, four volcanic hydrogeologic units, two intrusive units, and two hydrogeologic units that represent the pre-Tertiary sedimentary rocks (Table 7.1).

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-age sedimentary rocks (Slate et al., 1999). The volcanic rocks of the NTS and vicinity can be categorized into four hydrogeologic units based on primary lithologic properties, degree of fracturing, and secondary mineral alteration. In general, the altered (typically zeolitized or 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; BN 2002c).

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 (quartzites, siltstones, shales) 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 Tertiary-age intracaldera intrusives and Mesozoic-age granite intrusives are both considered to behave as a confining unit due to low primary porosity, low permeability, and because most fractures are probably filled with secondary minerals.

HYDROSTRATIGRAPHIC UNITS OF THE NTS AREA

The rocks at the NTS and vicinity are grouped into roughly sixty HSUs. The more important and widespread HSUs in the area are discussed separately, from oldest to youngest, in this section. Additional information regarding other HSUs is summarized in tables introduced in Section 7.5.

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 (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 form 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 area, 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 7.4). The two are probably related in both source and time and may 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 7.4, the volcanic rocks are divided into aquifer or confining unit 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, 1998b; Gonzales and Drellack 1999; BN 2002c).

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 1,138 m (3,732 ft) in the deepest subbasins.

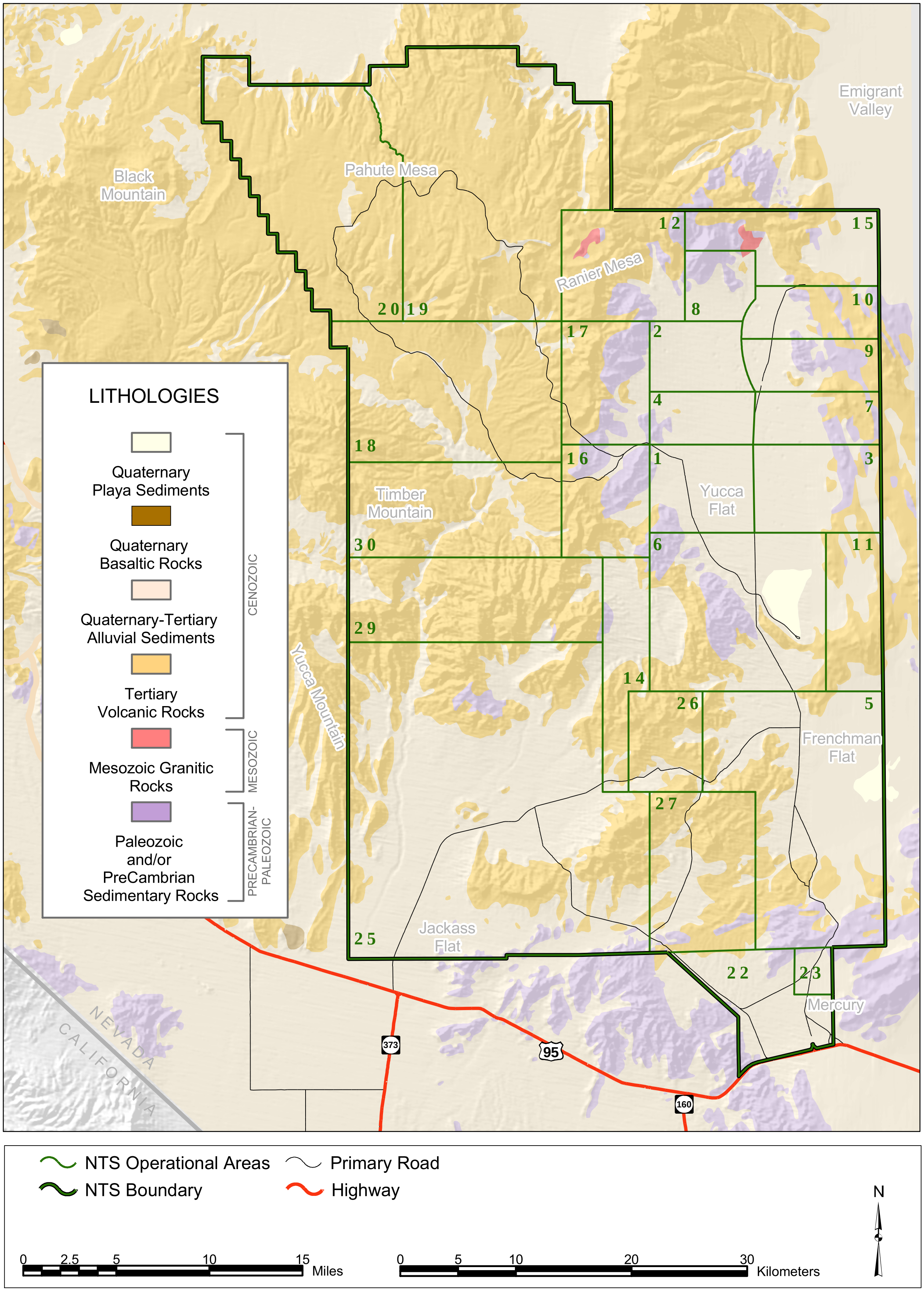


Figure 7.4 Generalized Geologic Map of the NTS and Vicinity

The alluvial aquifer HSU is restricted primarily to the basins of the NTS (Figure 7.4). 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.

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. Juxtapositioning 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. 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 Southwest Nevada Volcanic Field (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. At least six major calderas have been identified in the SWNVF, a multi-caldera silicic volcanic field that formed by the voluminous eruption of zoned ignimbrites between 16 and 7.5 million years ago (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).

HYDRAULIC PROPERTIES

It is difficult to give precise hydraulic conductivity values for NTS HSUs because of their spacial variability (aquifer heterogeneity). Volcanic rocks typically are extremely variable in lithologic character both laterally and vertically, which accounts for some of the observed heterogeneity. In some areas, units of different character are so finely interbedded that they are assigned to a composite unit (e.g., lava flows embedded within zeolitized bedded tuffs) whose overall hydrologic properties are variable. Another cause of heterogeneity is the irregular distribution of the effects of hydrothermal alteration. Hydraulic properties have rarely been measured for specific HSUs, as borehole hydraulic test intervals tended to span HSU contacts. However, laboratory and field measurements of hydraulic conductivity, flow rates, and temperature profiles indicate that almost all of the groundwater at the NTS is moving through fractures (GeoTrans 1995).

General Hydraulic Characteristics of NTS Rocks

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 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). Prediction of the influence of any fault on the hydrologic system thus is made very difficult by the uncertainties associated with estimating the hydraulic properties of that fault, complicated by the potential for the fault to juxtapose permeable and less permeable water-bearing units.

Table 7.2 presents a 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 7.4, 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).

Effect of Underground Nuclear Explosions on Hydraulic Characteristics

Underground nuclear explosions may affect hydraulic properties of the geologic medium (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), and usually are addressed in the UGTA program on a case-by-case basis or in sub-CAU-scale models, rather than in regional or CAU-level models.

7.5 HYDROGEOLOGY OF THE NTS TEST AREAS

Most NTS underground nuclear detonations were conducted in three main test areas: (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 utilized test area, hosting 659 underground tests (747 detonations), four of which were high-yield detonations (Allen et al., 1997).

In addition to the three main test areas, 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 7.3 is a synopsis of information about each underground test area at the NTS, and Figure 7.5 is a map showing the areal distribution of underground nuclear tests conducted at the NTS.

The location of each underground nuclear tests is classified as a Corrective Action Site (CAS). These in turn have been grouped into six 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 geographical testing areas on the NTS (Figure 7.5). The hydrogeology of the NTS idle test areas is summarized in the following sections.

FRENCHMAN FLAT

The Frenchman Flat CAU consists of ten CASs located in the northern part of NTS Area 5 and southern part of Area 11 (Figure 7.5). The detonations were conducted in vertical emplacement holes and two mined shafts. Nearly all the tests were conducted in alluvium above the water table.

Geologic Overview of Frenchman Flat

The stratigraphic section for the Frenchman Flat area 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

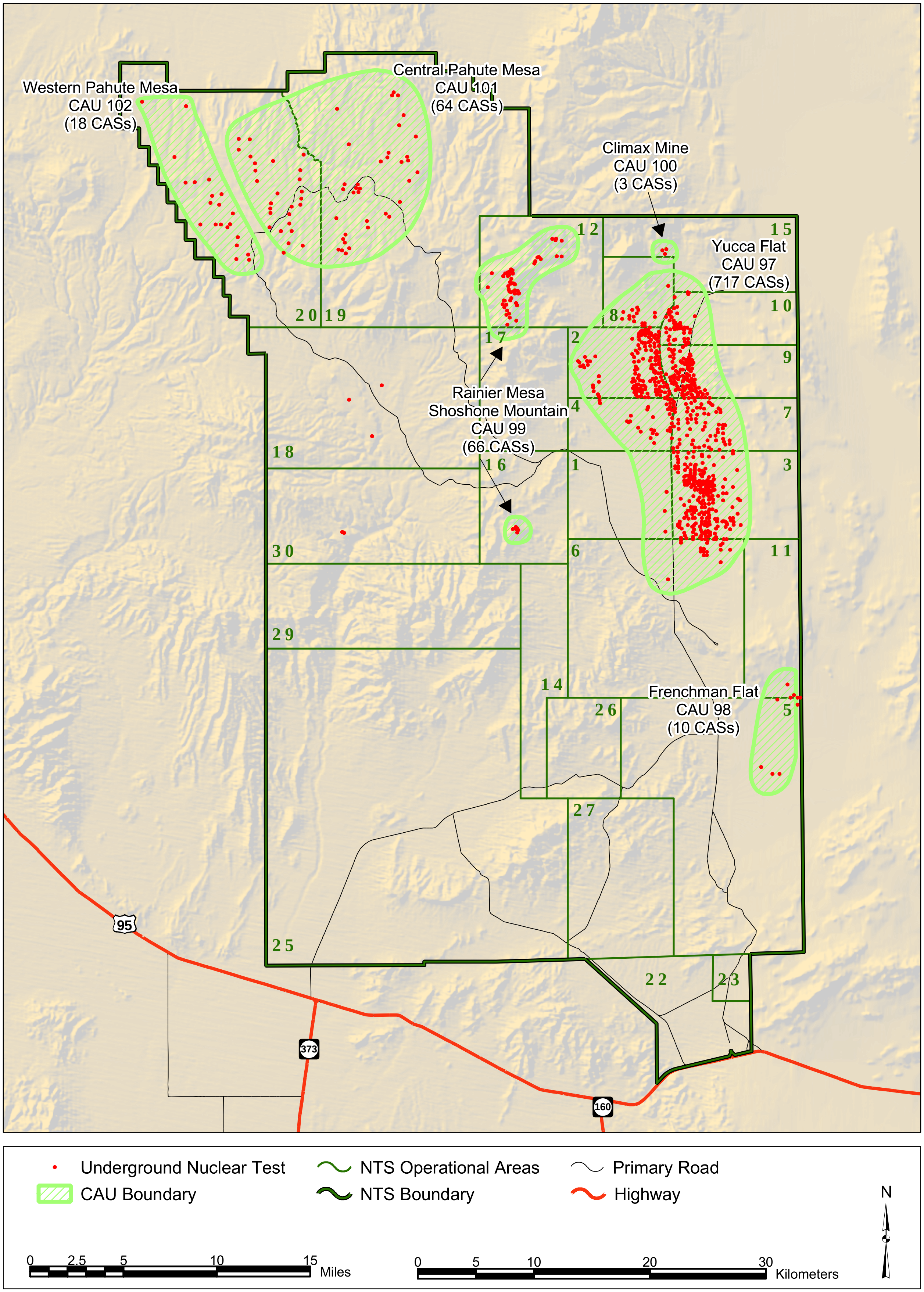


Figure 7.5 CAUs and CASs on the NTS

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.

The structural geology of the Frenchman Flat area 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 million years ago, the region has undergone 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 east-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 series of relatively narrow, east-dipping, half-graben subbasins elongated in a northern direction (Figure 7.6).

Hydrogeology Overview of Frenchman Flat

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.

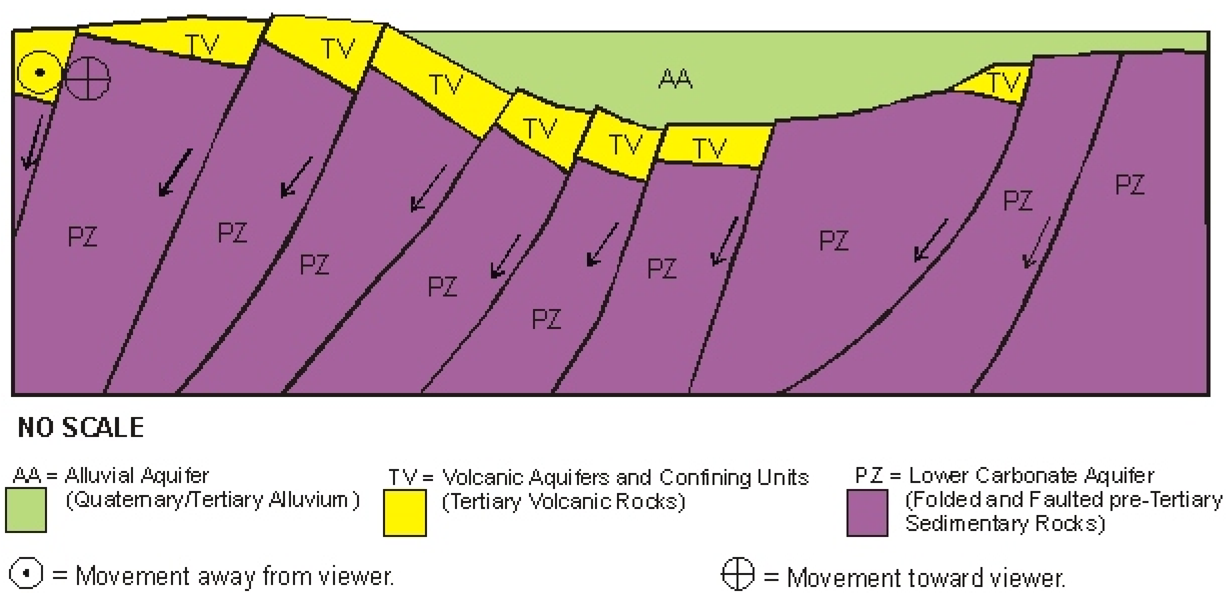


Figure 7.6 Conceptual East-West Cross Section Through Frenchman Flat Showing SubBasins Formed by Fault Blocks

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 volcanic confining unit (WVCU), the tuff confining unit (TCU), the volcaniclastic confining unit (VCU), the LCA, and the LCCU (Table 7.4).

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 area. 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 (Figure 7.3). An increasing westward flow vector in southern NTS may be due to preferential flow paths subparallel to the east-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.

YUCCA FLAT

The Yucca Flat/Climax Mine CAU consists of 717 CASs located in NTS Areas 1, 2, 3, 4, 6, 7, 8, 9, 10, and three CASs located in Area 15 (Figure 7.5). These tests were typically conducted in vertical emplacement holes and a few related tunnels (Table 7.3).

The Yucca Flat and Climax Mine testing areas 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 testing area on the NTS (Figure 7.5). 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 (503 m [1,650 ft]) provides additional operational and environmental benefits.

This section provides brief descriptions of the geologic and hydrogeologic setting of the Yucca Flat/Climax Mine area, as well as a discussion of the hydrostratigraphic framework. This summary was compiled from various sources, including 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.

Geology Overview of Yucca Flat

Yucca Flat is a topographically closed basin with a playa at its southern end (Figure 7.4). 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 (Figure 7.4). These rocks also compose the “basement” of the basin, which is now covered by alluvium.

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). During Cenozoic time, the sedimentary and intrusive rocks were buried by thick sections of volcanic material deposited in several eruptive cycles from source areas (calderas) to the north and west. The volcanic rocks include primarily ash-flow tuffs, ash-fall tuffs, and reworked tuffs.

Large-scale normal faulting began in the Yucca Flat area in response to regional extensional movements near the end of this period of volcanism. This faulting formed the Yucca Flat basin, and as 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 configuration of the Yucca Flat basin is illustrated on the generalized west-east cross section shown in Figure 7.7. The cross section is simplified to show the positions of only the primary hydrostratigraphic units in the region. This cross section provides a conceptual illustration of the irregular Precambrian and Paleozoic rocks overlain by the Tertiary-age volcanic units and the basin-filling alluvium at the surface. The main Tertiary-age, basin-forming large-scale normal faults are also shown.

Hydrogeology Overview of Yucca Flat

All the rocks of the Yucca Flat study area can be classified as one of eight hydrogeologic units, which include the alluvial aquifer, four volcanic hydrogeologic units, an intrusive unit, and two hydrogeologic units that represent the pre-Tertiary rocks (Table 7.1).

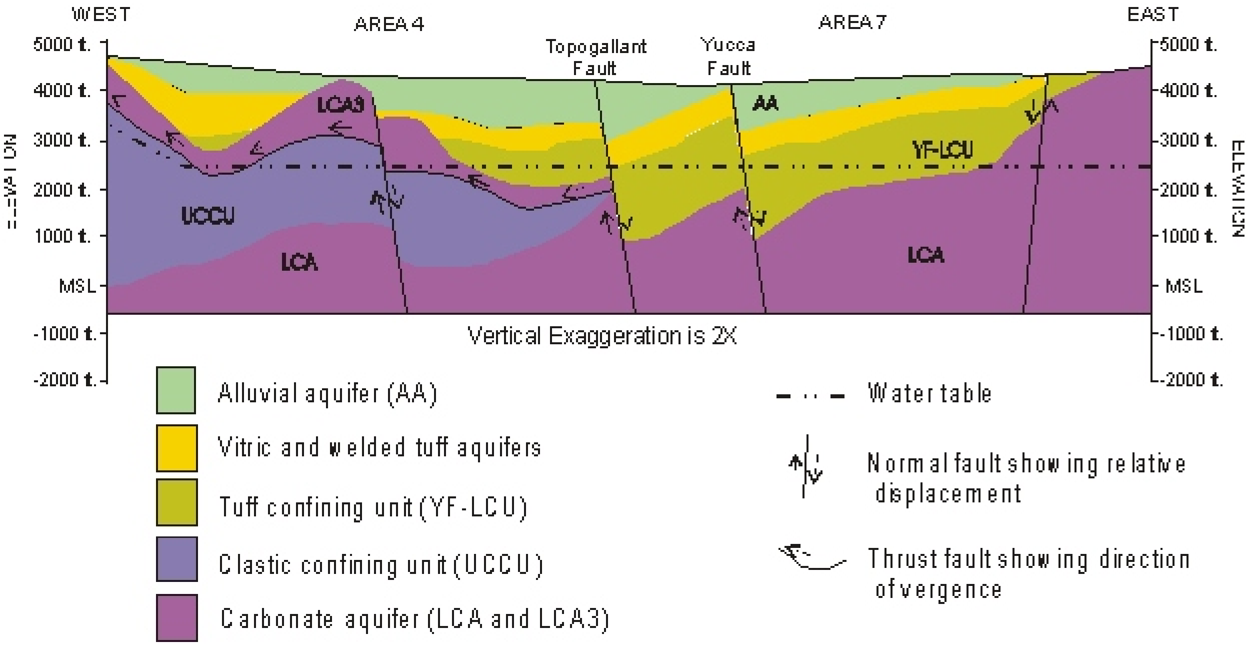


Figure 7.7 Generalized West-East Hydrogeologic Cross Section Through Central Yucca Flat

The strata in the Yucca Flat area 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 7.5, 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 7.4.

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.

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 the Yucca Flat area 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 Section 7.4). In Yucca Flat these units are generally present in the central portions of the basin. They can be saturated in the deepest structural subbasins.

Water-level Elevation and Groundwater Flow Direction

Water-level data are abundant for Yucca Flat, as a result of more than thirty 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 regional 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). 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.

Fluid 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.

Based on the existing data and as interpreted from the regional groundwater flow model (DOE 1997c), the overall groundwater flow direction in the Yucca Flat area is to the south and southwest (Figure 7.3). Groundwater ultimately discharges at Franklin Lake Playa to the south and Death Valley to the southwest.

PAHUTE MESA

The Western and Central Pahute Mesa CAUs, encompassing Areas 19 and 20 of the NTS, were the site of 85 underground nuclear tests (DOE 2000b) (Figure 7.5). These detonations were all conducted in vertical emplacement holes (Table 7.3). 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 static water level, test-related contaminants are available for transport via a groundwater flow system that may extend to discharge areas in Oasis Valley. So, like the testing areas of Frenchman Flat and Yucca Flat, a CAU-level hydrostratigraphic framework model is also being developed for the PM-OV area to support modeling of groundwater flow and contaminant transport for the UGTA program (BN 2002c).

Geology Overview of Pahute Mesa

Pahute Mesa is a structurally high-volcanic plateau in the northwest portion of the NTS (Figure 7.4). This physiographic feature covers most of NTS Areas 19 and 20, which are the second most utilized testing areas at the NTS. Consequently, there are numerous drill holes which provide a substantial amount of subsurface geologic and hydrologic information (BN 2002c; Warren et al., 2000a,b). Borehole and geophysical data 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.

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.

The SCCC consists of at least two nested calderas, the Grouse Canyon caldera and younger Area 20 caldera (13.7 and 13.25 million years old, respectively; Sawyer et al., 1994).

Like the Silent Canyon caldera complex, 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 million years old, 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 million years old; Sawyer et al., 1994) in the southern portion of the model area.

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 million years ago, of tuffs assigned to the Thirsty Canyon Group (Sawyer et al., 1994).

Underlying the Tertiary 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 9,600 m (31,500 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 this 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 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 7.4), 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 7.8. For a more detailed geologic summary, see Ferguson et al., (1994); Sawyer et al., (1994); and BN (2002c).

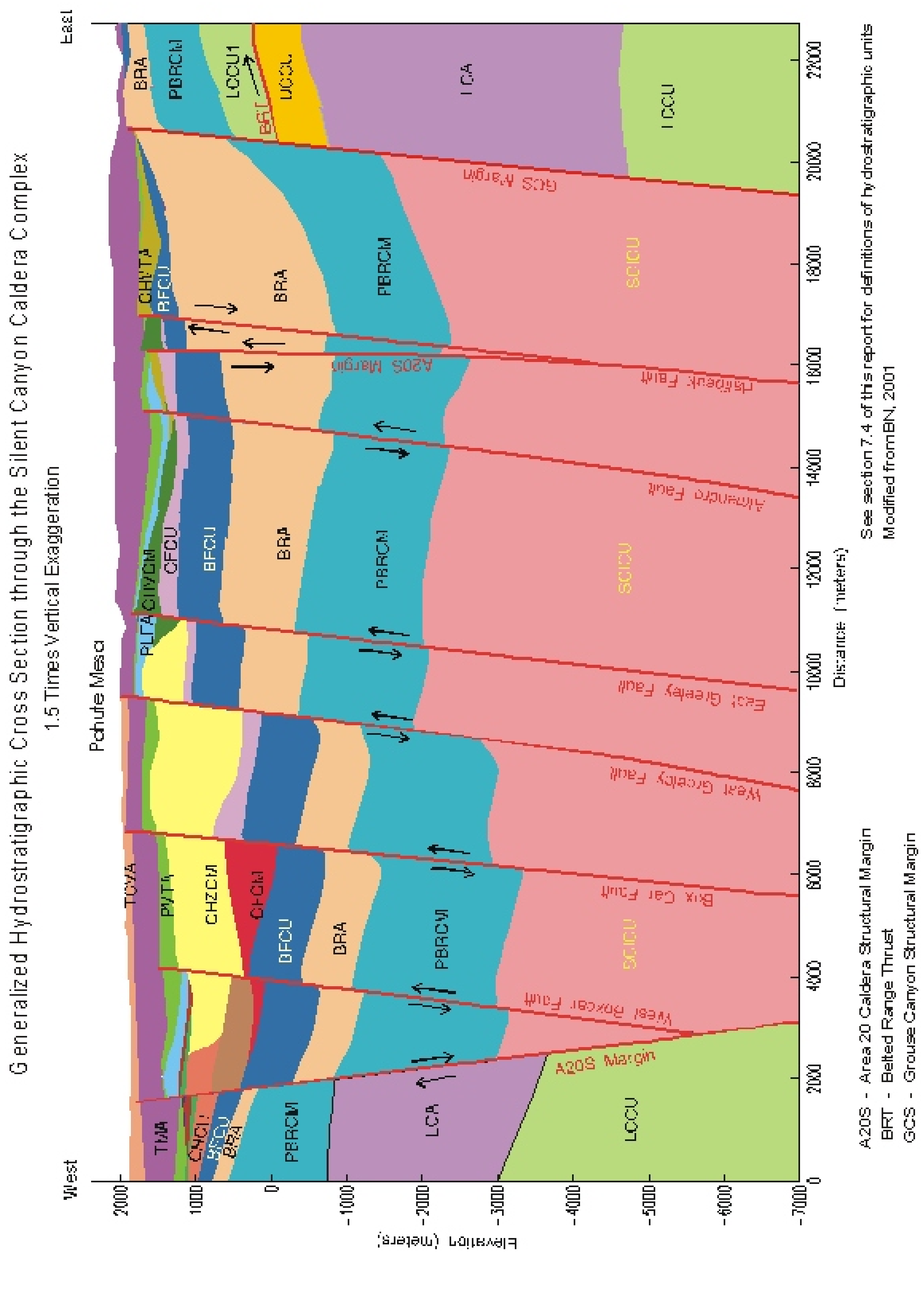


Figure 7.8 Generalized Geologic Cross Section Through Pahute Mesa

Hydrogeology Overview of Pahute Mesa

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 7.4, their work has provided the foundation for most subsequent hydrogeologic studies at the NTS (IT 1996a; BN 2002c).

The hydrogeology of PM-OV area 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.

All the rocks in the PM-OV area can be classified as one of nine hydrogeologic units, which include the alluvial aquifer, four volcanic hydrogeologic units, two intrusive units, and two hydrogeologic units that represent the pre-Tertiary rocks (Table 7.1).

The rocks within the PM-OV area are grouped into 46 HSUs for the UGTA framework model (Table 7.6). The volcanic units are organized into 40 HSUs that include 16 aquifers, 13 confining units, and 11 composite units (comprising a mixture of hydraulically variable units). The underlying pre-Tertiary rocks are divided into six HSUs, including two aquifers and four confining units. HSUs that are common to several CAUs at the NTS are briefly discussed in Section 7.4.

Water-level Elevation and Groundwater Flow Direction

Water-level data are relatively abundant for the underground test area on Pahute Mesa in the northwestern portion of the NTS, as a result of more than thirty 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 regional 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.

RAINIER MESA

Rainier Mesa/Shoshone Mountain CAU consists of 60 CASs on Rainier Mesa and six on Shoshone Mountain, which are located in NTS Areas 12 and 16 respectively (Figure 7.5). Rainier Mesa and Aqueduct Mesa form the southern extension of the northeast trending Belted Range (Figure 7.4). Together, these two mesas constitute the third major area utilized for underground testing of nuclear weapons at the NTS between 1957 and 1992. Weapons effects 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 test area.

Geology Overview of Rainier Mesa and Shoshone Mountain

Both mesas are composed of Miocene age air-fall and ash-flow tuffs, which were 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). The stratigraphic units and lithologies are similar to those present in the subsurface of Yucca Flat (Section 7.5). 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 trace of the CP thrust fault extends through the pre-Tertiary rocks of Rainier Mesa, and several high-angle, normal faults have been mapped in the volcanic rocks at both test areas. 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.

Hydrogeology Overview of Rainier Mesa and Shoshone Mountain

Construction of UGTA CAU-level models for the Rainier Mesa and Shoshone Mountain test areas has not yet begun. 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 7.5).

Water-level Elevation and Groundwater Flow Direction

The SWL at Rainier Mesa is at a depth of about 258 m (846 ft), or about 1,847 m (6,061 ft) elevation above Mean Sea Level and typically within the TCU. This anomalously high water level relative to the regional water level reflects the presence of water perched above the underlying tuff confining units (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; 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.

Regional groundwater flow from Rainier Mesa may be directed either toward Yucca Flat or, because of the intervening UCCU, to the south toward Alkali Flat discharge area (Figure 7.3). The groundwater flow direction beneath Shoshone Mountain is probably southward as indicated in Figure 7.3.

7.6 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 formations (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, ^{14}C 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, sorbtion, and natural decay, to operate.

It is imperative that those responsible for developing viable monitoring programs understand this unique hydrogeologic setting. As described in this chapter, a vast amount of hydrogeologic data has been acquired in support of NTS programs over the last 40 years, and data continue to be acquired. Now scientists are using these data to develop and improve models for predicting groundwater flow and contaminant transport at the NTS. All of these resources, including databases, groundwater flow models, and subject matter experts, were utilized during the development of the Routine Radiological Environmental Monitoring Program (RREMP) (DOE 1998a).

Another beneficial consequence of previous and current NTS activities is the availability of an array of boreholes that penetrate the saturated zone. A significant number of these “holes of opportunity” are in optimal locations, with appropriate well completions that provide access to aquifers of interest. Selected monitoring wells and water supply wells, both on and off the NTS, have been incorporated into a monitoring network for the RREMP. Additional wells will become available as the UGTA characterization wells are phased into the RREMP. Analytical results from routine sampling of these wells are reported in Chapter 8.0, “Groundwater Monitoring.”

Table 7.1 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 hydro-geologic 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 trans-missivities 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 (2002c).

Table 7.2 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 7.1 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).

Table 7.3 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.
Pahute Mesa	19, 20	85	85	1965 - 1992	31 - 1452 m (100 - 4765 ft)	Alluvium (thin) Volcanic tuffs & lavas	Almost all were large-diameter vertical emplacements above and below static water level; includes 19 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 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 volcanics	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 tunnel-based 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[b] 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) JOHNNIE BOY was detonated at a depth of 1.75 ft (essentially a surface burst) approximately one mile east of Buckboard Mesa.
Note: Source: Allen, et al., 1997.

Table 7.4 Hydrostratigraphic Units of the Frenchman Flat 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 7.1 for descriptions of hydrogeologic units.
Note: Adapted from IT, 1998b.

Table 7.5 Hydrostratigraphic Units of the Yucca Flat 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 7.1 for description of hydrogeologic units.

Note: Adapted from Gonzales and Drellack, 1999.

Table 7.6 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

(a) See Table 7.1 for definitions of hydrogeologic units.

Table 7.6 (Hydrostratigraphic Units of the Pahute Mesa-Oasis Valley Area, cont.)

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	Lava and welded ash-flow tuff

(a) See Table 7.1 for definitions of hydrogeologic units.

Table 7.6 (Hydrostratigraphic Units of the Pahute Mesa-Oasis Valley Area, cont.)

Hydrostratigraphic Unit (Symbol)	Dominant HydrogeologicUnit(s)[a]	Typical Lithologies
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
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	CA	Limestone and dolomite
Lower Clastic Confining Unit - Thrust Plate	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 7.1 for definitions of hydrogeologic units.

Eleana Range (No Date Provided)

8.0 GROUNDWATER MONITORING

Groundwater monitoring on and near the Nevada Test Site (NTS) is of particular importance due to the existing and potential groundwater contamination resulting from historical underground nuclear testing activities. Sixty groundwater monitoring locations both onsite and offsite were sampled for radioactivity by Bechtel Nevada (BN) in Calendar Year (CY) 2001. All analytical results received for tritium, the primary target analyte, were below Safe Drinking Water Act (SDWA) regulatory standards, while the vast majority were below measurable levels. Results received in 2001 were of high quality and continue to indicate that radionuclides have not traveled significant distances from underground test areas. Activities conducted within the Underground Testing Area (UGTA) program for year 2001 are described in Chapter 4.0 of this report.

8.1 INTRODUCTION

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 (U.S. Department of Energy [DOE] 1996b; DOE 2000b). This legacy of nuclear testing has resulted in the contamination of groundwater in some areas. Figure 8.1 indicates 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 the DOE directives, groundwater on and near the NTS is monitored for radioactivity. Monitoring in the past has been conducted by the U.S. Public Health Service, U.S. Geological Survey (USGS), U.S. Environmental Protection Agency (EPA), and others. In 1998, BN was tasked by the DOE, National Nuclear Security Administration Nevada Operations Office (NNSA/NV) to establish and manage the NTS Routine Radiological Environmental Monitoring Plan (RREMP), a single integrated and comprehensive monitoring program. The RREMP details groundwater monitoring objectives, regulatory drivers, and quality assurance protocols, which are also summarized in Chapter 4.0.

The NTS groundwater monitoring network consists of a variety of monitoring locations to determine if and to what extent aquifers have been impacted by radionuclides originating from activities on the NTS. These locations include onsite supply wells, wells specifically designed to monitor groundwater, natural springs, domestic offsite wells and point of opportunity locations. The onsite and offsite locations sampled in 2001 along with the predicted groundwater flow paths are presented in Figures 8.2 and 8.3, respectively. The NTS groundwater monitoring locations are located in a complex hydrogeologic setting as described in Chapter 7.0.

8.2 GROUNDWATER MONITORING ANALYTES

The analytes of interest for groundwater monitoring are based on the radiological source term from historical nuclear testing, regulatory/permit requirements, and characterization needs. Typical analyses are presented in Table 8.1 and include both radiological and chemical parameters to assess impacts to aquifers from past nuclear testing and to characterize the groundwater system. The sampling frequency presented in Table 8.1 is based on well type and location. The isotopic inventory remaining from nuclear testing is presented in the NTS Environmental Impact Statement (DOE 1996c) and 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 "puddle glass" and are not available for groundwater transport in the near term (Smith 1993; Smith et al., 1995). Tritium is the radioactive species created in the greatest quantities and is widely believed to be one of the most mobile. Tritium is therefore the primary target analyte and 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 1996c; International Technology [IT] 1997).

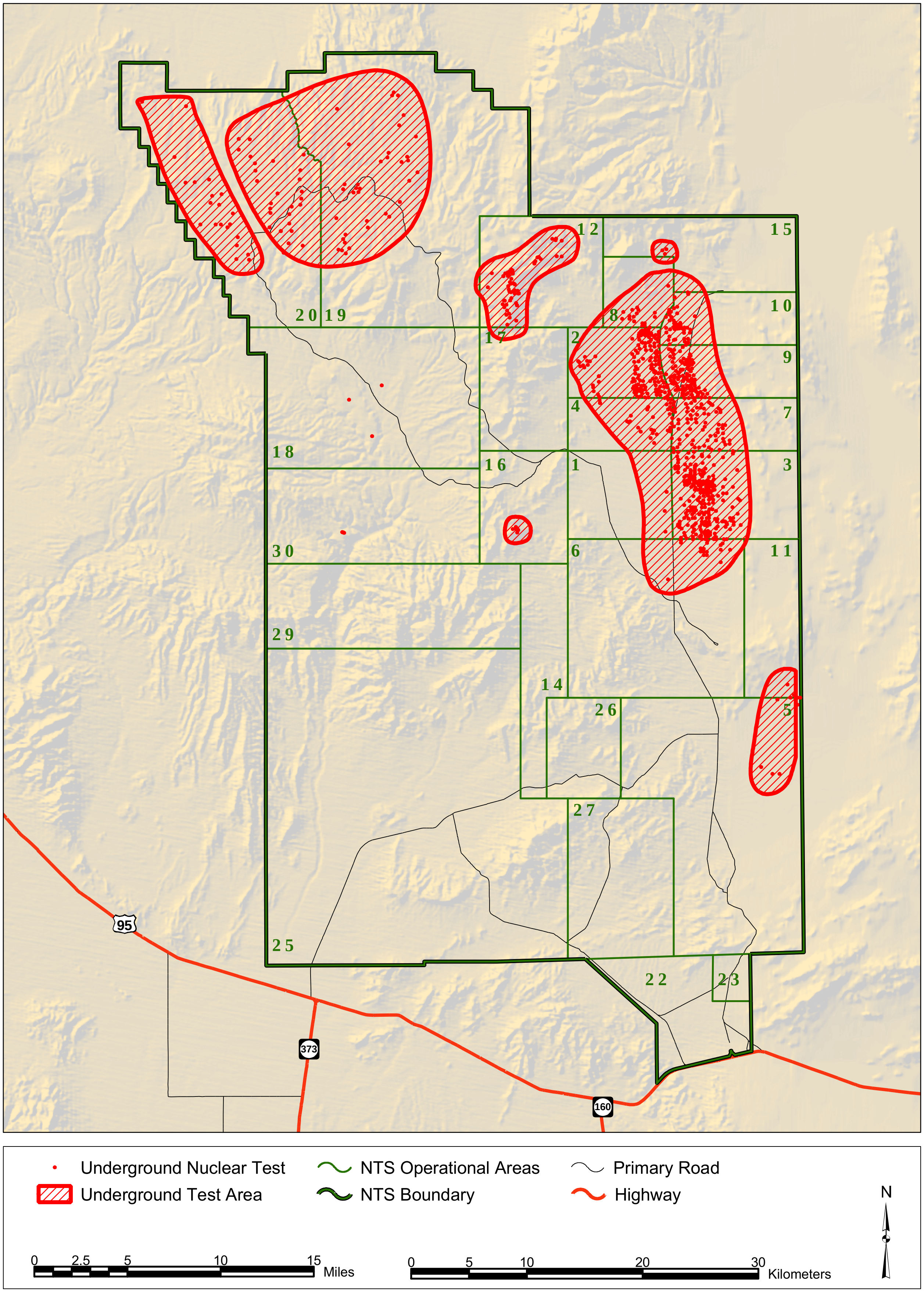
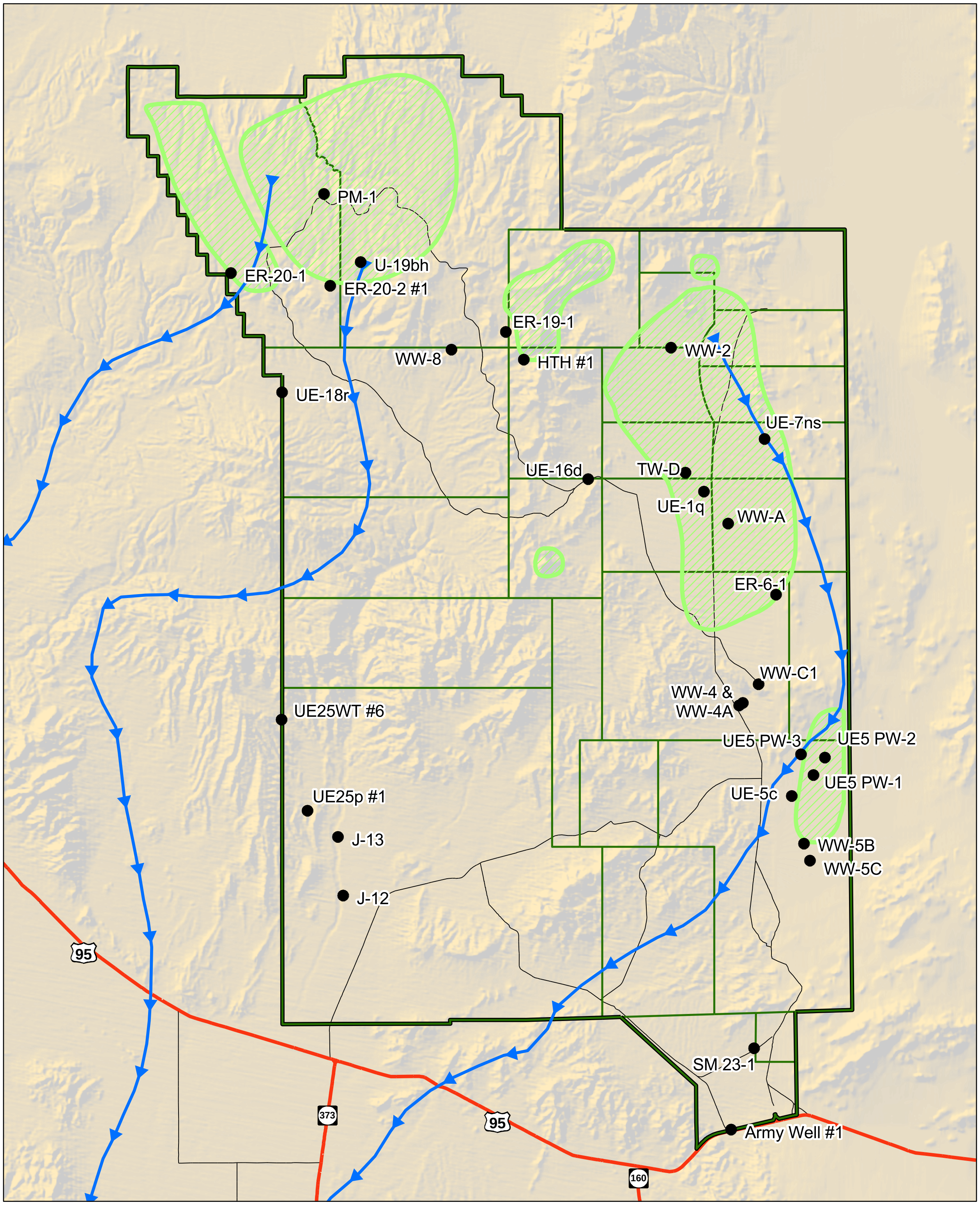


Figure 8.1 Areas of Potential Groundwater Contamination on the NTS



Monitoring Locations
Corrective Action Unit Boundary
Predicted Regional Groundwater Flowline
NTS Operational Areas
NTS Boundary
Primary Road
Highway

0 2.5 5 10 15 Miles
0 5 10 20 30 Kilometers
N

Figure 8.2 NTS Onsite Groundwater Monitoring Locations - 2001

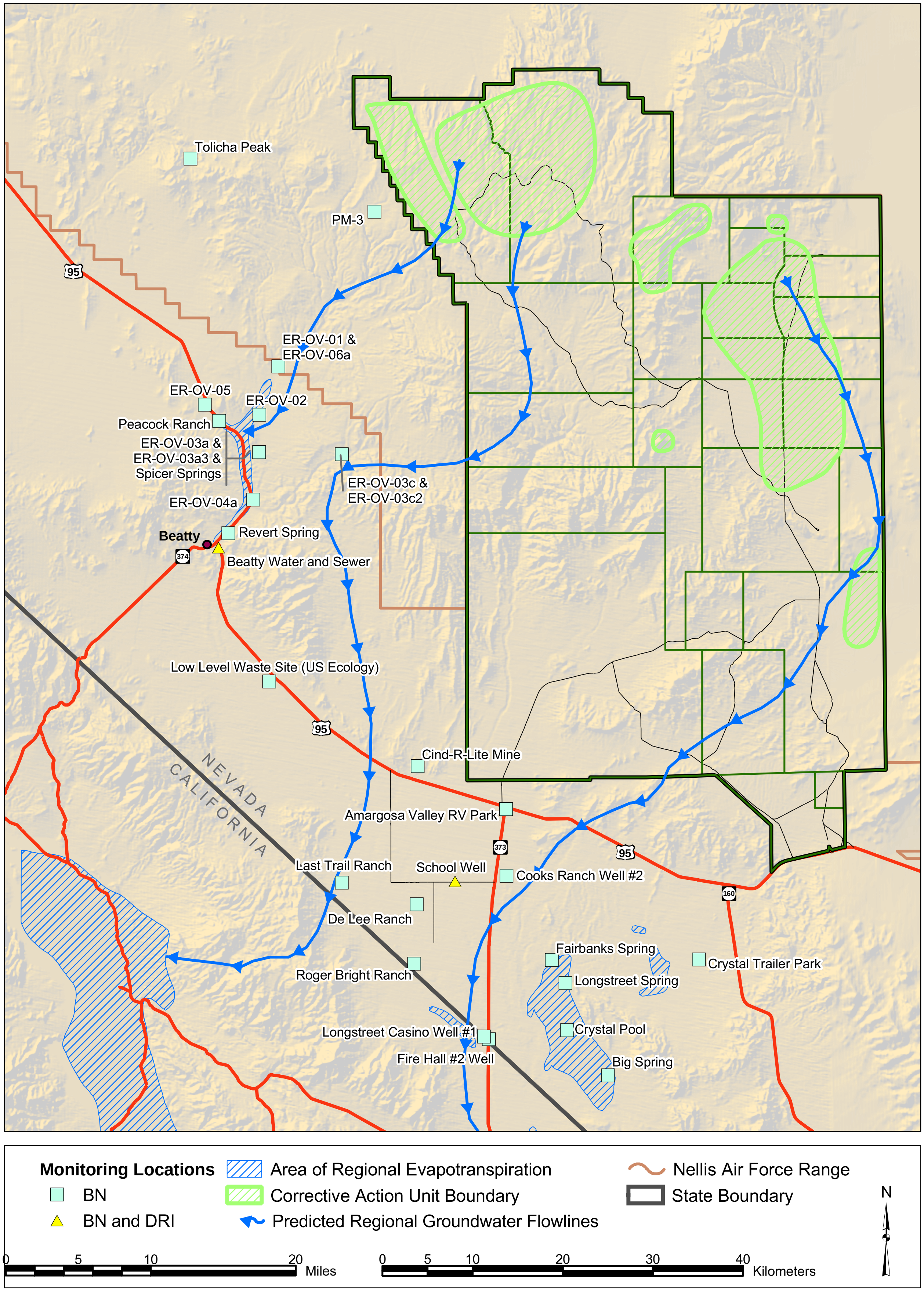


Figure 8.3 NTS Offsite Groundwater Monitoring Locations - 2001

The majority of tritium results presented in this chapter are from enriched samples. Tritium samples are enriched to achieve a very low detection limit. The enrichment process concentrates tritium in the samples to give an effective minimum detectable concentration (MDC) of near 10 pCi/L whereas the MDC for a standard (non-enriched) tritium analysis ranges from 200-400 pCi/L. The uncertainty/error values presented in the summary tables at the end of this chapter represent the counting uncertainty/error of the analytical method. Although the uncertainty associated with the enrichment process has not yet been quantified, it is estimated to be up to 20 percent and is not encompassed by the counting uncertainty/error. It is therefore important to note that the total or system error associated with the enrichment and analysis process for tritium samples is somewhat higher than the values presented in the summary tables.

8.3 GROUNDWATER MONITORING RESULTS

QUALITY ASSURANCE

The results are discussed below.

TRITIUM

Onsite Supply Wells

Quarterly samples for tritium analyses were collected from the water supply wells in 2001 with all results below the MDC. The only onsite water supply well with a history of validated detections for tritium is Water Well C-1. This well was injected with approximately 0.1 to 0.2 Curies of tritium by a researcher conducting a tracer test in 1962 (Lyles 1990). All data collected to date indicate that the current onsite water supply network has not been impacted by subsurface nuclear testing.

Figure 8.4 is a time series plot of tritium concentrations for locations which have a history of detectable tritium and were sampled in 2001. This plot illustrates the decrease of the annually averaged tritium concentrations in Well C-1 over time. Figure 8.5 shows the locations of the wells presented in Figure 8.4.

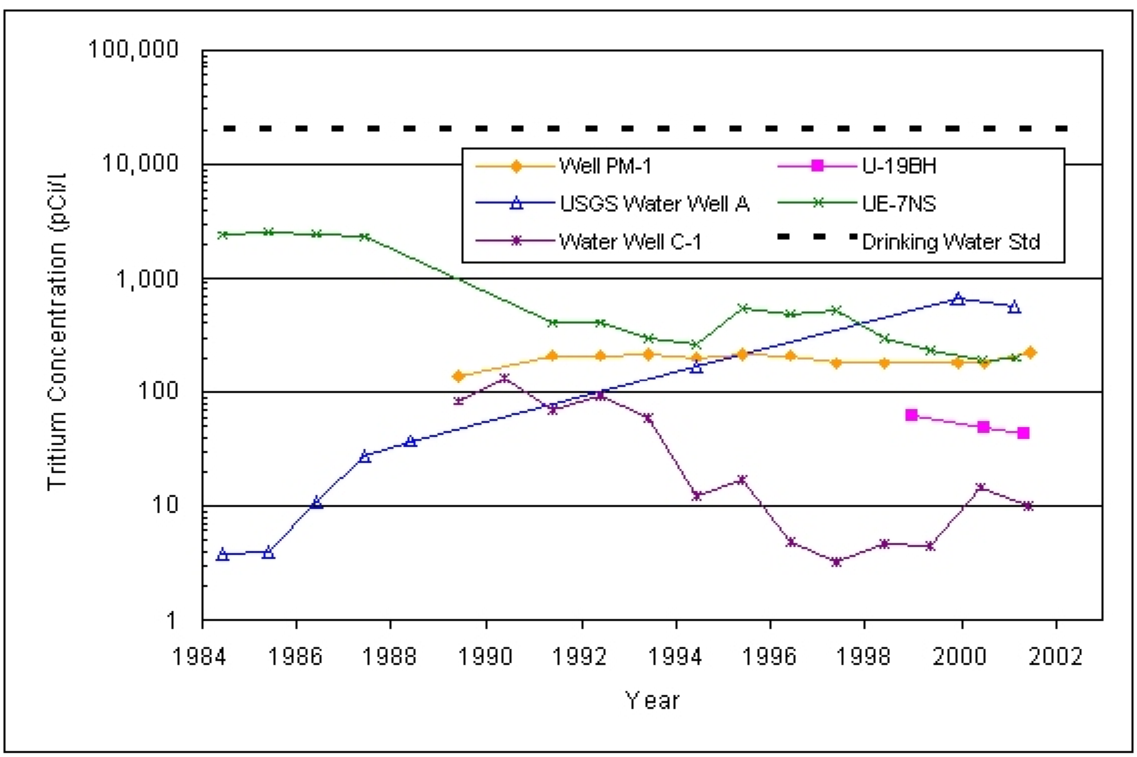


Figure 8.4 Wells with a History of Detectable Tritium

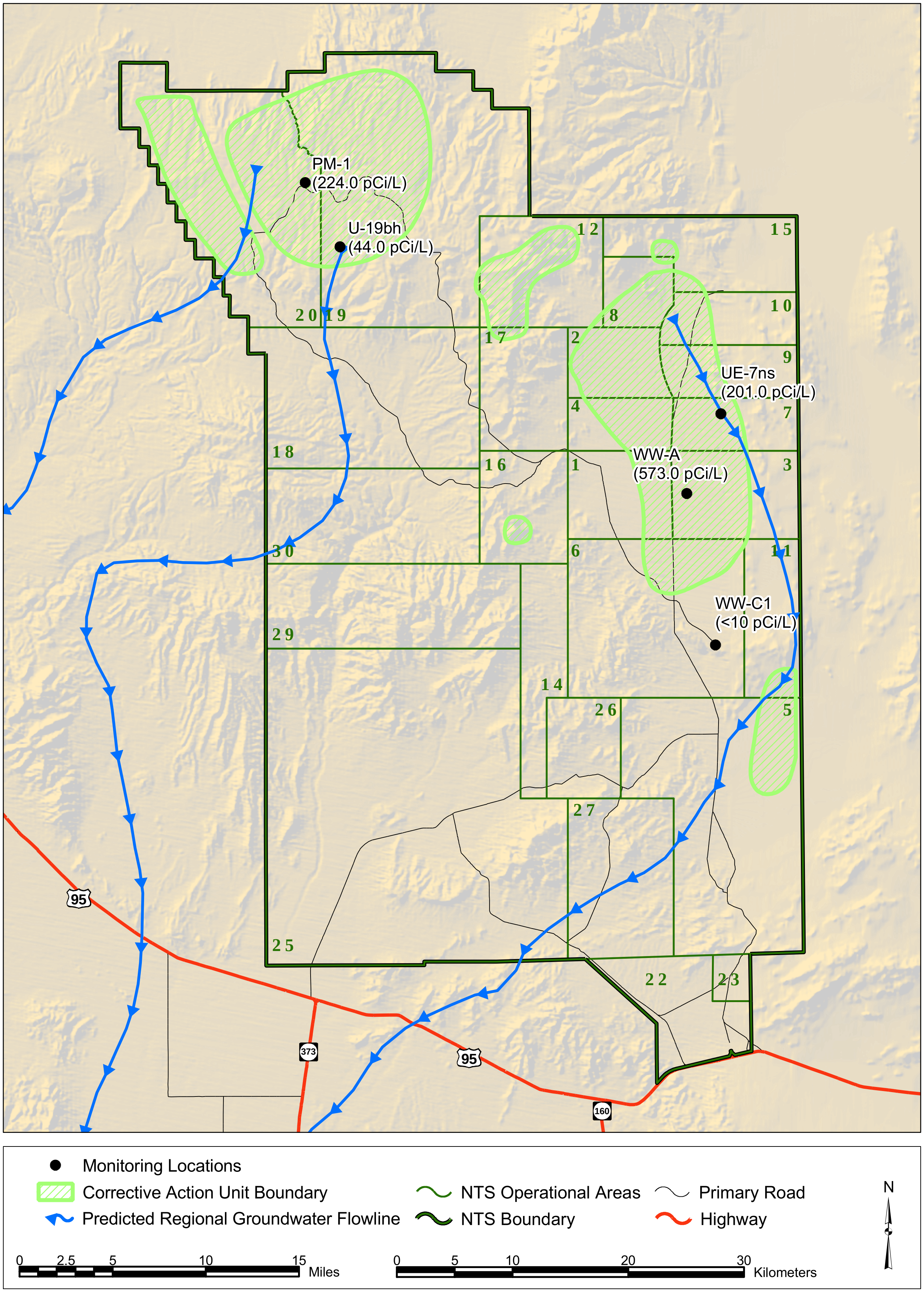


Figure 8.5 NTS Groundwater Monitoring Locations With a History of Detectable Tritium - 2001

Analytical results for all tritium samples are presented in Table 8.2. This table shows all results were well below the regulatory standard of 20,000 pCi/L and MDC.

Onsite Monitoring Wells

Of the 19 onsite monitoring wells sampled in year 2001, only 5 had results above the MDC for tritium. These locations are Wells PM-1, UE-7nS, U-19bh, Ue25p#1, and Water Well A. These wells, with the exception of Ue25p#1, are located within 1 km of underground nuclear tests and are shown in Figure 8.5. The uncertainty of the Ue25p#1 result encompasses the MDC. This well is located over 15 miles from the nearest underground test and does not have a history of detectable tritium.

Well PM-1, located on Pahute Mesa, has a history of tritium concentrations near 200 pCi/L over the last ten years. This well has an unslotted casing from ground surface to a depth of 2,300 m and an open hole from 2,300 - 2,356 m below ground surface. Sampling depths have historically ranged from 3 - 100 m below the static water level (~643 m below ground surface). In 2001, samples were collected throughout the borehole profile to identify where the tritium was entering the borehole. Results from the profile sampling showed a decreasing tritium concentration with depth indicating that the tritium is entering the borehole near the water table. Future studies are being proposed to investigate current borehole conditions at this location.

Potential sources of the tritium detected in Well PM-1 include the FARM (U-20ab), GREELEY (U-20g), and KASSERI (U-20z) underground nuclear tests. The FARM test, although believed to be downgradient, is the closest test detonated near or below the water table to PM-1. The GREELEY and KASSERI tests were of relatively large magnitude and detonated 2,429 and 1,196 m, upgradient of PM-1, respectively.

Well UE-7nS was drilled 137 m from the BOURBON underground nuclear test (U-7n) conducted in Yucca Flat in 1967. This well was routinely sampled between 1978 and 1987 and again since 1992. In year 2001, approximately 200 pCi/L of tritium was detected in water samples from Well UE-7nS. This result is consistent with the trend of decreasing concentrations seen in recent years; however, Finnegan and Thompson (2002) reported increased tritium concentrations at this location after repeated runs downhole with a bailer. They suggest that the turbulence from the repeated bailer runs may be mixing in higher tritium concentrations from below, but caution that more data is necessary to confirm this hypothesis.

Well UE-7nS is the second known site on the NTS where the regionally important carbonate aquifer has been impacted by radionuclides from nuclear testing (Smith et al., 1999). Well UE-2ce is the first known location on the NTS where the regionally important carbonate aquifer has been impacted. This well is located less than 200 m from the NASH test (conducted in Yucca Flat in 1967) and is not currently configured for sampling.

Well U-19bh is an inventory emplacement borehole on Pahute Mesa, which is currently used for sampling. This location has a tritium concentration slightly above the MDC. The origin of the tritium is unclear. Investigations at this location suggest that the water in this borehole is from a perched aquifer (Brikowski et al., 1993). There were several nuclear detonations conducted near the U-19bh borehole; however, identifying the likely source of tritium is particularly difficult due to a lack of data regarding the perched system. Results from a tracer test conducted in Well U-19bh (Brikowski et al., 1993) indicate that there is little flow across the borehole. These results therefore indicate that the water chemistry of the borehole may not be representative of the aquifer; however, due to the presence of tritium, the data is presented as a point of interest.

Water Well A, located in Yucca Flat, has had measurable tritium since the late 1980's. Measured concentrations in 2001 are lower than those reported in 1999 and may indicate the beginning of a downward trend at this location. Water Well A is completed in alluvium and located within 1 km of 14 underground nuclear tests, most of which appear to be upgradient of Well A.

It is significant to note that radionuclide contamination has not been detected in Well U-3cn #5. This well is completed in the regionally significant carbonate aquifer 60 m from the BILBY (U-3cn) test. BILBY was conducted in 1963 in a zeolitic volcanic tuff confining unit (section 7.4) less than 120 m above the carbonate aquifer.

Figure 8.4 is a time series plot of tritium concentration for locations sampled in 2001 with a history of detectable tritium. Data presented in Figure 8.4 prior to 1999 for Wells PM-1, UE-7nS, and Water Well A are annual averages obtained from EPA. Figure 8.5 shows the locations of wells with detectable tritium from samples collected in CY 2001. Results for all onsite monitoring well samples are presented in Table 8.2.

Offsite Locations

Thirty offsite locations were sampled for tritium analyses in 2001 (see Figure 8.3). All results were below the MDC and are presented in Table 8.2.

GROSS ALPHA

Onsite Supply Wells

Quarterly samples were collected from the supply wells for gross alpha analyses in CY 2001. All results were below the regulatory standard of 15 pCi/L, with the exception of the fourth quarter result from Water Well C-1, which slightly exceeded the standard, with a value of 17 pCi/L. A field duplicate was also collected with a result of 13 pCi/L. SDWA regulations require annual averages to be below the standard; therefore, the well was within compliance for 2001 when the quarterly results were averaged. In addition to man-made radionuclides, many naturally occurring minerals/elements contribute to alpha radiation (e.g. minerals containing uranium). These elements are more abundant in volcanic source rocks. Therefore, wells producing water from these rocks will likely have relatively higher gross alpha values. Results of all gross alpha analyses for samples collected in 2001 are presented in Table 8.3.

Figure 8.6 shows the annual averages of gross alpha analyses for the supply wells from the past ten years. This figure illustrates that the regulatory standard for gross alpha has not been exceeded since 1991.

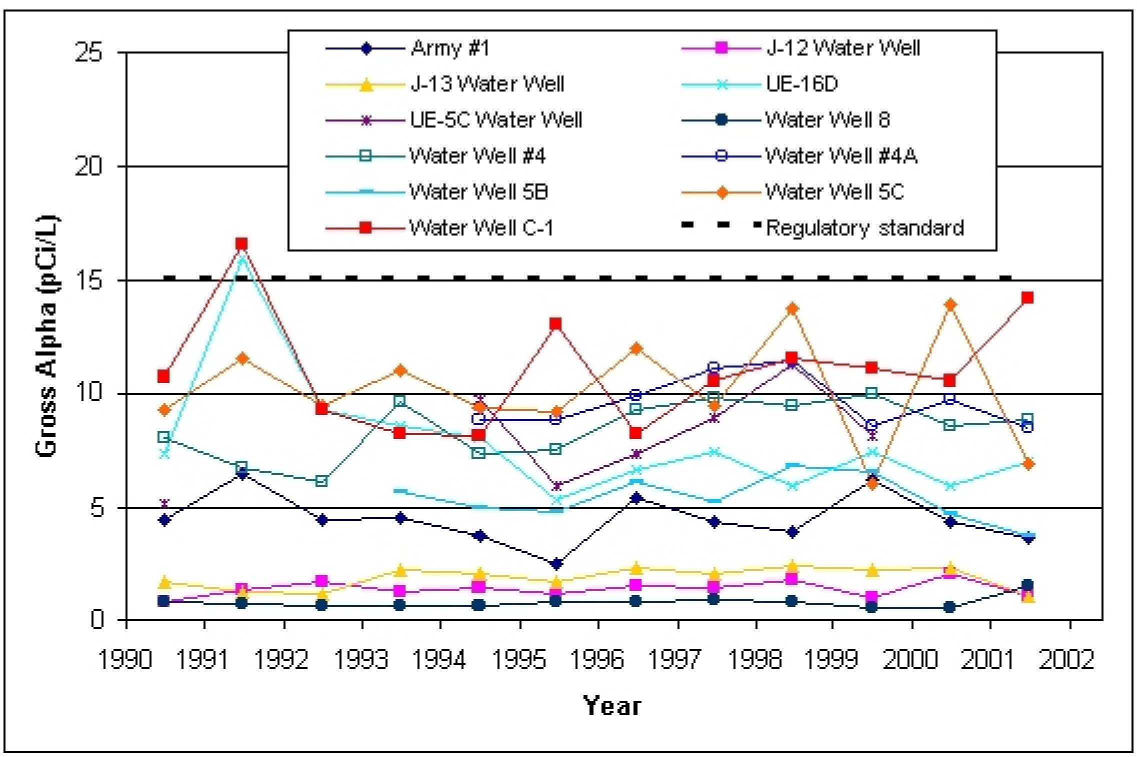


Figure 8.6 Annual Averages of Gross Alpha in Supply Wells

Onsite Monitoring Wells/Offsite Locations

During 2001, 13 onsite monitoring wells and 16 offsite locations were sampled for gross alpha analyses. All samples were below the regulatory standard with the exception of onsite Well UE-25P #1, which slightly exceeded the regulatory standard and is used solely as a monitoring location. Table 8.3 presents all gross alpha results for samples collected in 2001.

GROSS BETA

Onsite Supply Wells

Results for all gross beta analyses collected from the supply wells in 2001 were well below the drinking water standard of 50 pCi/L. Figure 8.7 is a plot of historical gross beta annual averages. This plot indicates that the gross beta concentrations within the water supply wells are stable, and there is no indication of significant increasing trends. Actual gross beta values for CY 2001 analyses are presented in Table 8.4.

Onsite Monitoring Wells/Offsite Locations

During 2001, samples were collected for gross beta analyses from 14 onsite monitoring wells and 23 offsite locations. All results were below drinking water standards and are presented in Table 8.4.

GAMMA SPECTROSCOPY

Ten supply wells, 17 onsite monitoring locations, and 25 offsite locations were sampled for gamma-emitting radionuclides in 2001. Nine locations had detectable concentrations of radionuclides. Results are presented in Table 8.5. All gamma results, when accounting for analytical uncertainty, encompass their MDCs.

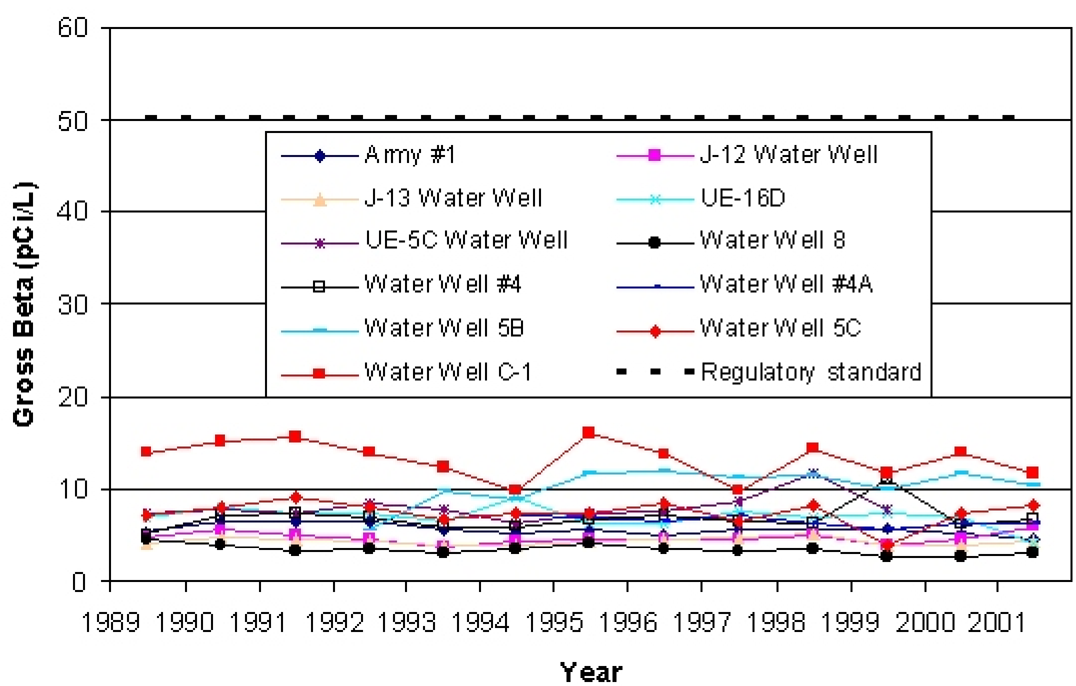


Figure 8.7 Annual Averages of Gross Beta in Supply Wells

RADIUM

During 2001, one onsite monitoring well, one offsite location, and ten supply wells were sampled for radium analyses. Results from all sampling locations were below the drinking water standard of 5 pCi/L for the combined ^{226}Ra and ^{228}Ra concentrations. Results from CY 2001 radium analyses are presented in Tables 8.6 and 8.7.

PLUTONIUM

Eight supply wells, 14 onsite monitoring locations, and 26 offsite locations were sampled for ^{238}Pu and $^{239+240}$Pu in 2001. All plutonium results were below the MDC and are presented in Tables 8.8 and 8.9.

STRONTIUM

During 2001, one onsite monitoring well, one offsite location, and eight supply wells were sampled for ^{90}Sr analyses. All 2001 results were below the MDC and are presented in Table 8.10.

8.4 SUMMARY OF GROUNDWATER MONITORING

In 2001, 60 groundwater monitoring locations were sampled for radioactivity. Of the 60 locations sampled, there were no results which exceeded the SDWA regulatory limit for the primary target analyte, tritium. In fact, over 90 percent of the locations sampled had tritium concentrations below measurable levels. Additionally, analytical data received in 2001 are of high quality, in good agreement with historical data, and indicate that radionuclides have not traveled significant distances from underground testing areas.

8.5 GROUNDWATER MONITORING OVERSIGHT ACTIVITIES

COMMUNITY ENVIRONMENTAL MONITORING PROGRAM - WATER MONITORING PROJECT

The Desert Research Institute (DRI) was tasked by the DOE, during fiscal year 2001, to provide independent verification of the tritium activity within some of the offsite groundwater wells and water supply systems in areas surrounding the NTS. Samples collected by DRI personnel provide not only an independent measure of the levels of radioactivity within these wells, but, in some cases, a direct comparison to the results obtained by the RREMP.

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 incorporated into the water molecule itself, it is also one of the most mobile.

Sample Locations

Sixteen wells, three water supply systems, and one spring were sampled during the period of March 6 to June 19, 2001. Sample locations were selected based upon input from the Community Environmental Monitors (DRI employees living within each community and acting as a liaison between DOE sponsored environmental monitoring programs and the local populace). All wells were sampled utilizing down hole submersible pumps. Samples from water supply systems were collected via discharge from a faucet connected to that system. The spring was sampled by hand at its orifice. Each well was pumped a minimum of 10 to 15 minutes prior to sampling to purge water from the pump tubing and well annulus. This process insured that the resultant sample was representative of local groundwater. Table 8.11 lists all of the wells, the date they were sampled, and the sampling method . The locations of the wells, spring, and municipal water supply sample points are also presented in Figure 8.3.

Procedures and Quality Assurance

DRI utilized several methods to ensure that radiological results reported herein conform to current quality assurance protocols. This was achieved through the use of standard operating procedures, field quality assurance samples, and laboratory quality assurance procedures.

DRI's standard operating procedures are detailed instructions that describe the method and materials, using step-by-step instructions, that are required to decontaminate and operate the sample equipment, 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. In addition, duplicate samples were collected to establish a measure of the repeatability of the analysis. Field quality assurance samples were collected solely to support the interpretation of the tritium samples. Six samples (30 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 limit of detection of the reported results. Analysis of field and laboratory quality assurance samples indicate a high degree of confidence can be associated with all of DRI's FY 2001 results.

Tritium Results

The results of tritium analyses from the DRI Tritium Laboratory are presented in Table 8.12. Tritium activities averaged 6.4 pCi/L and ranged from <1 to 34 pCi/L. All sample analyses were well below the safe drinking water limit of 20,000 pCi/L. The highest activities were associated with samples collected from Henderson and Boulder City. The water in these samples originated from Lake Mead. Slightly elevated tritium activities in Lake Mead are well documented by previous investigations and are due to residual tritium persisting in the environment that originated from atmospheric nuclear testing.

8.6 VADOSE ZONE MONITORING (VZM)

As explained in Chapter 4.0 of this report, the vadose zone is monitored at three general types of sites on the NTS: Radioactive Waste Management Sites (RWMSs), Resource Conservation and Recovery Act closure sites, and permitted sanitary landfills. Vadose zone monitoring (VZM) is conducted at various locations in addition to, or in lieu of, groundwater monitoring for the purpose of protecting groundwater resources.

A VZM data set has been collected for the past eight years at the Area 5 weighing lysimeter facility. This facility consists of two weighing lysimeters located about 400 m (1312 ft) southwest of the Area 5 RWMS. Each lysimeter consists of a steel box 2 m (6.6 ft) deep, filled with soil and having an area of 2 m x 4 m (6.6 ft x 13 ft). Each lysimeter is mounted on a sensitive scale, which is continuously monitored using an electronic loadcell. 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 facility has been in continuous operation since March 1994 and has provided data to support the important assumption made in the Area 3 and Area 5 Performance Assessments of no downward movement of water beyond plant rooting depths. This facility has also provided data to justify other NTS closure covers (DOE 2000c; d).

Total soil water storage is illustrated in Figure 8.8 for the period of March 1994, through December 2001. Daily precipitation totals are also illustrated in Figure 8.8. The soil water storage increases, early in the data record for the vegetated lysimeter, were due to irrigations to ensure that transplanted vegetation survived. Note the steep decrease in soil water storage in the vegetated lysimeter following high-rainfall periods. Also note that the vegetated lysimeter is considerably drier than the bare-soil lysimeter, despite the paucity of plants in the vegetated lysimeter (about 15 percent cover). No drainage has ever been measured from the permeable bottoms of either lysimeter to date. However, volumetric water content at a depth of 170 cm (5.6 ft) in the bare-soil lysimeter has increased from about 9 to 14 percent since the facility was installed.

In addition to the weighing lysimeter facility, a drainage lysimeter facility was installed next to the U-3ax/bl disposal unit at the Area 3 RWMS. This facility is instrumented with soil water content and matric potential sensors and will be used to test the effectiveness of different surface treatments in support of long-term waste cover design.

In addition to lysimeter facilities, vadose zone monitoring of waste cell covers and floors using automated systems has been conducted at the Area 5 RWMS since late 1998. Soil water content at various depths with time is illustrated in Figure 8.9 for an automated waste cover monitoring system on the cover of Pit 3 at the Area 5 RWMS. Note the depth of infiltration has not exceeded 90 cm (3 ft) before that water was returned to the atmosphere by evaporation. For further details on, and data from, the RWMS VZM program, refer to "NTS 2001 Waste Management Monitoring Report Area 3 and Area 5 Radioactive Waste Management Sites," (BN 2002b).

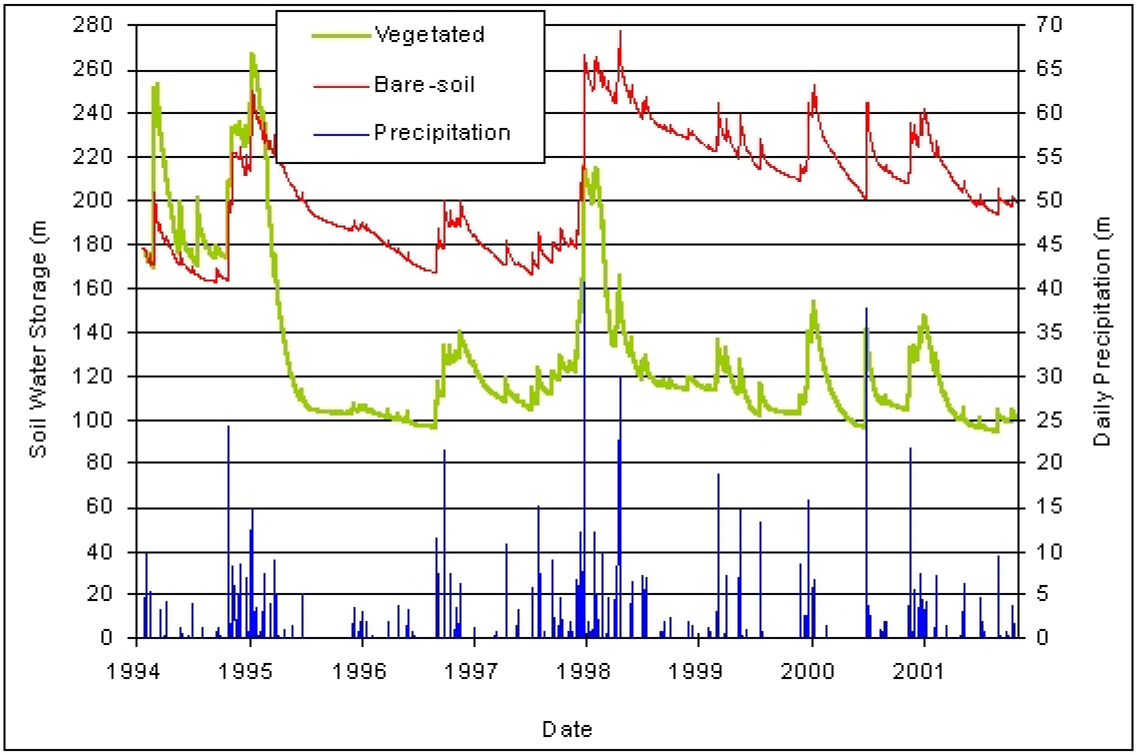


Figure 8.8 Weighing Lysimeter and Precipitation Data from March 1994 through December 2001

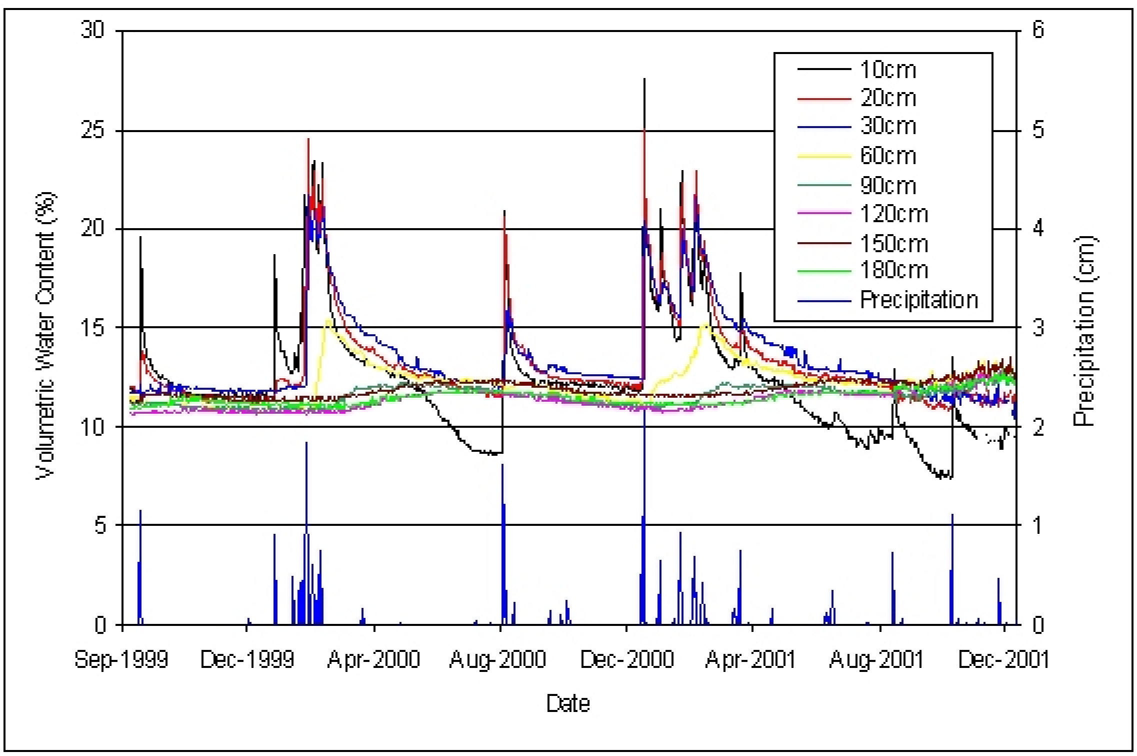


Figure 8.9 Soil Water Content in Pit 3 Waste Cover (North Side) using an Automated TDR System

Table 8.1 Typical Sampling and Analysis Schedule for RREMP Groundwater Monitoring

Sample Location Type		Analysis	Sample Frequency	Regulatory Driver
Onsite Locations	Potable water supply well within CAU	Ie & II	Quarterly	40 CFR 61 and DOE Order 5400
		III & IV	Annually	"
	Other potable water supply well	I & II	Quarterly	DOE Order 5400 Series
		III & IV	Annually	"
	CAU non-potable water supply well	Ie	Quarterly	DOE Order 5400 Series
		II, III, & IV	Annually	"
	Other non-potable water supply well	I	Semiannually	DOE Order 5400 Series
		II, III, & IV	Biennially	"
	Monitoring Well (Non-water supply)	I	Annually	DOE Order 5400 Series
		II, III, & IV	Biennially	"
	Source Characterization Well[(a)]	I, II, III, & IV	Biennially[(b)]	DOE Order 5400 Series
	New Wells	Ie, II, III, & IV	Quarterly[(c)]	DOE Order 5400 Series
Offsite Locations[(d)]	Group A locations (Oasis Valley and vicinity)	Ie, IIg	Quarterly	40 CFR 61 and DOE Order 5400
		II, III+	Annually	"
	Group B locations (more distant)	I, IIg	Semiannually	DOE Order 5400 Series
	Group C locations (most distant)	I, IIg	Annually	DOE Order 5400 Series
	New locations	Ie, II, III+, IV	First sample	40 CFR 61 and DOE Order 5400

(a) Source Characterization Wells are currently known as the Hot Well Network. Additional sampling parameters may be specified for each hot well.
(b) Biennial frequency can be modified for well-specific sampling program.
(c) After four quarterly samples are acquired, sampling parameters and frequency will be based on the well type.
(d) Offsite locations include both drilled wells and natural springs.

Note: All parameters and frequencies of analysis are subject to revision after data are acquired and reviewed, if justified.
Corrective Action Units (CAUs) are as defined by Underground Testing Area (UGTA) Project (IT, 1996c).

Type I Analysis include Standard Tritium; at select wells enriched tritium analysis (Type Ie) will be performed.
Type II Analysis include Gross Alpha and Gross Beta. For drinking water wells, also includes Ra-226 & 228 analyses. Type IIg analysis includes only Gamma emitters.
Type III Analysis include Gamma emitters, Plutonium. Type III+ analysis includes Type III plus Sr-90.
Type IV Analysis include pH, Specific Conductivity, Temperature, Principal Cations/Anions, Total Dissolved Solids, Alkalinity, and Bicarbonate.

Table 8.2 Summary of Tritium Results - 2001

Area	Location	Date Sampled	Result (pCi/L)	Lab. Qualifier	MDC (pCi/L)	Error (2 sigma)	Sampling Method
Onsite Supply Wells							
05	Water Well 5B	2001-02-06	-10.95	(a)	11.40	7.85	pump
05	Water Well 5B	2001-04-03	-5.16	(a)	11.55	8.81	pump
05	Water Well 5B	2001-07-31	-5.80	(a)	10.14	6.57	pump
05	Water Well 5B	2001-10-30	-3.24	(a)	18.98	10.94	pump
05	Water Well 5B [(b)]	2001-10-30	-10.65	(a)	17.34	11.01	pump
05	Water Well 5C	2001-02-06	-12.61	(a)	11.26	7.73	pump
05	Water Well 5C	2001-04-03	-2.99	(a)	10.05	6.50	pump
05	Water Well 5C	2001-07-31	-3.83	(a)	10.05	7.85	pump
05	Water Well 5C	2001-10-31	-2.03	(a)	17.34	11.65	pump
06	Water Well #4	2001-02-06	-8.74	(a)	10.92	7.43	pump
06	Water Well #4	2001-04-03	-3.30	(a)	11.08	7.34	pump
06	Water Well #4	2001-07-31	5.00	(a)	10.00	6.33	pump
06	Water Well #4 [(b)]	2001-07-31	0.51	(a)	10.10	7.12	pump
06	Water Well #4	2001-10-30	-2.25	(a)	17.85	10.07	pump
06	Water Well #4A	2001-02-06	-13.30	(a)	10.41	7.01	pump
06	Water Well #4A	2001-04-03	-3.12	(a)	10.47	7.32	pump
06	Water Well #4A	2001-07-31	2.64	(a)	10.13	6.17	pump
06	Water Well #4A [(b)]	2001-07-31	-1.77	(a)	10.18	5.93	pump
06	Water Well #4A	2001-10-30	-7.63	(a)	17.34	9.86	pump
06	Water Well C-1	2001-02-06	-10.31	(a)	32.16	6.70	pump
06	Water Well C-1	2001-04-03	5.88	(a)	9.84	6.59	pump
06	Water Well C-1	2001-07-31	7.55	(a)	9.91	6.13	pump
06	Water Well C-1	2001-10-30	3.83	(a)	17.72	9.56	pump
16	UE-16d Eleana Water Well	2001-02-06	-11.38	(a)	11.84	5.87	pump
16	UE-16d Eleana Water Well	2001-04-03	-3.12	(a)	10.47	5.23	pump
16	UE-16d Eleana Water Well	2001-07-31	8.06	(a)	9.95	5.07	pump
16	UE-16d Eleana Water Well	2001-10-30	-5.90	(a)	17.72	7.72	pump
18	Water Well 8 (USGS HTH-8)	2001-02-06	-13.25	(a)	10.35	6.00	pump
18	Water Well 8 (USGS HTH-8)	2001-04-03	-6.10	(a)	10.21	8.46	pump
18	Water Well 8 (USGS HTH-8)	2001-07-31	4.29	(a)	10.00	6.19	pump
18	Water Well 8 (USGS HTH-8)	2001-10-30	-5.14	(a)	17.85	10.37	pump
18	Water Well 8 (USGS HTH-8) [(b)]	2001-10-30	-6.16	(a)	17.09	8.51	pump
22	Army #1 Water Well	2001-02-06	-7.36	(a)	11.52	5.97	pump
22	Army #1 Water Well	2001-04-04	-5.82	(a)	9.78	7.23	pump
22	Army #1 Water Well	2001-08-01	0.00	(a)	10.43	5.65	pump
22	Army #1 Water Well	2001-10-31	-6.66	(a)	17.59	8.83	pump
25	J-12 Water Well	2001-02-07	-11.79	(a)	10.52	8.49	pump
25	J-12 Water Well	2001-04-04	-1.50	(a)	10.05	7.11	pump
25	J-12 Water Well	2001-08-01	5.56	(a)	10.19	6.48	pump
25	J-12 Water Well [(b)]	2001-08-01	5.09	(a)	10.19	8.80	pump
25	J-12 Water Well	2001-10-31	-0.65	(a)	18.12	10.53	pump
25	J-13 Water Well	2001-02-07	-10.98	(a)	11.43	17.41	pump
25	J-13 Water Well	2001-04-04	-4.95	(a)	11.08	21.08	pump
25	J-13 Water Well	2001-08-01	-1.39	(a)	9.72	23.61	pump
25	J-13 Water Well [(b)]	2001-08-01	1.42	(a)	10.38	8.96	pump
25	J-13 Water Well	2001-10-31	-3.54	(a)	17.09	48.23	pump
25	J-13 Water Well [(b)]	2001-10-31	-0.35	(a)	12.89	11.23	pump

(a) Below detectable limit.
(b) Field duplicate.

Table 8.2 (Summary of Tritium Results - 2001, cont.)

Area Location		Date Sampled	Result (pCi/L)	Lab. Qualifier	MDC (pCi/L)	Error (2 sigma)	Sampling Method
Onsite Monitoring							
1	UE-1q	2001-01-31	-5.67	(a)	11.52	7.41	bailer
02	Water Well 2 (USGS HTH #2)	2001-09-05	-2.94	(a)	10.44	8.62	bailer
02	Water Well 2 (USGS HTH #2) (b)	2001-09-05	0.96	(a)	10.71	9.35	bailer
03	USGS Water Well A	2001-02-20	568.08		10.61	10.47	bailer
03	USGS Water Well A (b)	2001-02-20	561.58		10.99	6.11	bailer
04	USGS Test Well D	2001-01-31	-5.55	(a)	11.35	6.75	bailer
05	UE-5c Water Well	2001-04-04	-12.66	(a)	12.03	8.59	pump
05	UE-5c Water Well	2001-10-30	0.85	(a)	18.98	13.86	pump
05	UE5PW-1 (b)	2001-05-29	-17.95	(a)	12.79	8.63	pump
05	UE5PW-1	2001-10-03	-4.10	(a)	16.40	9.56	pump
05	UE5PW-1 (b)	2001-10-03	-1.76	(a)	16.64	9.70	pump
05	UE5PW-2	2001-05-29	-12.33	(a)	13.16	6.46	pump
05	UE5PW-2 (b)	2001-05-29	-10.67	(a)	13.05	7.29	pump
05	UE5PW-2	2001-10-03	0.00	(a)	16.89	29.92	pump
05	UE5PW-2 (b)	2001-10-03	-5.64	(a)	16.77	12.33	pump
05	UE5PW-3	2001-05-29	-7.72	(a)	13.20	7.09	pump
05	UE5PW-3 (b)	2001-05-29	-17.14	(a)	13.30	6.70	pump
05	UE5PW-3	2001-10-03	1.90	(a)	16.52	10.00	pump
05	UE5PW-3 (b)	2001-10-03	3.01	(a)	16.52	11.56	pump
06	ER-6-1	2001-02-21	-5.01	(a)	30.56	5.46	bailer
06	ER-6-1	2001-02-21	-6.77	(a)	10.32	5.91	bailer
07	UE-7nS	2001-02-28	201.47		10.78	7.55	bailer
07	UE-7nS (b)	2001-02-28	191.92		10.00	7.12	bailer
17	USGS HTH #1	2001-04-19	-8.65	(a)	11.30	6.23	bailer
17	USGS HTH #1	2001-04-19	-6.15	(a)	10.09	6.38	bailer
17	USGS HTH #1	2001-04-19	-6.25	(a)	10.23	7.13	bailer
17	USGS HTH #1	2001-04-19	-7.50	(a)	9.82	6.14	bailer
18	UE-18r	2001-05-01	-14.77	(a)	12.62	5.79	bailer
18	UE-18r	2001-05-01	-16.12	(a)	12.50	8.57	bailer
19	U-19BH	2001-05-07	38.86		13.26	5.08	bailer
19	U-19BH (b)	2001-05-07	44.19		14.49	6.97	bailer
19	ER-19-1	2001-05-31	-6.42	(a)	11.01	5.05	bailer
19	ER-19-1	2001-05-31	-1.04	(a)	11.40	7.25	bailer
20	ER-20-1	2001-07-02	-6.07	(a)	11.21	6.31	bailer
20	ER-20-1 (b)	2001-07-02	-0.96	(a)	11.06	6.73	bailer
20	ER-20-2 #1	2001-07-25	-3.72	(a)	11.16	16.19	bailer
20	WELL PM-1	2001-06-20	224.30		18.22	6.07	bailer
23	SM-23-1	2001-02-12	1.54	(a)	10.32	6.42	pump
25	UE-25 WT #6	2001-08-14	0.27	(a)	10.64	10.57	bailer
25	UE-25 WT #6 (b)	2001-08-14	3.17	(a)	10.77	10.58	bailer
25	UE-25P #1	2001-08-16	11.22		10.18	9.15	bailer
25	UE-25P #1 (b)	2001-08-16	12.41		9.82	7.65	bailer

(a) Below detectable limit.
(b) Field duplicate.

Table 8.2 (Summary of Tritium Results - 2001, cont.)

Area Location		Date Sampled	Result (pCi/L)	Lab. Qualifier	MDC (pCi/L)	Error (2 sigma)	Sampling Method
Offsite Wells and Springs							
95	Amargosa Valley RV Park	2001-11-28	7.85	(a)	25.65	11.2	pump
95	Amargosa Valley RV Park (b)	2001-11-28	0.85	(a)	26.38	11.52	pump
95	Beatty Water and Sewer	2001-11-29	-18.96	(a)	26.13	12.26	pump
95	Beatty Water and Sewer (b)	2001-11-29	1.21	(a)	24.95	9.91	pump
95	Big Springs	2001-07-23	-2.75	(a)	10.09	15.50	grab
95	Big Springs (b)	2001-07-23	-1.29	(a)	10.30	5.97	grab
95	Cind-R-Lite Mine	2001-11-29	-6.63	(a)	24.95	11.08	pump
95	Cook's Ranch Well #2	2001-11-28	-0.43	(a)	26.73	10.91	pump
95	Crystal Pool	2001-07-23	-2.79	(a)	10.23	5.58	grab
95	Crystal Pool (b)	2001-07-23	-3.21	(a)	10.09	5.69	grab
95	Crystal Trailer Park	2001-11-28	-14.48	(a)	26.38	13.24	pump
95	Crystal Trailer Park (b)	2001-11-28	-13.31	(a)	22.34	12.10	pump
95	De Lee Ranch	2001-11-28	-5.99	(a)	18.52	6.91	pump
95	ER-OV-01	2001-04-24	-18.33	(a)	12.12	11.80	bailer
95	ER-OV-01 (b)	2001-04-24	-20.35	(a)	13.43	10.35	bailer
95	ER-OV-01	2001-10-17	-5.01	(a)	17.23	9.15	bailer
95	ER-OV-01 (b)	2001-10-17	-9.85	(a)	17.74	10.44	bailer
95	ER-OV-02	2001-04-23	-12.64	(a)	12.50	6.02	bailer
95	ER-OV-02	2001-10-16	-3.50	(a)	17.23	7.80	bailer
95	ER-OV-02 (b)	2001-10-16	-3.45	(a)	16.99	8.53	bailer
95	ER-OV-03A	2001-10-15	-8.79	(a)	17.23	9.65	bailer
95	ER-OV-03A (b)	2001-10-15	-8.67	(a)	16.99	9.51	bailer
95	ER-OV-03A3	2001-10-15	4.08	(a)	15.26	11.53	bailer
95	ER-OV-03C	2001-04-24	-21.78	(a)	13.30	5.09	bailer
95	ER-OV-03C	2001-10-16	-1.22	(a)	17.23	8.58	bailer
95	ER-OV-03C (b)	2001-10-16	-7.59	(a)	17.23	8.51	bailer
95	ER-OV-03C2	2001-04-24	-14.23	(a)	12.56	5.86	bailer
95	ER-OV-03C2	2001-10-16	-6.39	(a)	16.09	8.48	bailer
95	ER-OV-03C2 (b)	2001-10-16	-7.30	(a)	17.23	10.43	bailer
95	ER-OV-04A	2001-10-17	-2.96	(a)	16.76	7.31	bailer
95	ER-OV-04A (b)	2001-10-17	-10.70	(a)	17.11	7.46	bailer
95	ER-OV-05	2001-10-17	-6.93	(a)	18.27	10.23	bailer
95	ER-OV-05 (b)	2001-10-17	4.59	(a)	17.36	9.29	bailer
95	ER-OV-06A	2001-04-24	-18.39	(a)	13.26	5.65	bailer
95	ER-OV-06A (b)	2001-04-24	-16.60	(a)	13.15	6.38	bailer
95	ER-OV-06A	2001-10-17	-8.61	(a)	17.74	11.68	bailer
95	ER-OV-06A (b)	2001-10-17	-4.10	(a)	17.87	10.07	bailer
95	Fairbanks Spring	2001-07-23	5.05	(a)	11.11	8.94	grab

(a) Below detectable limit.
(b) Field duplicate.

Table 8.2 (Summary of Tritium Results - 2001, cont.)

Area	Location	Date Sampled	Result (pCi/L)	Lab. Qualifier	MDC (pCi/L)	Error (2 sigma)	Sampling Method
Offsite Wells and Springs, cont.							
95	Fairbanks Spring [b]	2001-07-23	2.87	[a]	10.66	6.52	grab
95	Last Trail Ranch	2001-11-28	2.90	[a]	18.23	11.84	pump
95	Last Trail Ranch [b]	2001-11-28	-2.85	[a]	18.52	14.77	pump
95	Peacock Ranch	2001-07-30	-4.17	[a]	10.19	5.97	grab
95	Roger Bright Ranch	2001-06-14	-1.00	[a]	11.50	5.55	pump
95	School Well	2001-11-28	-5.69	[a]	18.52	8.72	pump
95	School Well [b]	2001-11-28	-6.90	[a]	17.81	8.39	pump
95	Spicer Ranch	2001-07-30	-2.73	[a]	10.45	5.91	grab
95	Spicer Ranch [b]	2001-07-30	-6.05	[a]	10.23	5.67	grab
95	Tolicha Peak	2001-11-29	-0.63	[a]	17.25	8.13	pump
95	U.S. Ecology	2001-11-29	-6.19	[a]	20.00	9.66	pump

(a) Below detectable limit.
(b) Field duplicate.

Table 8.3 Summary of Gross Alpha Results - 2001

Area	Location	Date Sampled	Result (pCi/L	Lab. Qualifier	MDC (pCi/L)	Error (2 sigma)	Sampling Method
Onsite Supply Wells							
05	Water Well 5 B	2001-02-06	3.88		1.12	2.56	pump
05	Water Well 5B	2001-07-31	1.88	(a)	2.46	1.61	pump
05	Water Well 5B	2001-10-30	5.4		1.6	1.4	pump
05	Water Well 5C	2001-02-06	3.49		1.81	2.81	pump
05	Water Well 5Cc	2001-07-31	6.31		3.88	2.63	pump
05	Water Well 5Cc	2001-10-31	11		1.5	2	pump
06	Water Well #4	2001-02-06	7.67		1.24	2.75	pump
06	Water Well #4	2001-07-31	12		3.49	3.63	pump
06	Water Well #4	2001-10-30	7.1		1.2	1.5	pump
06	Water Well #4A	2001-02-06	8.59		1.82	5.11	pump
06	Water Well #4Aa	2001-07-31	8.53		3.33	2.9	pump
06	Water Well #4Aa	2001-10-30	8.3		1.6	1.8	pump
06	Water Well C-1	2001-02-06	12.1		1.56	6.8	pump
06	Water Well C-1	2001-07-31	13.5		2.51	3.45	pump
06	Water Well C-1	2001-10-30	17		2.1	3	pump
16	Ue-16d Eleana Water Well	2001-02-06	4.11		1.27	4.6	pump
16	Ue-16d Eleana Water Well	2001-07-31	8.47		2.68	2.75	pump
16	Ue-16d Eleana Water Well	2001-10-30	8.5		1.6	1.8	pump
18	Water Well 8 (USGS HTH-8)	2001-02-06	0.736	(a)	0.93	0.764	pump
18	Water Well 8 (USGS HTH-8)	2001-04-03	0.621	(a)	1.4	0.887	pump
18	Water Well 8 (USGS HTH-8)	2001-07-31	-1.49	(a)	2.02	1.08	pump
18	Water Well 8 (USGS HTH-8)	2001-10-30	-0.75	(a)	1.8	0.98	pump
22	Army #1 Water Well	2001-02-06	3.17		1.14	1.57	pump
22	Army #1 Water Well	2001-08-01	3.88		3.42	2.23	pump
22	Army #1 Water Well	2001-10-31	3.8		1.3	1.1	pump
25	J-12 Water Well	2001-02-07	1.25	(a)	1.48	1.01	pump
25	J-12 Water Well	2001-04-04	0.983	(a)	1.2	0.946	pump
25	J-12 Water Well	2001-08-01	0.331	(a)	1.76	1.03	pump
25	J-12 Water Well	2001-10-31	2		1.2	0.84	pump
25	J-13 Water Well	2001-02-07	1.4		1.19	1.08	pump
25	J-13 Water Well	2001-04-04	0.565	(a)	1.56	0.976	pump
25	J-13 Water Well	2001-08-01	1.3	(a)	1.37	0.936	pump
25	J-13 Water Well	2001-10-31	0.98	(a)	1.5	0.9	pump
Onsite Monitoring Wells							
1	UE-1q	2001-01-31	6.77		1.52	4.58	bailer
02	Water Well 2 (USGS HTH #2)	2001-09-05	11		3.2	3.3	bailer
03	USGS Water Well A	2001-02-20	0.83	(a)	1.01	0.769	bailer
04	USGS Test Well D	2001-01-31	0.665	(a)	0.914	0.728	bailer
05	UE5PW-1	2001-10-03	4.5		1.4	1.3	pump
05	UE5PW-2	2001-10-03	3.7		1.7	1.3	pump
05	UE5PW-3	2001-10-03	3.4		1.6	1.2	pump
06	ER-6-1	2001-02-21	3.41		1.34	1.79	bailer
06	ER-6-1	2001-02-21	4.93		1.61	3	bailer

(a) Below detectable limit.
(b) Field duplicate.

Table 8.3 (Summary of Gross Alpha Results - 2001, cont.)

Area Location	Date Sampled	Result (pCi/L)	Lab. Qualifier	MDC (pCi/L)	Error (2 sigma)	Sampling Method
Onsite Monitoring Wells, cont.						
17 USGS HTH #1	2001-04-19	-0.211	(a)	1.6	0.762	bailer
17 USGS HTH #1	2001-04-19	1.27	(a)	2.39	1.59	bailer
17 USGS HTH #1	2001-04-19	0.687	(a)	2.14	1.23	bailer
17 USGS HTH #1	2001-04-19	1.32	(a)	2.03	1.32	bailer
20 ER-20-1	2001-07-02	0.897		0.874	0.591	bailer
20 ER-20-2 #1	2001-07-25	7.36		2.78	2.72	bailer
20 ER-20-2 #1	2001-07-25	7.36		2.78	2.72	bailer
20 ER-20-2 #1	2001-07-25	7.36		2.78	2.72	bailer
23 SM-23-1	2001-02-12	3.91		1.09	2.55	pump
25 UE-25 WT #6	2001-08-14	17		6.9	4.9	bailer
25 UE-25P #1	2001-08-16	16		1.4	2.9	bailer
Offsite Wells and Springs						
95 Beatty Water and Sewer	2001-11-29	10.4		1.15	1.89	pump
95 Big Springs	2001-07-23	3.03		2	1.48	grab
95 Cind-R-Lite Mine	2001-11-29	4.73		1	1.13	pump
95 Crystal Pool	2001-07-23	3.75		2.96	2.13	grab
95 ER-OV-03C	2001-10-16	9.8		0.96	1.7	bailer
95 ER-OV-03C2	2001-10-16	7.6		0.93	1.4	bailer
95 ER-OV-06A	2001-10-17	8.3		1.9	1.9	bailer
95 Fairbanks Spring	2001-07-23	4.16		3.88	2.37	grab
95 Longstreet Casino Well #1	2001-07-23	3.94		2.25	1.74	pump
95 Longstreet Spring	2001-07-23	2.42		2.12	1.43	grab
95 Peacock Ranch	2001-07-30	0.862	(a)	2.45	1.48	grab
95 Revert Spring	2001-07-30	7.97		3.18	2.82	grab
95 Roger Bright Ranch	2001-06-14	7.24		3.49	3.57	pump
95 Spicer Ranch	2001-07-30	14.9		3.81	3.6	grab
95 Tolicha Peak	2001-11-29	3.62		1.03	0.956	pump
95 U.S. Ecology	2001-11-29	7.31		1.92	1.79	pump

(a) Below detectable limit.
(b) Field duplicate.

Table 8.4 Summary of Gross Beta Results - 2001

Area	Location	Date Sampled	Result (pCi/L)	Lab. Qualifier	MDC (pCi/L)	Error (2 sigma)	Sampling Method
Onsite Supply Wells							
5	Water Well 5B	2001-02-06	9.78		1.93	1.92	pump
05	Water Well 5B	2001-04-03	11.8		2.66	2.65	pump
05	Water Well 5B	2001-10-30	10		1.4	1.8	pump
05	Water Well 5C	2001-02-06	8.51		2.22	1.89	pump
05	Water Well 5C	2001-04-03	8.85		2.73	2.19	pump
05	Water Well 5C	2001-10-31	7.7		1.4	1.4	pump
06	Water Well #4	2001-02-06	7.47		1.84	1.57	pump
06	Water Well #4	2001-04-03	7.99		1.66	1.54	pump
06	Water Well #4	2001-10-30	5.1		1.3	1.1	pump
06	Water Well #4A	2001-02-06	7.97		2.13	2.04	pump
06	Water Well #4A	2001-04-03	4.96		2.56	1.87	pump
06	Water Well #4A	2001-10-30	6.1		1.4	1.2	pump
06	Water Well C-1	2001-02-06	16.2		2.37	2.98	pump
06	Water Well C-1	2001-04-03	4.17		3.03	2.31	pump
06	Water Well C-1	2001-10-30	15		2.1	2.5	pump
16	Ue-16d Eleana Water Well	2001-02-06	3.53		2.47	2.09	pump
16	Ue-16d Eleana Water Well	2001-04-03	0.906	(a)	2.5	1.47	pump
16	Ue-16d Eleana Water Well	2001-10-30	8.3		1.4	1.5	pump
18	Water Well 8 (USGS HTH-8)	2001-02-06	4.34		1.82	1.75	pump
18	Water Well 8 (USGS HTH-8)	2001-04-03	2.37		2.25	1.47	pump
18	Water Well 8 (USGS HTH-8)	2001-10-30	2.8		1.4	0.95	pump
22	Army #1 Water Well	2001-02-06	5.68		1.68	1.35	pump
22	Army #1 Water Well	2001-04-04	1.99		1.92	1.22	pump
22	Army #1 Water Well	2001-10-31	5.8		1.3	1.2	pump
25	J-12 Water Well	2001-02-07	7.92		2.24	1.86	pump
25	J-12 Water Well	2001-04-04	4.62		1.68	1.33	pump
25	J-12 Water Well	2001-10-31	5.6		1	1	pump
25	J-13 Water Well	2001-02-07	4.58		1.95	1.44	pump
25	J-13 Water Well	2001-04-04	4.32		1.68	1.37	pump
25	J-13 Water Well	2001-10-31	4		1.3	1	pump
Onsite Monitoring							
1	UE-1q	2001-01-31	12.5		2.11	2.2	bailer
2	Water Well 2 (USGS HTH #2)	2001-09-05	8.2		3.2	2.4	bailer
3	USGS Water Well A	2001-02-20	6.66		1.91	1.58	bailer
04	USGS Test Well D	2001-01-31	9		1.79	1.79	bailer
05	UE5PW-1	2001-10-03	3.7		1.8	1.2	pump
05	UE5PW-2	2001-10-03	6.3		1.7	1.4	pump
05	UE5PW-3	2001-10-03	2.5		1.7	1.1	pump
06	ER-6-1	2001-02-21	9.73		2.4	2.26	bailer
06	ER-6-1	2001-02-21	15.3		2.46	3.42	bailer
17	USGS HTH #1	2001-04-19	1.29	(a)	2.69	1.61	bailer
17	USGS HTH #1	2001-04-19	2.35		2.17	1.38	bailer
17	USGS HTH #1	2001-04-19	1.33	(a)	2.13	1.29	bailer
17	USGS HTH #1	2001-04-19	0.019	(a)	2.37	1.35	bailer
18	UE-18R	2001-05-01	3.44		1.6	1.08	bailer
18	UE-18R	2001-05-01	6.8		1.66	1.29	bailer
20	ER-20-1	2001-07-02	3.64		1.08	0.483	bailer
20	ER-20-2 #1	2001-07-25	7.33		1.84	0.876	bailer
23	SM-23-1	2001-02-12	13.1		1.93	2.28	pump
25	UE-25 WT #6	2001-08-14	17		6.9	4.9	bailer
25	UE-25P #1	2001-08-16	9.1		1.8	1.8	bailer

(a) Below detectable limit.
(b) Field duplicate.

Table 8.4 (Summary of Gross Beta Results - 2001, cont.)

Area Location	Date Sampled	Result (pCi/L)	Lab. Qualifier	MDC (pCi/L)	Error (2 sigma)	Sampling Method
Offsite Wells and Springs						
95 Amargosa Valley Rv Park	2001-11-28	1.86		0.971	0.655	pump
95 Beatty Water and Sewer	2001-11-29	11.5		1.48	1.89	pump
95 Big Springs	2001-07-23	5.26		1.39	0.693	grab
95 Cind-R-Lite Mine	2001-11-29	4.28		1.33	1.05	pump
95 Cook's Ranch Well #2	2001-11-28	10.6		1.55	1.8	pump
95 Crystal Pool	2001-07-23	7.17		2.1	0.898	grab
95 Crystal Trailer Park	2001-11-28	6.84		1.1	1.2	pump
95 De Lee Ranch	2001-11-28	6.98		1.01	1.18	pump
95 ER-OV-03C	2001-10-16	2.8		1.1	0.81	bailer
95 ER-OV-03C2	2001-10-16	3.6		0.99	0.81	bailer
95 ER-OV-06A	2001-10-17	13		2	2.2	bailer
95 Fairbanks Spring	2001-07-23	3.82		2.28	0.992	grab
95 Fire Hall #2 Well	2001-11-28	11.9		2.08	2.14	pump
95 Last Trail Ranch	2001-11-28	10.8		2.53	2.21	pump
95 Longstreet Casino Well #1	2001-07-23	7.14		1.69	0.858	pump
95 Longstreet Spring	2001-07-23	10.1		1.52	0.75	grab
95 Peacock Ranch	2001-07-30	7.34		1.49	0.717	pump
95 Revert Spring	2001-07-30	3.04		2.35	1.08	grab
95 Roger Bright Ranch	2001-06-14	10.6		5.68	1.47	pump
95 Roger Bright Ranch - [(b)]	2001-06-14	13.1		2.26	0.661	pump
95 School Well	2001-11-28	8.56		1.06	1.39	pump
95 Spicer Ranch	2001-07-30	5.57		2.17	1.39	grab
95 Tolicha Peak	2001-11-29	6.04		1.34	1.22	pump
95 U.S. Ecology	2001-11-29	11.4		2.18	2.14	pump

(a) Below detectable limit.
(b) Field duplicate.

Table 8.5 Summary of Gamma Results - 2001

Area	Location	Date Sampled	Analyte	Result (pCi/L)	MDC (pCi/L)	Error (2 sigma)	Sampling Method
Onsite Supply Wells							
06	Water Well #4	2001-07-31	Thorium-234	213	200	227	pump
06	Water Well #4	2001-07-31	Uranium-238	213	200	227	pump
25	J-12 Water Well	2001-08-01	Lead-212	6.54	6.4	9.45	pump
Onsite Monitoring Wells							
05	UE5PW-2	2001-10-03	Lead-214	23.9	21.4	12.1	pump
05	UE5PW-3	2001-10-03	Lead-214	29.3	19.6	11.4	pump
06	ER-6-1	2001-02-21	Potassium-40	95.4	66.9	77.4	bailer
17	USGS HTH #1	2001-04-19	Actinium-228	28.8	20	27.4	bailer
17	USGS HTH #1	2001-04-19	Cesium-137	8.2	6.69	6.21	bailer
17	USGS HTH #1	2001-04-19	Lead-212	8.2	4.91	8.38	bailer
17	USGS HTH #1	2001-04-19	Lead-212	17.4	11.6	13.2	bailer
23	SM-23-1	2001-02-12	Lead-212	7.36	7.13	8.96	pump
Offsite Wells and Springs							
95	Cook's Ranch Well #2	2001-11-28	Bismuth-214	13.9	12.3	8.19	pump
95	Fairbanks Spring	2001-07-23	Potassium-40	33	29.2	34	grab

Table 8.6 Summary of ^{226}Ra Results - 2001

Area	Location	Date Sampled	Result (pCi/L)	Lab. Qualifier	MDC (pCi/L)	Error (2 sigma)	Sampling Method
Onsite Supply Wells							
05	Water Well 5B	2001-02-06	0.224	(a)	0.632	0.362	pump
05	Water Well 5B	2001-04-03	0.561		0.109	0.295	pump
05	Water Well 5B	2001-07-31	0.136	(a)	0.421	0.235	pump
05	Water Well 5B	2001-10-30	0.32	(a)	0.4	0.26	pump
05	Water Well 5C	2001-02-06	0.313	(a)	0.329	0.263	pump
05	Water Well 5C	2001-04-03	0.27	(a)	0.358	0.25	pump
05	Water Well 5C	2001-07-31	-0.114	(a)	0.536	0.224	pump
05	Water Well 5C	2001-10-31	0.39		0.21	0.19	pump
06	Water Well #4	2001-02-06	0.378		0.348	0.293	pump
06	Water Well #4	2001-04-03	0.66		0.36	0.35	pump
06	Water Well #4	2001-07-31	0.476		0.395	0.314	pump
06	Water Well #4	2001-10-30	0.1	(a)	0.45	0.25	pump
06	Water Well #4A	2001-02-06	0.245		0.111	0.197	pump
06	Water Well #4A	2001-04-03	0.184	(a)	0.648	0.36	pump
06	Water Well #4A	2001-07-31	0.474	(a)	0.608	0.406	pump
06	Water Well #4A	2001-10-30	0.21	(a)	0.32	0.2	pump
06	Water Well C-1	2001-02-06	0.656		0.508	0.43	pump
06	Water Well C-1	2001-04-03	0.602		0.36	0.322	pump
06	Water Well C-1	2001-07-31	1.91		0.471	0.566	pump
06	Water Well C-1	2001-10-30	1.6		0.33	0.39	pump
16	Ue-16d Eleana Water Well	2001-02-06	0.448		0.33	0.305	pump
16	Ue-16d Eleana Water Well	2001-04-03	0.366	(a)	0.48	0.321	pump
16	Ue-16d Eleana Water Well	2001-07-31	0.863		0.472	0.414	pump
16	Ue-16d Eleana Water Well	2001-10-30	1.3		0.55	0.44	pump
18	Water Well 8 (USGS HTH-8)	2001-02-06	0.178	(a)	0.534	0.302	pump
18	Water Well 8 (USGS HTH-8)	2001-04-03	0.493		0.379	0.309	pump
18	Water Well 8 (USGS HTH-8)	2001-07-31	0.238	(a)	0.428	0.27	pump
18	Water Well 8 (USGS HTH-8)	2001-10-30	0.06	(a)	0.43	0.23	pump
22	Army #1 Water Well	2001-02-06	0.53		0.519	0.39	pump
22	Army #1 Water Well	2001-04-04	0.601		0.399	0.358	pump
22	Army #1 Water Well	2001-08-01	1.2		0.682	0.705	pump
22	Army #1 Water Well	2001-10-31	0.29	(a)	0.45	0.28	pump
25	J-12 Water Well	2001-02-07	0.18	(a)	0.483	0.278	pump
25	J-12 Water Well	2001-04-04	0.416		0.374	0.289	pump
25	J-12 Water Well [(b)]	2001-04-04	0.526	(a)	0.629	0.444	pump
25	J-12 Water Well	2001-08-01	0.18	(a)	0.542	0.306	pump
25	J-12 Water Well	2001-10-31	0.14	(a)	0.23	0.15	pump
25	J-13 Water Well	2001-02-07	0.042	(a)	0.39	0.184	pump
25	J-13 Water Well	2001-04-04	0.262	(a)	0.528	0.32	pump
25	J-13 Water Well	2001-08-01	0	(a)	0.343	0.145	pump
25	J-13 Water Well	2001-10-31	0.1	(a)	0.29	0.17	pump
Onsite Monitoring							
23	SM-23-1	2001-02-12	2.35		1.56	1.41	pump
Offsite Wells and Springs							
95	Roger Bright Ranch	2001-06-14	0.397	(a)	0.867	0.519	pump

(a) Below detectable limit.
(b) Field duplicate.

Table 8.7 Summary of ^{228}Ra Results - 2001

Area Location	Date Sampled	Result (pCi/L)	Lab. Qualifier	MDC (pCi/L)	Error (2 sigma)	Sampling Method
Onsite Supply Wells						
5 Water Well 5B	2001-02-06	0.149	(a)	0.913	0.534	pump
05 Water Well 5B	2001-04-03	0.215	(a)	0.887	0.521	pump
05 Water Well 5B	2001-07-31	1.32		0.873	0.511	pump
05 Water Well 5B	2001-10-30	0.16	(a)	0.94	0.56	pump
05 Water Well 5C	2001-02-06	-0.182	(a)	0.878	0.503	pump
05 Water Well 5C	2001-04-03	0.395	(a)	0.913	0.546	pump
05 Water Well 5C	2001-07-31	1.09		0.948	0.555	pump
5 Water Well 5C	2001-10-31	0.94		0.93	0.59	pump
06 Water Well #4	2001-02-06	-0.0655	(a)	0.823	0.477	pump
06 Water Well #4	2001-04-03	0.849	(a)	1.01	0.628	pump
06 Water Well #4	2001-07-31	1.17		0.908	0.543	pump
06 Water Well #4	2001-10-30	0.94		0.88	0.56	pump
06 Water Well #4A	2001-02-06	0.0398	(a)	0.903	0.525	pump
06 Water Well #4A	2001-04-03	-1.78	(a)	1.29	0.779	pump
06 Water Well #4A	2001-07-31	2.36		0.972	0.643	pump
06 Water Well #4A	2001-10-30	0.61	(a)	0.9	0.56	pump
06 Water Well C-1	2001-02-06	0.343	(a)	0.642	0.389	pump
06 Water Well C-1	2001-04-03	0.913		0.861	0.628	pump
06 Water Well C-1	2001-07-31	2.7		1.1	0.712	pump
06 Water Well C-1	2001-10-30	0.91	(a)	0.92	0.58	pump
16 Ue-16d Eleana Water Well	2001-02-06	0.654	(a)	0.799	0.501	pump
16 Ue-16d Eleana Water Well	2001-04-03	0.408	(a)	0.961	0.573	pump
16 Ue-16d Eleana Water Well	2001-07-31	2.72		0.879	0.76	pump
16 Ue-16d Eleana Water Well	2001-10-30	0.7	(a)	0.99	0.62	pump
18 Water Well 8 (USGS HTH-8)	2001-02-06	0.0894	(a)	0.877	0.511	pump
18 Water Well 8 (USGS HTH-8)	2001-04-03	0.824	(a)	0.886	0.571	pump
18 Water Well 8 (USGS HTH-8)	2001-07-31	0.458	(a)	1.18	0.711	pump
18 Water Well 8 (USGS HTH-8)	2001-10-30	0.07	(a)	0.96	0.57	pump
22 Army #1 Water Well	2001-02-06	0.756	(a)	0.827	0.529	pump
22 Army #1 Water Well	2001-04-04	1.15	(a)	1.72	1.06	pump
22 Army #1 Water Well	2001-08-01	0.829	(a)	1.26	0.698	pump
22 Army #1 Water Well	2001-10-31	1.2		1.1	0.72	pump
25 J-12 Water Well	2001-02-07	-0.233	(a)	1.21	0.698	pump
25 J-12 Water Well	2001-04-04	0.32	(a)	1.12	0.656	pump
25 J-12 Water Well	2001-08-01	1.02	(a)	1.02	0.565	pump
25 J-12 Water Well	2001-10-31	0.06	(a)	1	0.61	pump
25 J-13 Water Well	2001-02-07	0.274	(a)	1.09	0.643	pump
25 J-13 Water Well	2001-04-04	0.595	(a)	0.868	0.536	pump
25 J-13 Water Well	2001-08-01	0.662	(a)	0.825	0.47	pump
25 J-13 Water Well	2001-10-31	0.77	(a)	0.98	0.61	pump
Onsite Monitoring						
23 SM-23-1	2001-02-12	0.751	(a)	1.02	0.628	pump
Offsite Wells and Springs						
95 Roger Bright Ranch	2001-06-14	3.02		1.1	1.28	pump

(a) Below detectable limit
(b) Field duplicate

Table 8.8 Summary of ^{238}Pu Results - 2001

Area	Location	Date Sampled	Result (pCi/L)	Lab. Qualifier	MDC (pCi/L)	Error (2 sigma)	Sampling Method
Onsite Supply Wells							
05	Water Well 5B	2001-07-31	0.00453	(a)	0.0068	0.00628	pump
05	Water Well 5C	2001-07-31	0	(a)	0.00728	0	pump
06	Water Well #4	2001-07-31	0	(a)	0.00609	0	pump
06	Water Well #4A	2001-07-31	0.00213	(a)	0.0064	0.00418	pump
18	Water Well 8 (USGS HTH-8)	2001-07-31	0	(a)	0.00739	0	pump
22	Army #1 Water Well	2001-08-01	-0.00473	(a)	0.0227	0.00655	pump
25	J-12 Water Well	2001-08-01	0.00408	(a)	0.00611	0.00565	pump
25	J-13 Water Well	2001-08-01	0.00225	(a)	0.00674	0.0044	pump
Onsite Monitoring Wells							
1	UE-1q	2001-01-31	0.0126	(a)	0.0482	0.0247	bailer
02	Water Well 2 (USGS HTH #2)	2001-09-05	0.011	(a)	0.028	0.016	bailer
04	USGS Test Well D	2001-01-31	0	(a)	0.0186	0	bailer
05	UE5PW-1	2001-10-03	0.0015	(a)	0.02	0.0087	pump
05	UE5PW-1	2001-10-03	0.003	(a)	0.028	0.013	pump
05	UE5PW-2	2001-10-03	-0.0003	(a)	0.024	0.0098	pump
05	UE5PW-2	2001-10-03	-0.018	(a)	0.044	0.015	pump
05	UE5PW-3	2001-10-03	-0.001	(a)	0.029	0.012	pump
05	UE5PW-3	2001-10-03	-0.0012	(a)	0.022	0.0081	pump
06	ER-6-1	2001-02-21	0.0421	(a)	0.0575	0.0391	bailer
17	USGS HTH #1	2001-04-19	0.00698	(a)	0.0457	0.0242	bailer
17	USGS HTH #1	2001-04-19	-0.00804	(a)	0.0208	0	bailer
17	USGS HTH #1	2001-04-19	-0.00804	(a)	0.0285	0	bailer
17	USGS HTH #1	2001-04-19	0.000036	(a)	0.0242	0.0158	bailer
18	UE-18r	2001-05-01	0.00451	(a)	0.0345	0.0153	bailer
18	UE-18r	2001-05-01	0.0238	(a)	0.0304	0.022	bailer
20	ER-20-1	2001-07-02	-0.00709	(a)	0.0543	0.0139	bailer
20	ER-20-2 #1	2001-07-25	0	(a)	0.00873	0	bailer
23	SM-23-1	2001-02-12	0	(a)	0.0215	0	pump
25	UE-25 WT #6	2001-08-14	0.016	(a)	0.058	0.032	bailer
25	UE-25 WT #6	2001-08-14	-0.011	(a)	0.048	0.015	bailer
25	UE-25P #1	2001-08-16	0.004	(a)	0.026	0.012	bailer
Offsite Wells and Springs							
95	Amargosa Valley RV Park	2001-11-28	0.00831	(a)	0.0312	0.0167	pump
95	Beatty Water And Sewer	2001-11-29	0.0022	(a)	0.0196	0.00891	pump
95	Big Springs	2001-07-23	0.00833	(a)	0.0125	0.0115	grab
95	Cind-R-Lite Mine	2001-11-29	0.00412	(a)	0.0165	0.00887	pump
95	Cook's Ranch Well #2	2001-11-28	-0.00627	(a)	0.0316	0.0103	pump
95	Crystal Pool	2001-07-23	0.0147	(a)	0.0205	0.0144	grab
95	Crystal Trailer Park	2001-11-28	-0.0104	(a)	0.0454	0.0162	pump
95	De Lee Ranch	2001-11-28	0	(a)	0.0323	0.0138	grab
95	De Lee Ranch	2001-11-28	-0.00117	(a)	0.0269	0.0106	grab
95	ER-OV-01	2001-10-17	0.0039	(a)	0.0078	0.0078	bailer
95	ER-OV-01	2001-10-17	0	(a)	0.041	0.017	bailer
95	ER-OV-02	2001-10-16	-0.0041	(a)	0.023	0.0064	bailer

(a) Below detectable limit.
(b) Field duplicate.

Table 8.8 (Summary of ^{238}Pu Results - 2001, cont.)

Area Location	Date	Result (pCi/L)	Lab. Qualifier	MDC (pCi/L)	Error (2 sigma)	Sampling Method
Offsite Wells and Springs, cont.						
95 ER-OV-03C	2001-10-16	-0.019	(a)	0.045	0.013	bailer
95 ER-OV-03C2	2001-10-16	0.0043	(a)	0.019	0.0098	bailer
95 ER-OV-03C2	2001-10-16	0.006	(a)	0.026	0.014	bailer
95 ER-OV-06A	2001-10-17	-0.001	(a)	0.024	0.0086	bailer
95 Fire Hall #2 Well	2001-11-28	-0.00295	(a)	0.0297	0.0113	pump
95 Longstreet Casino Well #1	2001-07-23	0	(a)	0.0468	0	pump
95 Longstreet Casino Well #1	2001-07-23	0.00385	(a)	0.0235	0.0104	pump
95 Longstreet Spring	2001-07-23	0.0281	(a)	0.0557	0.0329	grab
95 Peacock Ranch	2001-07-30	0.000841	(a)	0.0326	0.0114	pump
95 Revert Spring	2001-07-30	0.0033	(a)	0.0202	0.00895	grab
95 School Well	2001-11-28	-0.00176	(a)	0.0165	0.00593	pump
95 Spicer Ranch	2001-07-30	0.0153	(a)	0.0347	0.0204	grab
95 Spicer Ranch	2001-07-30	0.0111	(a)	0.0295	0.0163	grab
95 Tolicha Peak	2001-11-29	-0.00951	(a)	0.0415	0.0148	pump
95 U.S. Ecology	2001-11-29	0	(a)	0.0056	0.0056	pump
95 U.S. Ecology	2001-11-29	-0.00621	(a)	0.0285	0.0071	pump

(a) Below detectable limit.
(b) Field duplicate

Table 8.9 Summary of $^{239+240}Pu$ Results - 2001

Area	Location	Date Sampled	Result (pCi/L)	Lab. Qualifier	MDC (pCi/L)	Error (2 sigma)	Sampling Method
Onsite Supply Wells							
5	Water Well 5B	2001-07-31	0	(a)	0.00679	0	pump
5	Water Well 5C	2001-07-31	-0.00243	(a)	0.0186	0.0048	pump
6	Water Well #4	2001-07-31	0	(a)	0.0155	0.0056	pump
06	Water Well #4A	2001-07-31	0.00213	(a)	0.0064	0.0042	pump
16	Ue-16d Eleana Water Well	2001-07-31	0.00637		0.00637	0.0072	pump
18	Water Well 8 (USGS HTH-8)	2001-07-31	0.00246	(a)	0.00738	0.0048	pump
22	Army #1 Water Well	2001-08-01	0.00237	(a)	0.0181	0.008	pump
25	J-12 Water Well	2001-08-01	0	(a)	0.00611	0	pump
25	J-13 Water Well	2001-08-01	0.00225	(a)	0.0172	0.0076	pump
Onsite Monitoring							
1	UE-1q	2001-01-31	0	(a)	0.0482	0.0175	bailer
02	Water Well 2 (USGS HTH	2001-09-05	0.0043	(a)	0.017	0.0093	bailer
03	USGS Water Well A	2001-02-20	-0.00875	(a)	0.0419	0.0121	bailer
03	USGS Water Well A	2001-02-20	0	(a)	0.062	0.0225	bailer
04	USGS Test Well D	2001-01-31	-0.0062	(a)	0.0594	0.0211	bailer
05	UE5PW-1 (b)	2001-10-03	0.0008	(a)	0.015	0.0061	pump
05	UE5PW-1	2001-10-03	-0.0044	(a)	0.024	0.0066	pump
05	UE5PW-2 (b)	2001-10-03	0.004	(a)	0.021	0.011	pump
05	UE5PW-2	2001-10-03	0.003	(a)	0.0064	0.0064	pump
05	UE5PW-3 (b)	2001-10-03	-0.003	(a)	0.024	0.0084	pump
05	UE5PW-3	2001-10-03	0.0009	(a)	0.018	0.007	pump
06	ER-6-1	2001-02-21	0.0256	(a)	0.0489	0.0308	bailer
06	ER-6-1	2001-02-21	-0.00598	(a)	0.0458	0.0117	bailer
06	ER-6-1	2001-02-21	0.00563	(a)	0.0169	0.0111	bailer
06	ER-6-1	2001-02-21	1.31E-09	(a)	0.042	0.0152	bailer
17	USGS HTH #1	2001-04-19	0.00948	(a)	0.0142	0.0132	bailer
17	USGS HTH #1	2001-04-19	0.0014	(a)	0.0348	0.0121	bailer
17	USGS HTH #1	2001-04-19	-0.00493	(a)	0.0475	0.0097	bailer
17	USGS HTH #1	2001-04-19	0.00326	(a)	0.0499	0.0199	bailer
17	USGS HTH #1	2001-04-19	0	(a)	0.0186	0	bailer
18	UE-18r	2001-05-01	0.0165	(a)	0.0253	0.0172	bailer
18	UE-18r	2001-05-01	2.68E-10	(a)	0.0344	0.0125	bailer
18	UE-18r	2001-05-01	-0.00792	(a)	0.0379	0.011	bailer
18	UE-18r	2001-05-01	0.0029	(a)	0.032	0.015	bailer
19	ER-19-1	2001-05-31	0.0113	(a)	0.0288	0.0166	bailer
19	ER-19-1	2001-05-31	-0.00768	(a)	0.0424	0.015	bailer
19	ER-19-1	2001-05-31	0	(a)	0.015	0	bailer
19	ER-19-1	2001-05-31	0.00592	(a)	0.0453	0.0201	bailer
19	U-19bh	2001-05-07	4.04E-10	(a)	0.0324	0.0133	bailer
20	ER-20-1	2001-07-02	0.00709	(a)	0.0213	0.0139	bailer
20	ER-20-2 #1	2001-07-25	0.00582	(a)	0.0222	0.0114	bailer
23	SM-23-1	2001-02-12	0.00716	(a)	0.0215	0.0141	pump
25	UE-25 WT #6	2001-08-14	0	(a)	0.02	0.02	bailer
25	UE-25 WT #6 (b)	2001-08-14	-0.0026	(a)	0.025	0.0089	bailer
25	UE-25P #1	2001-08-16	0.0062	(a)	0.0063	0.0086	bailer

(a) Below detectable limit.
(b) Field duplicate.

Table 8.9 (Summary of $^{239+240}$Pu Results - 2001, cont.)

Area	Location	Date	Result (pCi/L)	Lab. Qualifier	MDC (pCi/L)	Error 2 (sigma)	Sampling Method
Offsite Wells and Springs							
95	Amargosa Valley RV Park	2001-11-28	-0.00227	(a)	0.0212	0.0076	pump
95	Beatty Water And Sewer	2001-11-29	-0.00331	(a)	0.0196	0.0056	pump
95	Big Springs	2001-07-23	-0.00339	(a)	0.0299	0.0066	grab
95	Big Springs [(b)]	2001-07-23	0	(a)	0.0109	0	grab
95	Cind-R-Lite Mine	2001-11-29	0.00118	(a)	0.0165	0.0067	pump
95	Cook's Ranch Well #2	2001-11-28	0.0107	(a)	0.0176	0.0129	pump
95	Crystal Pool	2001-07-23	-0.00764	(a)	0.0419	0.0106	grab
95	Crystal Pool [(b)]	2001-07-23	-0.00284	(a)	0.0482	0.0219	grab
95	Crystal Trailer Park	2001-11-28	-0.00521	(a)	0.0343	0.0114	pump
95	De Lee Ranch	2001-11-28	-0.000641	(a)	0.0228	0.0082	pump
95	De Lee Ranch [(b)]	2001-11-28	0.00583	(a)	0.00588	0.0081	pump
95	ER-OV-01 [(b)]	2001-10-17	-0.0023	(a)	0.022	0.0078	bailer
95	ER-OV-01	2001-10-17	-0.0032	(a)	0.028	0.01	bailer
95	ER-OV-02	2001-10-16	0.001	(a)	0.018	0.0072	bailer
95	ER-OV-03C	2001-10-16	0.002	(a)	0.026	0.012	bailer
95	ER-OV-03C2 [(b)]	2001-10-16	0	(a)	0.028	0.011	bailer
95	ER-OV-03C2	2001-10-16	0.0012	(a)	0.02	0.0082	bailer
95	ER-OV-06A	2001-10-17	0.008	(a)	0.019	0.012	bailer
95	Fairbanks Spring	2001-07-23	-0.00419	(a)	0.0371	0.0082	grab
95	Fairbanks Spring [(b)]	2001-07-23	-0.00256	(a)	0.0225	0.005	grab
95	Fire Hall #2 Well	2001-11-28	0.00118	(a)	0.0166	0.0067	pump
95	Last Trail Ranch	2001-11-28	0.00122	(a)	0.0172	0.007	pump
95	Longstreet Casino Well #1	2001-07-23	0.0156	(a)	0.0467	0.0306	pump
95	Longstreet Casino Well #1 [(b)]	2001-07-23	0.00326	(a)	0.00977	0.0064	pump
95	Longstreet Spring	2001-07-23	0.00488	(a)	0.0147	0.0096	grab
95	Longstreet Spring [(b)]	2001-07-23	0.00108	(a)	0.0268	0.0108	grab
95	Peacock Ranch	2001-07-30	0	(a)	0.0136	0	grab
95	Peacock Ranch [(b)]	2001-07-30	0	(a)	0.0109	0	grab
95	Revert Spring	2001-07-30	-0.00928	(a)	0.0389	0.0105	grab
95	Revert Spring [(b)]	2001-07-30	0.0033	(a)	0.0201	0.009	grab
95	Roger Bright Ranch	2001-06-14	0.00779	(a)	0.0117	0.0108	pump
95	School Well	2001-11-28	0.00117	(a)	0.0165	0.0067	pump
95	Spicer Ranch	2001-07-30	0.000877	(a)	0.0347	0.0122	grab
95	Spicer Ranch [(b)]	2001-07-30	-0.0054	(a)	0.0295	0.0075	grab
95	Tolicha Peak	2001-11-29	0.00204	(a)	0.0313	0.014	pump
95	U.S. Ecology	2001-11-29	0	(a)	0.0056	0.0056	pump
95	U.S. Ecology [(b)]	2001-11-29	0.00138	(a)	0.0194	0.0079	pump

(a) Below detectable limit
(b) Field duplicate.

Table 8.10 Summary of ^{90}Sr Results - 2001

Area	Location	Date Sampled	Result (pCi/L)	Lab. Qualifier	MDC (pCi/L)	Error (2 sigma)	Sampling Method
Onsite Supply Wells							
5	Water Well 5B	2001-02-06	-0.107	(a)	0.456	0.199	pump
5	Water Well 5B	2001-04-03	-0.216	(a)	0.439	0.254	pump
5	Water Well 5B	2001-07-31	0.166	(a)	0.46	0.278	pump
5	Water Well 5C	2001-07-31	0.228	(a)	0.398	0.253	pump
6	Water Well #4	2001-07-31	0.0984	(a)	0.472	0.28	pump
6	Water Well #4A	2001-07-31	0.11	(a)	0.343	0.205	pump
6	Water Well C-1	2001-02-06	-0.0354	(a)	0.391	0.172	pump
6	Water Well C-1	2001-07-31	0.0596	(a)	1.06	0.443	pump
16	UE-16d Eleana Water Well	2001-07-31	0.42	(a)	1	0.478	pump
18	Water Well 8 (USGS HTH-8)	2001-07-31	0.192	(a)	0.342	0.218	pump
22	Army #1 Water Well	2001-08-01	0.26	(a)	0.599	0.365	pump
25	J-12 Water Well	2001-08-01	0.312	(a)	0.526	0.339	pump
25	J-13 Water Well	2001-08-01	0.0159	(a)	0.697	0.407	pump
Onsite Monitoring							
23	SM-23-1	2001-02-12	0.168	(a)	0.439	0.214	pump
23	SM-23-1	2001-02-12	0.168	(a)	0.439	0.214	pump
Offsite Wells and Springs							
95	Roger Bright Ranch	2001-06-14	-0.832	(a)	4.97	2.87	pump

(a) Below detectable limit.
(b) Field duplicate.

Table 8.11 Summary of the DRI Groundwater Monitoring Program - 2001

Monitoring Location	Date	Sampling Method
Alamo city water supply system - source of water is municipal well field	2001-03-06	By hand from distribution system
Amargosa school well	2001-05-23	By hand from well head
Beatty Water and Sanitation - municipal well	2001-05-23	By hand from well head
Boulder City water treatment plant - source of water is Lake Mead	2001-04-04	By hand at treatment plant
Caliente municipal water supply well	2001-03-13	By hand from well head
Cedar City municipal water supply well located 8 mi west of town	2001-03-15	By hand from well head
Delta municipal well	2001-03-14	By hand from well head
Goldfield Utilities Klondike #2 located 12 miles north of town	2001-03-07	By hand from well head
Henderson CCSN, source of water is municipal water system originating at Lake Mead	2001-05-16	By hand from distribution system
Indian Springs municipal well	2001-03-29	By hand from well head
Las Vegas Valley Water District #103	2001-06-19	By hand from well head
Medlin Ranch spring located 11 miles west of ranch house	2001-03-06	Sampled by hand at spring orifice
Overton municipal water supply well located 18 miles north west of town	2001-03-14	By hand from well head
Pahrump municipal well	2001-04-04	By hand from well head
Pioche municipal well located ½ mile east of town	2001-03-29	By hand from well head
Rachel - Little Ale Inn well	2001-03-13	By hand from well head
St. George municipal water supply well located 15 mi north of town	2001-03-06	By hand from well head
Terrell Ranch house well	2001-03-15	By hand from well head
Tonopah Public Utilities well field located 12 miles from town	2001-03-07	By hand from well head

Table 8.12 Summary of DRI Groundwater Tritium Results - 2001

Sample Point	**Results (pCi/L)**	**Uncertainty (2 Std Deviation pCi/L)**	**Minimum Detection Limit (pCi/L)**
Alamo city water supply system - source of water is municipal well field	7	9	0.78
Amargosa school well	3	6	0.78
Beatty Water and Sanitation - municipal well	3	6	0.82
Boulder City water treatment plant - source of water is Lake Mead	34	10	0.82
Caliente municipal water supply well	12	10	0.78
Cedar City municipal water supply well located 8 mi west of town	1	8	0.85
Delta municipal well	1	9	0.85
Goldfield Utilities Klondike #2 located 12 miles north of town	<1	8	0.78
Henderson CCSN, source of water is municipal water system originating at Lake Mead	34	9	0.82
Indian Springs municipal well	2	8	0.82
Las Vegas Valley Water District #103	<1	7	0.78
Medlin Ranch spring located 11 miles west of ranch house	13	8	0.78
Milford municipal water supply well located 1 mi south of town	<1	8	0.78
Overton municipal water supply well located 18 miles NW of town	1	6	0.82
Pahrump municipal well	1	6	0.85
Pioche municipal well located ½ mile east of town	<1	9	0.78
Rachel - Little Ale Inn well	<1	7	0.78
St. George municipal water supply well located 15 mi north of town	9	7	0.85
Terrell Ranch house well	<1	8	0.78
Tonopah Public Utilities well field located 12 miles from town	<1	8	0.78

9.0 QUALITY ASSURANCE

It is the policy of the U. S. Department of Energy, National Nuclear Security Administration Nevada Operations Office (NNSA/NV) that all data produced for its environmental surveillance and effluent monitoring programs be of known quality. Therefore, a quality assurance (QA) program is used for collection and analysis of samples for radiological parameters to ensure that data produced by the Bechtel Nevada (BN) Subcontracted Radiochemistry Laboratory meets customer-and regulatory-defined requirements. Data quality is assured through process-based QA, procedure-specific QA, measurement quality objectives (MQOs), and performance evaluation programs (PEPs). The QA program for radiological data consists of participation in the Quality Assessment Program (QAP) administered by the NNSA/NV Environmental Measurements Laboratory (EML), the InterLaB RadCheM™ Proficiency Testing Program directed by Environmental Resource Associates (ERA), the Radiochemistry Intercomparison Program provided by the National Institute of Standards and Technology (NIST), and the Mixed Analyte Performance Evaluation Program (MAPEP) conducted by the Idaho National Engineering and Environmental Laboratory (INEEL). Thermoluminescent dosimeter (TLD) radiation measurement QA for the program is assessed by the BN Dosimetry Group's participation in the NNSA/NV's Laboratory Accreditation Program and intercomparisons provided by the Battelle Pacific Northwest National Laboratory (PNNL) during the course of the year.

9.1 POLICY

Environmental surveillance, conducted onsite by BN, is governed by the NNSA/NV QA policy as set forth in DOE Order 414.1A (DOE 1999). The Order outlines ten specific elements that must be considered for compliance with the QA policy. These elements are:

1. Program
2. Personnel Training and Qualification
3. Quality Improvement
4. Documents and Records
5. Work Processes
6. Design
7. Procurement
8. Inspection and Acceptance Testing
9. Management Assessment
10. Independent Assessment

9.2 OVERVIEW OF THE LABORATORY QA PROGRAM

The Subcontracted Radiochemistry Laboratory implements the requirements of the DOE Order O 414.1A through integrated quality procedures. The quality of data and results is ensured through both process-based and procedure-specific QA. BN is assured of quality data from the subcontracted laboratory through both a review of the subcontracted laboratory's QA Plan by BN as well as the subcontracted laboratory's successful participation in the NNSA's Environmental Management Consolidated Audit Program.

Procedure-specific QA begins with the development and implementation of Organizational Procedures (OPs) and Operating Instructions (OIs), which contain the analytical procedures and required quality control samples for a given analysis. Personnel employed by the subcontracted laboratory are trained and qualified to perform a given analysis, including the successful analysis of a quality control sample. Analysis-specific operational checks and calibration standards traceable to either the NIST or the U. S. Environmental Protection Agency (EPA) are required. Quality control samples, e.g., spikes, blanks, laboratory control samples (LCS), and replicates, are included for each analytical procedure. Compliance with analytical procedures is measured through procedure-specific assessments or surveillances.

An essential component of process-based QA is data review and verification to assess data usability. Data review requires a systematic, independent review against pre-established criteria to verify that the data are valid for their intended use. Data verification ensures that the reported results correctly represent the sampling and/or analyses performed and includes assessment of quality control sample results. Data processing by Environmental Technical Services (ETS) personnel ensures that analytical results meet project requirements. Data checks are made by ETS for internal consistency, proper identification, transmittal errors, calculation errors, and transcription errors. 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. Data validation is an analyte and sample specific process that extends the evaluation of data beyond method, procedural, or contractual compliance to determine the analytical quality of a specific data set. The goals of data validation are to evaluate the quality of the data, ensure that all project requirements are met, determine the impact on data quality of those requirements that were not met, and document the results of the data validation. Data validation is performed on approximately 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). Validation is conducted by the ETS Organization using OPs and OIs in conjunction with applicable project specific work plans, field sampling plans, QA project plans, analytical method references, and laboratory statements of work.

Process-based QA programs also include periodic operational checks of analytical parameters such as reagent water quality and storage temperatures. Periodic calibration is required for all measuring equipment such as analytical balances, analytical weights, and thermometers.

The overall effectiveness of the QA program is determined through systematic assessments of analytical activities. Systematic problems are documented and corrective actions tracked through System Deficiency Reports.

9.3 MEASUREMENT QUALITY OBJECTIVES (MQOs)

MQOs are commonly described in terms of representativeness, comparability, precision, accuracy, blank analysis, and interlaboratory comparison studies. Definite numerical goals may be set and quantitative assessments performed for these components of the data.

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).

Representativeness also refers to whether the locations and frequency of sampling are such that calculational models will lead to a correct estimate of potential effective dose equivalent to a member of the public when measured radioactivity concentrations are put into the model. An environmental monitoring plan for the, “Nevada Test Site Routine Radiological Environmental Monitoring Plan” (DOE 1998a) has been established to achieve representativeness for environmental data. Factors which were considered in designing this monitoring plan include locations of known and potential sources, historical and operational knowledge of isotopes and pathways of concern, hydrological, and topographical data, and locations of human populations.

COMPARABILITY

Comparability refers to the degree of confidence and consistency in the laboratory’s analytical results, or defined as "the confidence with which one data set can be compared to another" (Stanley and Verner 1985). To achieve comparability in measurement data, sample collection and handling, laboratory analyses, and data analysis and validation are performed in accordance with established Ops and OIs. Standard reporting units and a consistent number of significant digits are used. Instruments are calibrated using NIST-traceable sources. Extensive QA measures are used for all analytical processes.

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 same 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 for samples is determined by comparing results for duplicate samples of particulates in air, tritiated water vapor, TLDs, and of some types of water samples.

ACCURACY

Accuracy refers to how well we can measure the true value of a given quantity and can be defined as "the degree of agreement of a measured value with the true or expected value of the quantity of concern" (Taylor 1987). For practical purposes, assessments of accuracy for the Subcontract Radiochemistry Laboratory are done by performing measurements on a LCS which is sometimes called a Blank Spike Sample. A LCS is a control sample of known composition, which is analyzed using the same sample preparation, reagents, and analytical methods as employed for the project samples.

The accuracy of these measurements, which is assumed to extend to other similar measurements performed by the laboratory, may be defined as the ratio of the measured value divided by the true value, expressed as a percent. The control limits (in percent) for accuracy that is monitored by using LCS results, are 80 to 120 percent, except for gross alpha and beta which are 50 to 120 percent.

BLANK ANALYSIS

A blank analysis is an artificial sample designed to monitor the introduction of artifacts into the measurement process. There are several types of blanks which monitor a variety of processes:

- **A laboratory blank** is taken through sample preparation and analysis only. It is a test for contamination in sample preparation and analysis.
- **A trip blank** is shipped to and from the field with the sample containers. It is not opened in the field and, therefore, provides a test for contamination from sample preservation, site conditions, and transport as well as sample storage, preparation, and analysis.
- **A field blank** is opened in the field and tests for contamination from the atmosphere as well as from sample preservation, site conditions, transport, sample storage, preparation, and analysis.
- **A rinsate blank** is taken from water used to decontaminate sampling equipment and is used to test for contamination from sampling equipment, site conditions, transport, sample storage, preparation, and analysis.

INTERLABORATORY COMPARISON STUDIES

The Subcontracted Radiochemistry Laboratories analyze special QA samples that are prepared using stringent quality control, by laboratories which specialize in preparing such samples. The values of the activities of these samples are not known by the staff of the Subcontracted Laboratory until several months after the measurements are made and the results sent back to the QA laboratory. These sample values are unknown to the analysts and serve to measure the capability of a laboratory for analyzing an analyte in a specific matrix.

The interlaboratory comparison studies that the Subcontracted Radiochemistry Laboratory participate in are the QAP administered by the NNSA EML, the InterLaB RadCheM™ Proficiency Testing Program directed by ERA, the Radiochemistry Intercomparison Program provided by the NIST and the MAPEP conducted by the INEEL.

The capability of the BN Dosimetry Group's TLD program is tested during the course of the year by their participation in the Battelle PNNL performance evaluation study program. They are also tested every two or three years by the NNSA's Laboratory Accreditation Program. This involves a three-part, single blind performance testing program followed by an independent onsite assessment of the overall program.

9.4 RESULTS FOR DUPLICATES, LABORATORY CONTROL SAMPLES, BLANK ANALYSIS, AND INTERLABORATORY COMPARISON STUDIES

A brief discussion of the year 2001 results for duplicates, laboratory control samples, blank analysis, and interlaboratory comparison studies are provided within this section. Summary tables are also included.

DUPLICATES (PRECISION)

A field duplicate is a sample 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 9.1.

LABORATORY CONTROL SAMPLES (ACCURACY)

The LCS results obtained for 2001 are summarized in Table 9.2. The LCS results were satisfactory with no more than two results being out of control for any given analysis/matrix category for the year.

BLANK ANALYSIS

The laboratory blank sample results obtained for 2001 are summarized in Table 9.3. The laboratory blank results were satisfactory with no more than one result being out of control for any given analysis/matrix category for the year.

INTERLABORATORY COMPARISON STUDIES

The interlaboratory comparison sample results obtained for 2001 are summarized in Tables 9.4 and 9.5.

Table 9.4 shows the summary of interlaboratory comparison sample results for the Subcontracted Radiochemistry Laboratory. The Subcontractor participated in the InterLaB RadCheM™ Proficiency Testing Program directed by ERA, the QAP administered by EML, and the MAPEP conducted by INEEL. The Subcontractor performed very well during the year by passing 102 out of 108 parameters analyzed.

Table 9.5 shows the summary of interlaboratory comparison sample results for the BN in-house Dosimetry Group. They participated in the Battelle PNNL performance evaluation study program during the course of the year. The Dosimetry Group performed very well during the year by passing 17 out of 18 TLDs analyzed. The only outlier was a S60/Cf-252 UN. Mixture (1:3), which was within the test range of 0.03 to 5 rem.

9.5 ESTIMATES OF DATA QUALITY

The measurement quality as discussed in Section 9.3 indicates that representativeness, comparability, and quality control of the data reported are acceptable. Also, data completeness for this data set met or exceeded completeness goals so these data are acceptable for their intended use.

Table 9.1 Summary of Field Duplicate Samples - 2001

Analysis	Matrix	Number[(a)] Samples Reported	Number[(b)] Reported above DL	Average Absolute[(c)] RPD of those above DL (%)
$^{239+240}$Pu	Air	24	14	64.4[(d)]
Gross Alpha	Air	85	79	21.6
Gross Beta	Air	85	85	10.5
Gamma - Be^7	Air	18	14	17.7
Tritium	Air	49	28	15.4
Uranium 234	Air	6	6	24.9
Uranium 238	Air	6	5	14.4
Gross Alpha	Water	1	1	NR [(e)]
Gross Beta	Water	1	1	21.1
$^{239+240}$Pu	Water	18	2	7.73
Gamma - Cs^{137}	Water	3	2	11.1
Tritium	Water	46	7	7.87
^{90}Sr	Water	2	0	NA
^{226}Ra	Water	1	0	NA
^{228}Ra	Water	0	NA	NA
TLDs	Ambient Radiation	472	472	3.17

NA = Not Applicable
NR = Not Reported

(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 here.
(b) Represents the number of field duplicate results reported above the detection limit (detection limit is not applicable for TLD).
(c) Reflects the Average Absolute RPD calculated for those field duplicates reported above the detection limit. The Absolute RPD calculation is as follows:

Where:
FD = Field Duplicate result
FS = Field Sample result

$$Absolute\ RPD = \frac{|FD - FS|}{(FD + FS)/2} \times 100$$

(d) The magnitude is due largely to three individual results at 194.4 percent, 143.0percent, and 127.1 percent. Calculated without these points, the Average Absolute RPD is 37.3 percent. These RPD values are likely due to the heterogeneity of the samples.
(e) Data Quality Assessment determined the single field duplicate did not meet minimum quality standards for reporting.

Table 9.2 Summary of Laboratory Control Samples (LCS) - 2001

Analysis	Matrix	Number of LCS Results Reported	Number Within Control Limits[(a)]
Gross Alpha	Air	46	46
Gross Beta	Air	46	46
$^{239+240}Pu$	Air	26	26
Gamma	Air	40	38
Tritium	Air	33	32
Gross Alpha	Water	13	11
Gross Beta	Water	13	13
$^{239+240}Pu$	Water	12	12
Gamma	Water	14	12
Tritium	Water	52	51
^{90}Sr	Water	5	5
^{226}Ra	Water	5	4
^{228}Ra	Water	6	6
Tritium	Soil	1	1
Gamma	Soil	8	7
^{90}Sr	Soil	4	3
$^{239+240}Pu$	Soil	4	4

(a) Control limits are as follows: 80 to 120 percent for all analyses and matrices except for gross alpha and beta which are 50 to 120 percent.

Table 9.3 Summary of Laboratory Blank Samples - 2001

Analysis	Matrix	Number of Blank Results Reported	Number Within Control Limits[(a)]
Gross Alpha	Air	136	136
Gross Beta	Air	136	136
$^{239+240}Pu$	Air	27	27
Gamma	Air	62	62
Tritium	Air	10	10
Gross Alpha	Water	20	20
Gross Beta	Water	20	20
$^{239+240}Pu$	Water	20	20
Gamma	Water	25	25
Tritium	Water	72	72
^{90}Sr	Water	9	9
^{226}Ra	Water	6	6
^{228}Ra	Water	7	7
Gross Alpha	Soil	1	1
Gross Beta	Soil	1	1
^{90}Sr	Soil	1	1
$^{239+240}Pu$	Soil	7	7
Gamma	Soil	18	18
Tritium	Soil	1	1

(a) Control limit is less than detection level.

Table 9.4 Summary of Interlaboratory Comparison Samples for the Subcontract Radiochemistry Laboratory - 2001

Analysis	Matrix	Number of Results Reported	Number Within Control Limits[(a)]
ERA Results			
Gross Alpha	Water	8	8
Gross Beta	Water	8	8
Gamma	Water	8	8
Tritium	Water	4	4
^{90}Sr	Water	8	8
^{226}Ra	Water	8	7
^{228}Ra	Water	8	8
EML Results			
Gross Alpha	Air	2	2
Gross Beta	Air	2	2
$^{239+240}Pu$	Air	3	3
Gamma	Air	2	2
Gross Alpha	Water	3	3
Gross Beta	Water	3	3
$^{239+240}Pu$	Water	2	2
Gamma	Water	3	3
Gamma	Soil	3	3
$^{239+240}Pu$	Soil	3	3
^{90}Sr	Soil	3	3
Gamma	Vegetation	3	3
$^{239+240}Pu$	Vegetation	3	3
^{90}Sr	Vegetation	3	3
MAPEP Results			
Gamma	Water	3	0
$^{239+240}Pu$	Water	3	3
^{90}Sr	Water	3	2
Gamma	Soil	3	3
$^{239+240}Pu$	Soil	3	3
^{90}Sr	Soil	3	2

(a) Control limits are determined by the individual interlaboratory comparison study.

Table 9.5 Summary of Interlaboratory Comparison TLD Samples for the BN in-house Dosimetry Group - 2001

Analysis	Matrix	Number of Results Reported	Number Within Control Limits[(a)]
TLDs	Ambient Radiation	18	17

(a) Control limits are determined by the Battelle PNNL performance evaluation study program.

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