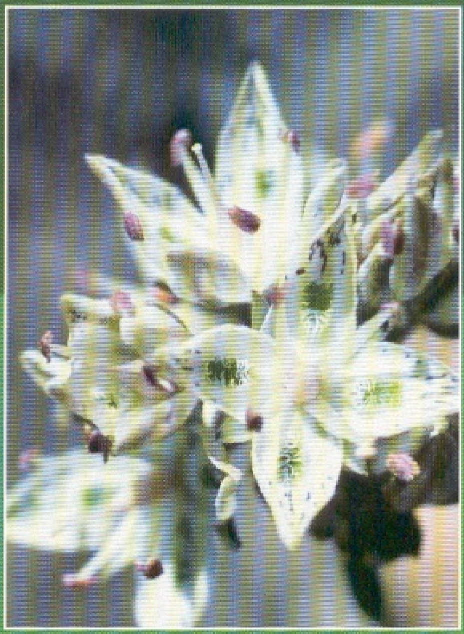
DOE/NV11718--463

Nevada Test Site

ANNUAL SITE ENVIRONMENTAL REPORT FOR CALENDAR YEAR - 1999

October 2000



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Prepared for U.S. Department of Energy
Nevada Operations Office

Bechtel Nevada

Contract No. DE-AC08-96NV11718

DISCLAIMER

DOE/NV/11718--463

NEVADA TEST SITE
ANNUAL SITE ENVIRONMENTAL REPORT
FOR CALENDAR YEAR 1999

Editors: Yvonne E. Townsend and Robert F. Grossman

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FOREWORD

Prior to 1989, annual reports of environmental monitoring and assessment results for the Nevada Test Site (NTS) were prepared in two separate parts. Onsite effluent monitoring and environmental monitoring results were reported in an onsite report prepared by the U.S. Department of Energy, Nevada Operations Office (DOE/NV). Results of the Offsite Radiological Surveillance and Long-Term Hydrological Monitoring programs conducted by the U.S. Environmental Protection Agency's (EPA's) Laboratory (various names) in Las Vegas, Nevada, were reported separately by that Agency.

Beginning with the 1989 Annual Site Environmental Report for the NTS, these two documents were combined into a single report to provide a more comprehensive annual documentation of the environmental protection activities conducted for the nuclear testing program and other nuclear and non-nuclear operations at the NTS. The two agencies have coordinated preparation of this eleventh combined onsite and offsite report through sharing of information on environmental surveillance and releases as well as meteorological, hydrological, and other supporting data used in dose-estimation calculations.

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ACKNOWLEDGEMENTS

The skill, dedication, and perseverance of Angela L. McCurdy in text processing and graphics support were crucial to the production of this report. Also, very crucial to the production of this report was the graphics support provided by John R. Coffey of the Geographical Information System Group. The review and advice offered by the DOE/NV's Environment, Safety and Health Division (ESHD) and the EPA's Radiation & Indoor Environments National Laboratory, Las Vegas (R&IE-LV) reviewers were invaluable. The efforts of Robert Furlow in coordinating the review of the 1999 ASER by the ESHD are greatly appreciated. Compilation and verification of onsite data were provided by Robert F. Grossman and Robert R. Kinnison. Statistical analyses of data were provided by Robert R. Kinnison. The cooperative support of Terry L. Mouck of the R&IE-LV in production of this combined onsite and offsite environmental report is greatly appreciated.

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TABLE OF CONTENTS

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LIST OF FIGURES

LIST OF TABLES

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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 = 3.7×10^{10} disintegrations per second = 3.7×10^{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

AIP	Agreement in Principle
ANOVA	Analysis of Variance
APCD	Air Pollution Control Division
ARL/SORD	Air Resources Laboratory, Special Operations and Research Division
ASCII	American Standard Code for Information Interchange
ASER	Annual Site Environmental Report
ASL	Analytical Services Laboratory
ASN	Air Surveillance Network
BCG	Biota Concentration Guide
BEIDMS	Bechtel Environmental Integrated Data Management System
BHPS	Bureau of Health Protection Services
BLM	U.S. Bureau of Land Management
BN	Bechtel Nevada
BOD	Biochemical Oxygen Demand
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)
CAU	Corrective Action Unit
CEDE	Committed Effective Dose Equivalent
CEI	Compliance Evaluation Inspection
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CP	Control Point
CRMP	Community Radiation Monitoring Program
CTLP	Community Technical Liaison Program
CWA	Clean Water Act
CX	Categorical Exclusion
CY	Calendar Year
DCG	Derived Concentration Guide
DDR	Data Discrepancy Report
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOE/HQ	DOE Headquarters
DOELAP	DOE Laboratory Accreditation Program
DOE/NV	DOE Nevada Operations Office
DQO	Data Quality Objectives
DRI	Desert Research Institute, University and Community College System, Nevada
EA	Environmental Assessment
EDE	Effective Dose Equivalent
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
EOD	Explosive Ordnance Disposal (NTS)
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
FFCAct	Federal Facilities Compliance Act
FIFRA	Federal Insecticide Fungicide and Rodenticide Act
FY	Fiscal Year
GCD	Greater Confinement Disposal
gpm	Gallons per Minute
HSC	Hazardous Materials Spill Center
HTO	Tritiated Water
HWSU	Hazardous Waste Storage Unit
ICRP	International Commission on Radiological Protection
ID	Identification
INEEL	Idaho National Engineering and Environmental Laboratory
IT	International Technology
LANL	Los Alamos National Laboratory
LAO	Los Alamos Operations (BN)
LDR	Land Disposal Restrictions
LLNL	Lawrence Livermore National Laboratory
LLW	Low-Level (Radioactive) Waste
LO	Livermore Operations (BN)
LTHMP	Long-Term Hydrological Monitoring Program
MAPEP	Mixed Analyte Performance Evaluation Program
MDC	Minimum Detectable Concentration
MEI	Maximally Exposed Individual
MOU	Memorandum of Understanding
MQO	Measurement Quality Objectives
MSL	Mean Sea Level
NAC	Nevada Administrative Code
NAFR	Nellis Air Force Range
NAGPRA	Native American Graves Protection and Repatriation Act
NDEP	Nevada Division of Environmental Protection
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
NLVF	North Las Vegas Facility (BN)
NPDES	National Pollution Discharge Elimination System
NR	National Register
NRHP	National Register of Historic Places
NSHPO	Nevada State Historic Preservation Office
NTS	Nevada Test Site
NVLAP	National Voluntary Laboratory Accreditation Program (NIST)
OEMP	Offsite Environmental Monitoring Program
ORSP	Offsite Radiological Safety Program
P2	Pollution Prevention

List of Acronyms and Expressions, cont.

PA	Performance Assessment
PCB	Polychlorinated Biphenyl
PE	Performance Evaluation
PEP	Performance Evaluation Program
PES	Performance Evaluation Study
PIC	Pressurized Ion Chamber
PPOA	Pollution Prevention Opportunity Assessments
QA	Quality Assurance
QAP	Quality Assessment Program
RBRC	Rechargeable Battery Recycling Corporation
RCRA	Resource Conservation and Recovery Act
RCT	Radiological Control Technician
R&IE-LV	Radiation & Indoor Environments National Laboratory - Las Vegas (EPA)
RMP	Resource Management Plan
ROD	Record of Decision
RREMP	Routine Radiological Environmental Monitoring Plan
RSD	Relative Standard Deviation
RSL	Remote Sensing Laboratory (BN)
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
SDWA	Safe Drinking Water Act
SQL	Structured Query Language
STL	Special Technologies Laboratory (BN)
TaDD	Tactical Demilitarization Development
TLD	Thermoluminescent Dosimeter
TRU	Transuranic Radionuclide
TSCA	Toxic Substances Control Act
TTR	Tonopah Test Range
UGTA	Underground Testing Area
U.S.	United States of America
USFWS	U. S. Fish and Wildlife Service
USES	U. S. Geological Survey
US	Underground Storage Tank
V.C.	Volatile Organic Compound
VIM	Vades Zone Monitoring
WACO	Washington Aerial Measurements Operations (BN)
WE	Waste Examination Facility
WIMP	Waste Isolation Pilot Plant
WI	Work Instructions
WPM-OF	Western Poohed Mesa Oasis Valley

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1.0 SUMMARY

Monitoring and surveillance, on and around the Nevada Test Site, (NTS) by United States Department of Energy (DOE) contractors and NTS user organizations during 1999, indicated that operations on the NTS were conducted in compliance with applicable DOE, state, and federal regulations and guidelines. All discharges of radioactive liquids remained onsite in containment ponds, and there was no indication of potential migration of radioactivity to the offsite area through groundwater. During 1999, no accidental or unplanned releases occurred on the NTS. Oversite surveillance by the U.S. Environmental Protection Agency's Radiation and Indoor Environments National Laboratory (R&IE-LV) around the NTS indicated that airborne radioactivity from diffusion and evaporation of liquid effluents was not detectable offsite; however, low levels of airborne $^{239+240}$Pu were detected offsite by high-volume air samplers. 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 calculated effective dose equivalent (EDE) to the maximally exposed individual (MEI) offsite would have been 0.12 mrem. This value is 1.2 percent of the federal dose limit prescribed for radionuclide air emissions. The EDEs calculated from measured radioactivity concentrations by high-volume offsite air samplers were all less than the model prediction. The MEI receiving this dose would also have received an external exposure of 143 mrem from natural background radiation. A maximized estimate of the EDE to the MEI, from the inhalation of NTS airborne emissions and the ingestion of milk and of wild life, was calculated to be 0.63 mrem/yr (0.0063 mSv/yr), which is only 0.63 percent of the 100 mrem/yr dose limit to the general public. There were no nonradiological releases to the offsite area. Hazardous wastes were shipped offsite to approved 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. A determination of compliance with dose limits for aquatic biota was postponed until characterization of the radioactivity in the E Tunnel sediments is completed.

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 DOE Nevada Operations Office (DOE/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 (ESHD) 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 DOE/NV, i.e., underground testing of nuclear explosive devices. DOE/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 1997c) to calculate potential EDEs to people living beyond the boundaries of the NTS and the surrounding exclusion areas.

1.2 RADIOLOGICAL ENVIRONMENT

Radiological effluents in the form of air emissions and liquid discharges are 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 1999 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 1999 included HTO, only slightly above detection limits, from the Radioactive Waste Management Site in Area 5 (RWMS-5), the SEDAN crater in Area 10, and the SCHOONER crater in Area 20 and resuspended $^{239+240}$Pu 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 assumed to be released from all sources, including postulated loss of standards during laboratory operations. The radioactive materials listed in this table were not detected in the offsite area above ambient radioactivity levels. Onsite liquid discharges to containment ponds included approximately 25 Ci (0.92 TBq) of tritium. This was much less than the tritium discharge last year. Evaporation of this material could have contributed HTO to the atmosphere, but diffusion caused the concentration to be too small to be detected by the tritium monitors onsite. Most likely only the tritium emissions from SEDAN and SCHOONER sites were detected by air sampling. 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. In 1999, samplers were operated at 29 locations on and near the NTS to collect air particulate samples and at 12 locations to collect HTO in atmospheric moisture. Grab samples were collected frequently from water supply wells, water taps, containment ponds, and sewage lagoons. Thermoluminescent dosimeters (TLDs) were placed at 85 locations on the NTS to measure ambient gamma exposures.

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 1,700 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 a few instances where very low levels of ^{137}Cs were detected.

Gross beta analysis of the air samples yielded an annual average for the network of 2.1×10^{-14} µCi/mL (0.89 mBq/m^3). Plutonium analyses of monthly composited air filters indicated an annual arithmetic average of 1×10^{-16} µCi/mL (3.7 µBq/m^3) for $^{239+240}Pu$ and 1.4×10^{-18} µCi/mL (0.052 µBq/m^3) of ^{238}Pu for all locations during 1999.

Slightly higher concentrations were found in samples from certain areas, but they were calculated to be only 0.02 percent of the Derived Air Concentration (DAC) 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.

Throughout the year atmospheric moisture was collected for two-week periods at 12 locations on the NTS and analyzed for HTO content. The annual arithmetic average of $(25 \pm 88) \times 10^{-6}$ pCi/mL (0.93 ± 3.3 Bq/m^3) was slightly higher than last year. The highest annual average concentrations were at the SCHOONER crater, the E Tunnel pond, and SEDAN crater in that order. The primary radioactive liquid discharge to the onsite environment in 1999 was about 25 Ci (0.92 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 one containment pond and nine sewage lagoon systems. 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. Water samples from the lagoons contained background levels of gross beta, tritium, plutonium, and strontium. Samples collected from the tunnel containment pond and containment ponds for Underground Test Area (UGTA) characterization wells contained detectable levels of radioactivity, as would be expected.

Water samples from onsite supply wells and drinking water distribution systems were also analyzed for radionuclides. The supply well average gross beta activity of 6.5×10^{-9} µCi/mL (0.24 Bq/L) was 2 percent of the DCG for ^{40}K (used for comparison purposes); gross alpha was 5.5×10^{-9} µCi/mL (0.21 Bq/L), which was 37 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 of about 15×10^{-9} µCi/mL (0.56 Bq/L), 0.28×10^{-9} µCi/mL (10 mBq/L), and 2.5×10^{-11} µCi/mL (0.93 mBq/L).

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 floor 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 the TLD network showed that the 9 historic stations had an average annual exposure of 91 mR, while the 16 boundary stations (located at higher elevation) had a higher average annual exposure of 119 mR. Both exposures were consistent with previous data.

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 Plan was implemented in the latter part of 1998.

OFFSITE ENVIRONMENTAL SURVEILLANCE

The offsite radiological monitoring program is conducted around the NTS by the EPA's Radiation and Indoor Environments National Laboratory-Las Vegas (R&IE-LV), under an Interagency Agreement with DOE. This program consists of several environmental sampling, radiation detection, and dosimetry networks as described below. These networks operated continuously during 1999.

The Air Surveillance Network (ASN) was made up of 19 continuously operating sampling locations surrounding the NTS, 6 of which also had high-volume air samplers. During 1999, no airborne radioactivity related to current activities at the NTS was detected on any sample from low-volume ASN samplers. Other than naturally occurring ^{7}Be, the only specific radionuclide detected by this network was ^{238}Pu or $^{239+240}Pu$ on air-filter samples from high volume air samplers. The network average gross beta in air results were slightly less than the average for the NTS network.

In 1999, external exposure was monitored by a network of 22 TLDs and 17 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 152 mR/yr, that 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.

Sampling of Long-Term Hydrological Monitoring Program (LTHMP) wells and surface waters around the NTS showed only background radionuclide concentrations. The concentrations of radioactivity that were detected in air or water samples posed no significant health risk to nearby residents.

A network of 17 Community Technical Liaison Program (CTLP) stations was operated by local residents, one without an air sampler. Each station was an integral part of the ASN and TLD networks. In addition, they were equipped with a PIC connected to a gamma-rate recorder. Samples and data from these CTLP stations were analyzed and reported by R&IE-LV and also interpreted and reported by the Desert Research Institute, University of Nevada System. All measurements for 1999 were consistent with previous years and were within the normal background range for the United States.

Although no radioactivity attributable to current NTS operations was detected by any of the offsite monitoring networks, based on the NTS airborne releases reported in Table 1.1, an atmospheric dispersion model calculation (CAP88-PC) indicated that the maximum potential EDE to any offsite individual would have been 0.12 mrem (1.2×10^{-3} mSv) at Springdale, and the dose to the population within 80 km of the several emission sites on the NTS would have been 0.38 person-rem (3.8×10^{-3} person-Sv), both of which were similar to last year. 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 receive an additional EDE of 0.5 mrem/yr (0.005 mSv/yr). Assuming also that this individual ingested milk, an additional EDE from ^{90}Sr would be 0.010 mrem/yr (1.0×10^{-4} mSv/yr). These added to the air pathway EDE gives a total of 0.63 mrem/yr (0.0063 mSv/yr). For comparison, the hypothetical person receiving this dose would also have been exposed to 143 mrem/yr (1.43 mSv/yr) from 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 standard 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 Biota Concentration Guide.

OVERALL ASSESSMENT

Gross beta measurements in air samples are a reasonable method for assessing the radioactive environment at a location. In order to indicate the present situation at the NTS, in comparison with that of previous years, the network annual average gross beta concentrations in NTS air for the last 34 years are plotted in Figure 1.1. The obvious peaks in this trend line are identified with associated tests, where possible. Also plotted are data from the NTS offsite network operated by EPA, where it exists.

Figure 1.1 indicates the decrease with time of gross beta concentration in air that occurs independently of the peaks. In the early years, the decrease occurred because atmospheric tests and Plowshare cratering tests were terminated. In the later years, improved containment methods to reduce accidental releases led to the extremely low levels of radioactivity in air. Only tests in the atmosphere and nuclear accidents at foreign locations interrupt the steady decrease of gross beta concentration in NTS air.

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 2.3, Chapter 2 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.

RADIOLOGICAL MONITORING AT OFFSITE SUPPORT FACILITIES

Fence line monitoring, using Panasonic UD-814 TLDs, was conducted at DOE/NV offsite support facilities in North Las Vegas, Nevada; Santa Barbara, California; and at the Remote Sensing Laboratory-Andrews (RSL-Andrews). The 1999 results indicated that only background radiation was detected at the fence line of these facilities.

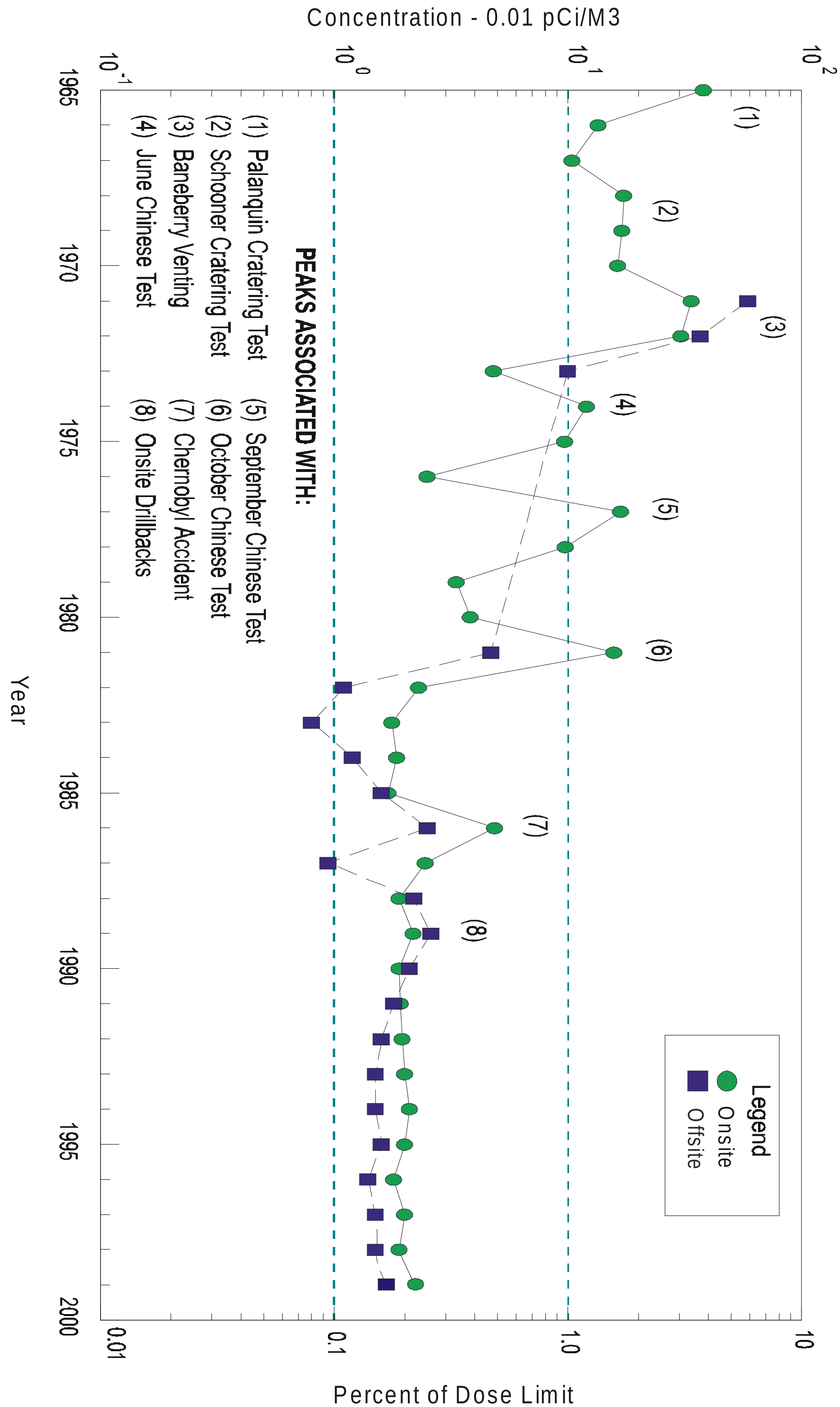


Figure 1.1 Trend of Gross Beta Concentration in Air at the NTS

In 1995, a small amount of tritium was accidently released from a calibration range building in North Las Vegas that was still detectable this year in the room where the release occurred. Monitoring of the release provided data for input into the CAP88-PC program for calculating offsite exposures. The maximum offsite exposure was estimated to be only 0.0014 mrem, which is far below the EPA permissible limit of 10 mrem.

1.3 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 1999, 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); seven permits for onsite drinking water distribution systems; one permit for sewage discharges to lagoon collection systems; five permits for septage 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, 1 sewage discharge permit, 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 1999, there were no projects that required state of Nevada notifications. The annual estimate for non-scheduled asbestos demolition/renovation projects for fiscal year 1999 was sent to EPA Region 9 in December 1998.

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 DOE and the state of Nevada.

The state's annual Compliance Evaluation Inspection during June 1999 found no violations.

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.

In June of 1999, the state inspected all NTS equipment regulated by the state air quality permit. There were no findings as a result of these inspections.

In compliance with the Safe Drinking Water Act (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, depending on the status as a community or non-community system.

Monitoring for polychlorinated biphenyls, as required by the Toxic Substances Control Act (TSCA), was done and was reported to the DOE/NV in May 1999.

At the Hazardous Materials Spill Center (HSC), 8 projects involving many different chemicals and a stream fate study (Frostproof) were conducted during 1999. None of the tests generated enough airborne contaminants to be detected at the NTS boundary during or after the tests. Boundary monitoring would have been performed by R&IE-LV personnel if necessary. Based upon reviews of the spill test plans in accordance with the monitoring plan for the facility, no biota baseline monitoring was required.

1.4 COMPLIANCE ACTIVITIES

DOE/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, TSCA, 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 included action on one Environmental Impact Statements (EISs), one Environmental Assessment (EA), and 12 Categorical Exclusions (CXs). A total of 35 other projects were excluded because they had been considered in the site-wide EIS 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 were within the regulated levels established by city or county publicly owned treatment works.

The American Indian Religious Freedom Act directs federal agencies to consult with Native Americans to protect their right to exercise their traditional religions. In 1999, work continued on a summary report, site records, and an artifact inventory of materials in the DOE/NV Curatorial Facility. Consultations with several Western Native American tribes were conducted to determine whether artifact collections should be repatriated.

The Ecological Monitoring and Compliance Program monitoring tasks, which were selected for 1999 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 HSC were also conducted.

Field surveys were conducted from June 1996 through February 1998 to identify those natural NTS springs, seeps, tanks, and playas, which could be designated by the United States Army Corps of Engineers as jurisdictional wetlands. During 1999, 18 of these wetlands were visited to characterize seasonal trends in physical and biological parameters.

The annual compliance report for calendar year 1999 NTS activities was prepared and submitted to the USFWS.

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

1.5 GROUNDWATER PROTECTION

The LTHMP was instituted in 1972 to be operated by the EPA under an Interagency Agreement. In 1999, the sampling of surface and groundwaters on and around the NTS was transferred from the LTHMP to the RREMP. 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. Through 1999, seven wells were completed, one offsite and six in the near offsite area, downgradient of the NTS.

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

1.6 RADIOACTIVE AND MIXED WASTE STORAGE AND DISPOSAL

Two RWMSs are operated on the NTS: one each in Areas 3 and 5. During 1999, the RWMSs received LLW generated at the NTS and other DOE 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 overpacked 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 1999 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 facilities offsite. Therefore hazardous waste is not disposed of onsite.

Pit 3 in RWMS-5 has interim status for mixed waste generated on the NTS.

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 (NTS 1996) and that have received DOE/NV approval of the waste stream(s) for disposal at the NTS.

1.7 QUALITY ASSURANCE

The quality assurance (QA) program covering NTS activities has three components. There are QA programs for nonradiological analyses, onsite radiological analyses, and offsite radiological analyses.

ONSITE NONRADIOLOGICAL QUALITY ASSURANCE

The onsite nonradiological QA program was not operative during 1999, because stable chemical analyses are done by offsite contract laboratories. These contract laboratories are monitored for their participation and performance in various performance evaluation programs.

ONSITE RADIOLOGICAL QUALITY ASSURANCE

The onsite radiological QA program includes conformance to best laboratory practice and implementation of the provisions of DOE Order O 414.1A (DOE 1999). The external QA intercomparison program for radiological data QA consists of participation in the DOE Quality Assessment Program administered by the DOE Environmental Measurements Laboratory (EML), in the InterLaB Rad CheM™ Proficiency Testing Program by Environmental Resource Associates, and in the Radiochemistry Intercomparison Program provided by the National Institute of Standards and Technology.

OFFSITE RADIOLOGICAL QUALITY ASSURANCE

The policy of the EPA requires participation in a centrally managed QA program by all EPA organizational units involved in environmental data collection. The external QA programs used by the R&IE-LV for the NTS Offsite Radiological Safety Program during 1999 consisted of the DOE Quality Assessment Program administered by the DOE EML and the Mixed Analyte Performance Evaluation Program (MAPEP) conducted by the Idaho National Engineering and Environmental Laboratory.

1.8 ISSUES AND ACCOMPLISHMENTS

PRINCIPAL COMPLIANCE PROBLEMS FOR 1999

- Lead was found above the SDWA action level in the Area 1 and Area 2-12 drinking water systems. All fixtures were removed or closed in the Area 1 system and no further lead sampling will take place unless the buildings are reopened. The problem in the Area 2-12 system is still being resolved.

ACCOMPLISHMENTS FOR 1999

- Implementation of the RREMP. The RREMP uses a DQO approach to identify the environmental data that must be collected for regulatory compliance and provides QA, Analysis and Sampling Plans to ensure that defensible data are generated. The RREMP provides one common integrated approach for all routine environmental monitoring both on and off the NTS. Other facilities also included in the RREMP are the associated DOE facilities at the North Las Vegas Facility (NLVF), the Remote Sensing Laboratory - Nellis (RSL-Nellis), the Los Alamos Operations, the Special Technologies Laboratory (STL), and the RSL-Andrews.

- The Bechtel Environmental Integrated Data Management System (BEIDMS), Oracle relational database, replaced the Laboratory Data Analysis System (LDAS) for the storage, documentation and retrieval for all environmental sampling results. BEIDMS integrates the preparation of chain-of-custody, sample labeling, QA, data verification/validation, and user-friendly querying in one system providing greater assurance that the data are defensible.

- NEPA Environmental Evaluation Checklists were completed for 60 proposed projects.

- Throughout 1999, DOE/NV continued to maintain and update the “DOE/NV Compliance Guide” (Volume III), a handbook containing procedures, formats, and guidelines for personnel responsible for NEPA compliance activities.

In 1999, the following accomplishments were achieved in the management of cultural resources at the NTS:

- Six cultural resources and seven archaeological sites were located and recorded. One of these sites, Camp Desert Rock, is considered a candidate for listing on the National Register of Historic Places.

- The NRHP approved the relocation of the train engine housed in the E-MAD facility in Area 25 to the train museum in Boulder City.

- A technical report on the archaeological data recovery program for the proposed Kistler Rocket Launch Facility was included in Nevada's Cultural Resources archives.

- The archaeological research on 2,900 petroglyph images from about 700 boulders, was documented in a report draft scheduled for completion in 2000.

- The Cultural Resources Management Plan for the NTS was completed and distributed.

- An annual report summarizing the curation compliance activities of Desert Research Institute was completed.

- A report was completed which summarized the recommendations of the Consolidated Group of Tribal Organizations in regard to the repatriation of selected artifacts from recent collections from the NTS.

- A survey was completed identifying 150 historic atmospheric nuclear testing remains in Frenchman Flat.

- DOE/NV sponsored a meeting with the Consolidated Group of Tribal Organizations to determine whether three small collections of Native American artifacts should be repatriated.

- Operations conducted under the Nevada Operations Site Pollution Prevention Program in 1999 resulted in recycle or new uses of nearly 1,169 metric tons of materials and approximately 107 metric tons of hazardous waste made useful (waste reduction).

- Continued use of a Just-in-Time supply system allowed NTS contractors to reduce product stock and control potentially hazardous products.

- Progress continued on the NTS groundwater characterization program by use of pumping programs on several wells to estimate yields and radionuclide content.

- Habitat maps of vegetation alliances on the NTS were completed to identify groups of visually similar vegetation, soils, slope, and hydrology which may warrant active protection from DOE projects.

- Monitoring of 26 sensitive species of vegetation and animals (Western Burrowing Owl, bats, and raptors) was begun to ensure their continued presence on the NTS by protecting them from impacts of DOE projects and to determine if further protection under State and Federal laws is necessary.

- The state issued a RCRA Research, Development, and Demonstration Permit for the construction and operation of a facility to develop treatment methods for demilitarizing rocket motors.

- DOE/NV has entered in 12 agreements, memoranda, and consent orders with other entities, including an Interagency Agreement and Memorandum of Understanding (MOU) with EPA regarding environmental surveillance and NESHAP compliance; Agreements in Principle with Alaska, Mississippi, and Nevada on environment, safety, and health oversight activities; a MOU with

Nevada covering radioactive releases; a MOU with Nellis Air Force Base regarding environmental restoration; a Settlement Agreement with Nevada on handling mixed TRU waste; a FFACO with Nevada on environmental restoration; and a Federal Facilities Compliance Act Consent Order regarding restricted waste streams on the NTS.

- The first annual consumer confidence report containing details on the two NTS community drinking water systems were issued in 1999.

1.9 CONCLUSION

The environmental monitoring results presented in this report document that operational activities on the NTS in 1999 were conducted so that no measurable radiological exposure occurred to the public in offsite areas. Calculation of the highest individual dose that could have been received by an offsite resident (based on estimation of onsite worst-case radioactive releases obtained by measurement or engineering calculation and assuming the person remained outdoors all year) equated to 0.12 mrem to a person living in Springdale, Nevada. This may be compared to that individual's exposure to 143 mrem from natural background radiation as measured by the PIC instrument at Beatty, Nevada.

There were no major incidents of nonradiological contaminant releases to the environment in 1999. Many contaminated sites are on schedule for remediation, and intensive efforts to characterize and protect the NTS environment, implemented in 1990, were continued in 1999.

The UGTA 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 - 1999[a]

Radionuclide	Half-life (years)	Quantity Released (Ci)[b]
Airborne Releases:		
^{3}H	12.35	338[c]
$^{239+240}Pu$	24065.[e]	0.24 [c]
Containment Ponds:		
^{3}H	12.35	24.7 [d]
^{238}Pu	87.743	5.5×10^{-6}
$^{239+240}Pu$	24065.[e]	4.8×10^{-5}
^{90}Sr	29.	3.2×10^{-5}
^{137}Cs	30.17	4.1×10^{-3}

(a) Assumes worst-case point and diffuse source releases; there were no unplanned releases .
(b) Multiply by 37 to obtain GBq.
(c) Includes calculated data from air sampling results, postulated loss of laboratory standards, and calculated resuspension of surface deposits.
(d) This amount is assumed to evaporate to become an airborne release.
(e) This is the halflife of ^{239}Pu.

Table 1.2 NTS Radiological Dose Reporting Table for Calendar Year 1999

Pathway	Dose to MEI (mrem)	Dose to MEI (mSv)	Percent of DOE 100-mrem Limit	Estimated Population Dose (person-rem)	Estimated Population Dose (person-Sv)	Population within 80 km	Estimated Natural Population Dose (person-rem)
Air+Milk+ Wild Life[a]	0.63	0.0063	0.63	0.38	0.0038	36,517	3,520
Air only	0.12	0.0012	1.2[b]	0.38	0.0038	36,517	3,520

(a) EDE of 0.50 mrem from wild life was based upon measurements of radionuclides in water, vegetation, and rabbit tissue samples collected at E Tunnel pond and CAMBRIC ditch. The MEI was assumed to harvest state bag limits for three types of wild game (doves, rabbits, and deer). EDE from ingestion of milk was 0.010 mrem/yr.

(b) Limit for Air pathway is 10 mrem.

View of Mercury, the Main Base Camp at the NTS

2.0 INTRODUCTION

The Nevada Test Site (NTS), located in southern Nevada, was the primary location for the testing of nuclear explosives in the continental U.S. 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. In 1999 NTS activities involving hazardous or radioactive materials consisted of subcritical nuclear tests; nonnuclear testing including controlled spills of hazardous material at the Hazardous Materials Spill Center (HSC); low-level radioactive and mixed waste disposal; and defense waste storage facilities for transuranic (TRU) and hazardous wastes.

The 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. Restricted access and extended wind transport times are notable features of the remote location of the NTS and adjacent United States Air Force lands. Also, characteristic of this area are the great depths to slow-moving groundwater and little or no surface water. These features afford protection to the inhabitants of the adjacent areas from potential exposure to radioactivity or other contaminants resulting from operations on the NTS. Population density within 80 km of the NTS is only 0.2 persons/km^2 versus approximately 30 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.

In addition to the NTS operations, the U.S. Department of Energy, Nevada Operations Office (DOE/NV) is accountable for six non-NTS Bechtel Nevada (BN) facilities in five different cities. These BN operations support DOE/NV programs with activities ranging from aerial measurements and aircraft maintenance to electronics and heavy industrial fabrication. All of these latter operations are in metropolitan areas.

2.1 NTS OPERATIONS

NTS DESCRIPTION

The NTS, located in Nye County, Nevada, as shown in Figure 2.1, has been operated by the DOE 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 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

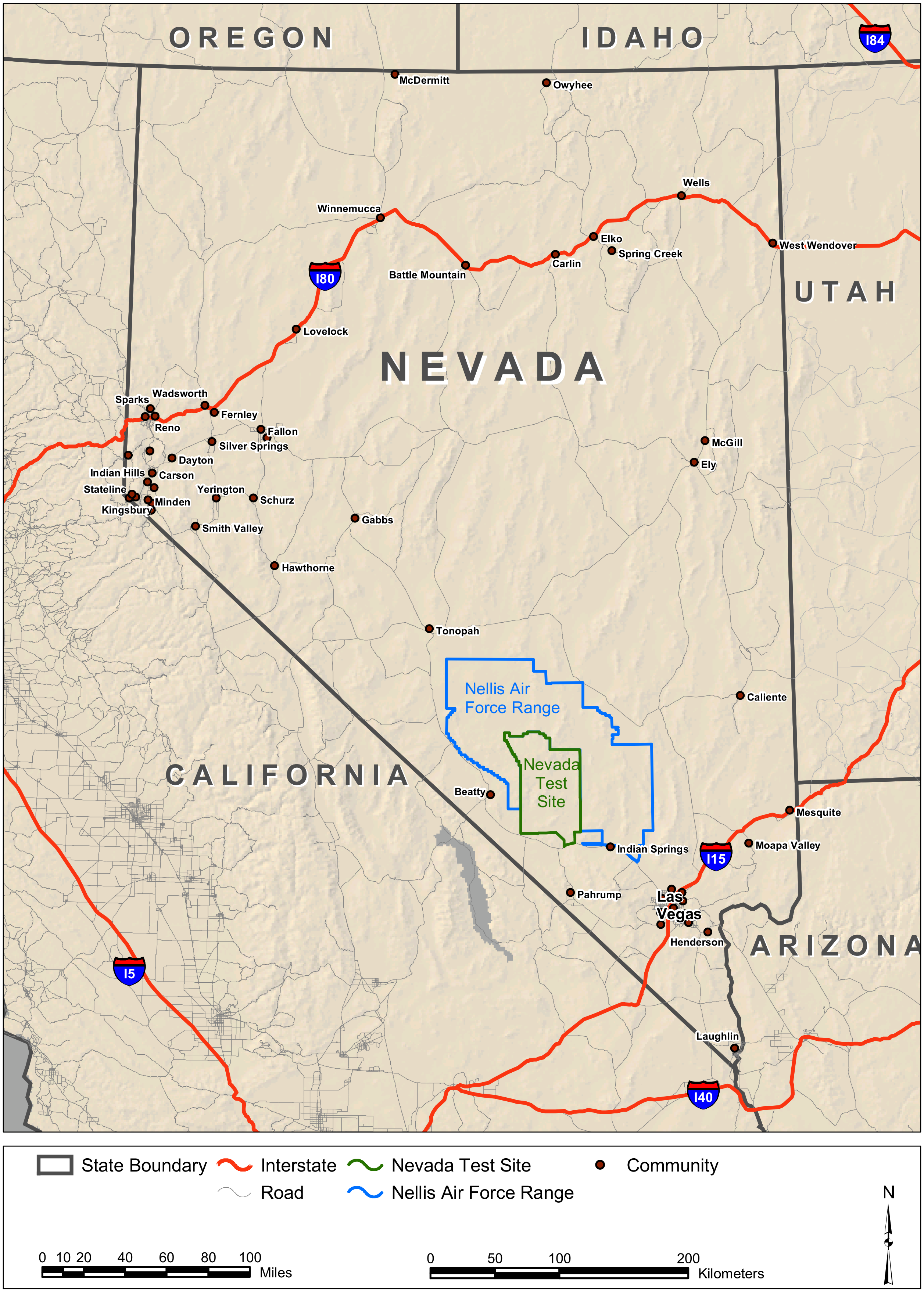


Figure 2.1 NTS Location in Nevada

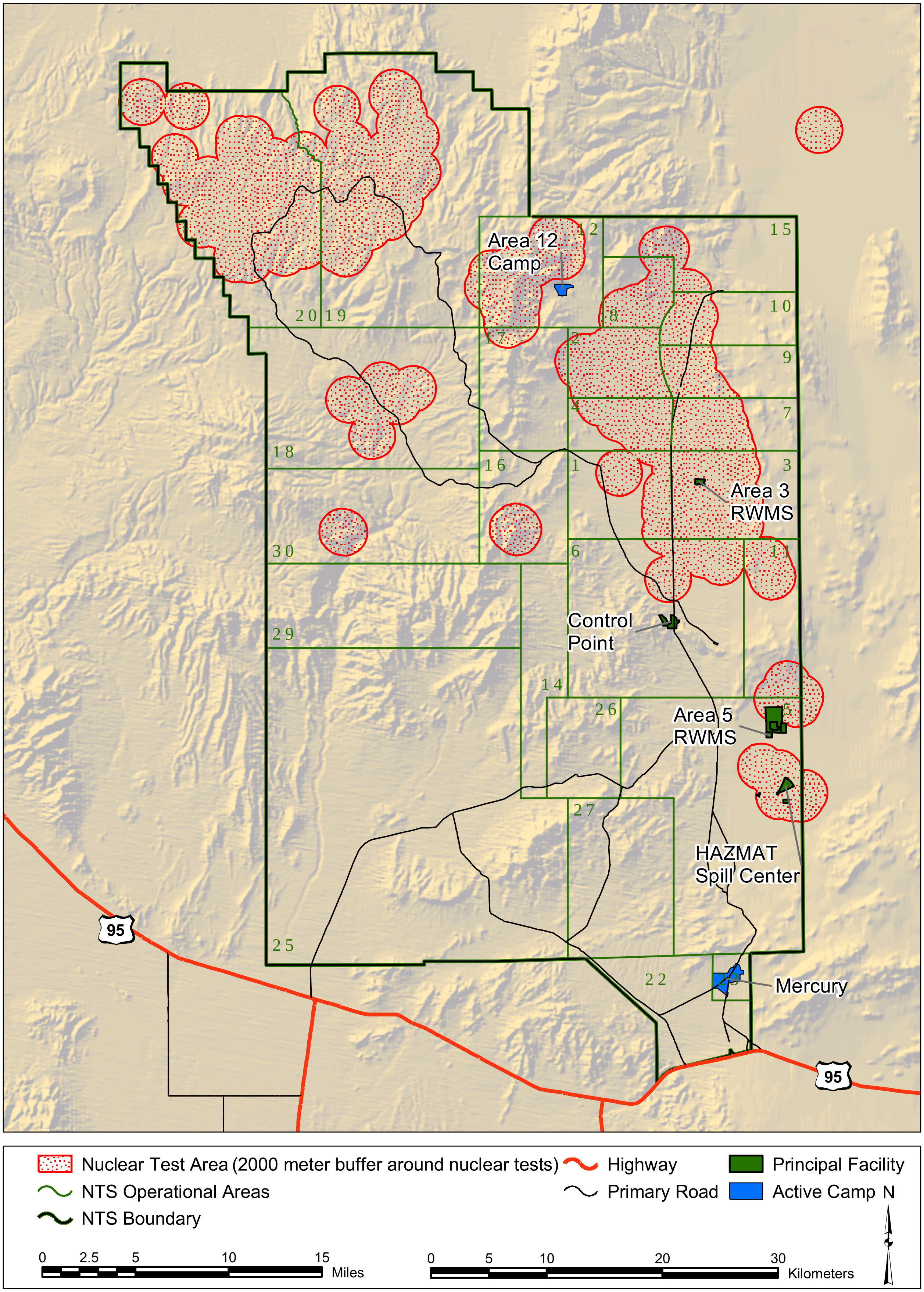


Figure 2.2 NTS Area Numbers, Principal Facilities, and Testing Areas - 1999

layout of the NTS, including the location of major facilities and the area numbers referred to in this report. The geographical areas previously used for nuclear testing are indicated in Figure 2.2. Mercury, located at the southern end of he NTS, is the main base camp for worker housing and administrative operations for the NTS.

MISSION AND NATURE OF OPERATIONS

The present mission of the DOE/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.

Past and present operations on the NTS are described in the following paragraphs.

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 (see Figure 2.3). All nuclear device tests are listed in DOE/NV Report NVO-209 (DOE 1994).

Underground nuclear tests were first conducted in 1951. 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. There have been no United States nuclear explosive tests since September 1992.

Other nuclear testing over the history of 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.

Limited nonnuclear testing has also occurred at the NTS, including spills of hazardous materials at the HSC in Area 5. The tests conducted at the HSC, from the latter half of

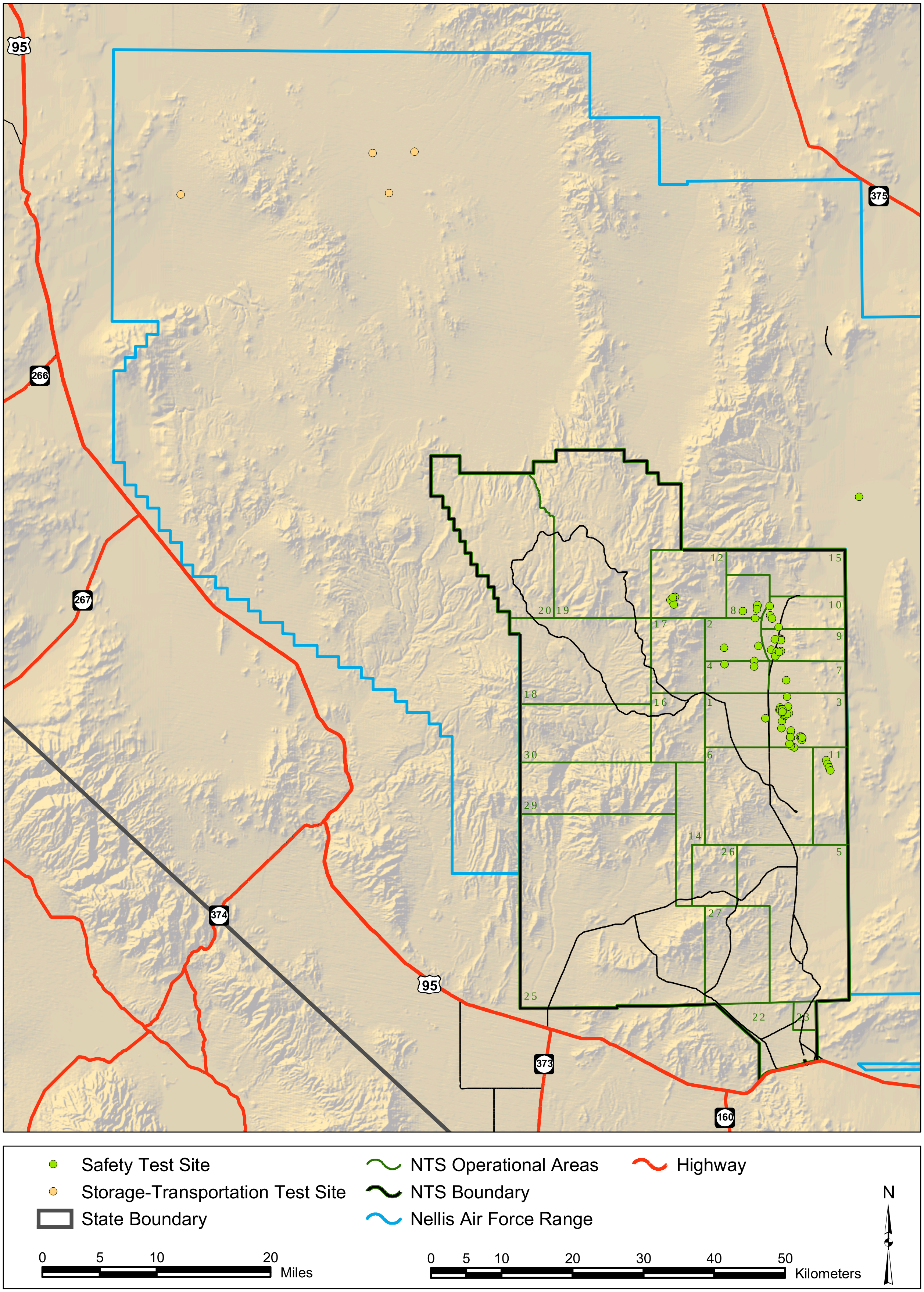


Figure 2.3 Location of Safety Tests on the NTS and the NAFR - 1999

the 1980s to date, involved controlled spilling of liquid materials to study both spill control and mitigation measures and the resultant dispersion and transport of airborne clouds. At the Explosive Ordnance Disposal in Area 11, explosive materials are destroyed, generally by detonation, with the amounts destroyed being limited in order to maintain downwind air concentrations within state limits. Tests are conducted involving depleted uranium and other materials at the Big Explosives Experimental Facility in Area 4.

Waste storage and disposal facilities for defense low-level radioactive waste (LLW) and mixed waste are located in Areas 3 and 5. At the Area 5 Radioactive Waste Management Site (RWMS-5), LLW from DOE-affiliated onsite and offsite generators is disposed of using standard shallow land disposal techniques.

TRU wastes are retrievably stored in surface containers at the RWMS-5 pending shipment to the Waste Isolation Pilot Plant (WIPP) facility in New Mexico. Nonradioactive hazardous wastes are accumulated at a special site before shipment to a licensed offsite disposal facility.

At the Area 3 RWMS (RWMS-3), bulk LLW (such as debris from atmospheric nuclear test locations) and LLW in large non-standard packages are emplaced and buried in selected surface subsidence craters (formed as a result of prior underground nuclear tests).

1999 ACTIVITIES

SUBCRITICAL EXPERIMENTS

No nuclear explosives tests were conducted during 1999, due to the moratorium announced in late 1992. There were three subcritical experiments which involved small amounts of special nuclear material that do not reach the fissioning stage during the experiment. However, continuous environmental surveillance for radioactivity and radiation was conducted both onsite and offsite, because of the large number of potential effluent sources that exist on the NTS as a result of the prior nuclear tests. The surveillance program and results are described in Chapters 4, 5, and 6.

NTS-RELATED ACTIVITIES

LLW and mixed waste handling and disposal, TRU waste storage and packaging prior to shipment to the WIPP in New Mexico, and remedial actions related to sites contaminated by tests of nuclear devices are some of the activities that occurred in 1999.

Compliance with state and federal environmental laws and regulations was another principal activity during 1999. Specifically included were actions related to, (1) National Environmental Policy Act documentation preparation, such as Environmental Impact Statements, Environmental Assessments, etc.; (2) Clean Air Act compliance for asbestos renovation projects, radionuclide emissions, and state air quality permits; (3) Clean Water Act compliance involving state wastewater permits; (4) Safe Drinking Water Act compliance involving monitoring of drinking water distribution systems; (5) Resource Conservation and Recovery Act management of hazardous wastes; (6) Comprehensive Environmental Response, Compensation, and Liability Act reporting; and (7) Toxic Substances Control Act management of polychlorinated biphenyls. Also included were preactivity surveys to detect and document archaeological and historic sites on the NTS. Compliance with the Endangered Species Act involved conducting pre-operation surveys to document the status of state of Nevada and federally listed endangered or threatened plant and animal species.

HAZARDOUS MATERIALS SPILL CENTER (HSC)

DOE/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 BN. The HSC is the basic research tool for studying the dynamics of accidental releases of various hazardous materials. This is described more completely in Chapter 6.

TOPOGRAPHY AND TERRAIN

The topography of the NTS is typical of the Great Basin Section of the Basin and Range physiographic province of Nevada, Arizona, and Utah. North-south-trending mountain ranges are separated by broad, flat-floored, and gently-sloped valleys. The topography is depicted in Figure 2.4. Elevations range from about 910 m (3,000 ft) above mean sea level (MSL) in the south and east, rising to 2,230 m (7,300 ft) in the mesa areas toward the northern and western boundaries. The slopes on the upland surfaces are steep and dissected, whereas the slopes on the lower surfaces are gentle and alluviated with rock debris from the adjacent highlands.

The principal effect upon the terrain from nuclear testing has been the creation of numerous dish-shaped surface subsidence craters, particularly in Yucca Flat. Most underground nuclear tests conducted in vertical shafts produced surface subsidence craters that occurred when the overburden above a nuclear cavity collapsed and formed a rubble "chimney" to the surface. A few craters have been formed as a result of tests conducted on or near the surface by shallow depth-of-burial cratering experiments, or following some tunnel events.

There are no continuously flowing streams on the NTS. Surface drainages for Yucca and Frenchman Flats closed-basin systems are onto the dry lake beds (playas) in each valley. The remaining areas of the NTS drain via arroyos and dry stream beds that carry water only during unusually intense or persistent storms. Rainfall or snow melt typically infiltrates quickly into the moisture-deficient soil or runs off in normally dry channels, where it evaporates and seeps into permeable sands and gravels. During extreme conditions, flash floods may occur.

GEOLOGY

The basic lithologic structure of the NTS is depicted in Figure 2.5. Investigations of the geology of the NTS, including detailed studies of numerous drill holes and tunnels, have been in progress by the U.S. Geological Survey (USGS) and other organizations since 1951. Because of the large number of drilled holes (see Figure 2.6), the NTS is probably one of the better geologically characterized large areas within the United States.

In general, the geology consists of three major rock units. These rock units are (1) complexly folded and faulted sedimentary rocks of Paleozoic age overlain at many places by; (2) volcanic tuffs and lavas of Tertiary age, which (in the valleys) are covered by; (3) alluvium of late Tertiary and Quaternary age. The sedimentary rocks of Paleozoic age are many thousands of feet thick and are comprised mainly of carbonate rocks (dolomite and limestone) with clastic rocks (shale and quartzite) near the top and at the bottom of the section. The volcanic rocks in the valleys are down-dropped and tilted along steeply dipping normal faults of late Tertiary age. The alluvium is rarely faulted and is derived from erosion of Tertiary and Paleozoic rocks. The volcanic rocks of the Tertiary age are predominantly rhyolitic tuffs and lavas, which erupted from various volcanic centers. The aggregate thickness of the volcanic rocks is many thousands of feet, but in most places the actual thickness of the section is far less because of erosion or nondeposition. These materials erupted before the collapse of large volcanic centers known as *calderas*. Alluvial materials fill the intermountain valleys and cover the adjacent slopes. These sediments attain thicknesses of 600 to 900 m (2,000 to 3,000 ft) in the central portions of the valleys.

HYDROGEOLOGY

The deep aquifers, slow groundwater movement, and exceedingly slow downward movement of water in the overlying unsaturated zone serve as significant barriers to transport of radioactivity from

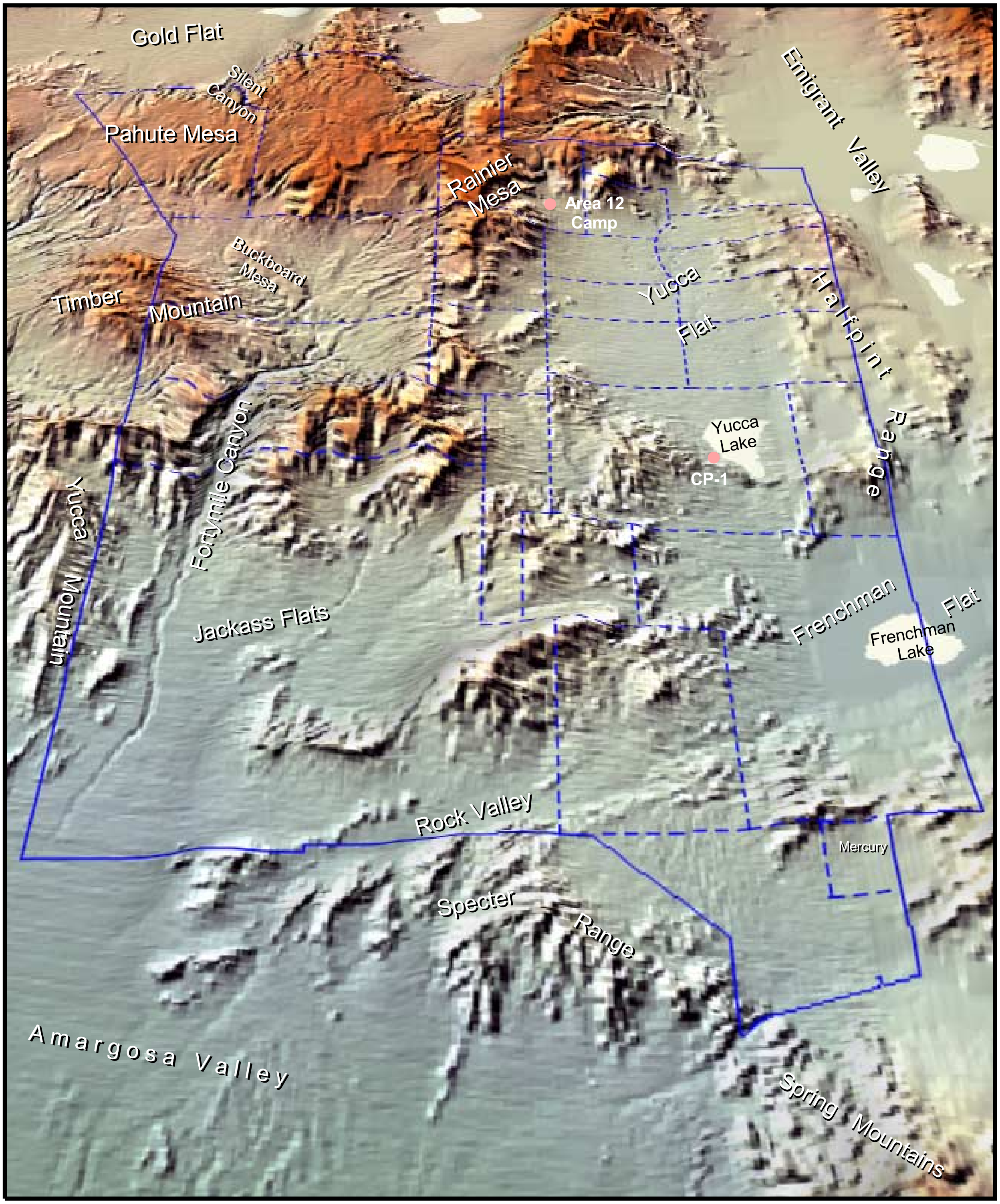


Figure 2.4 Topography of the NTS

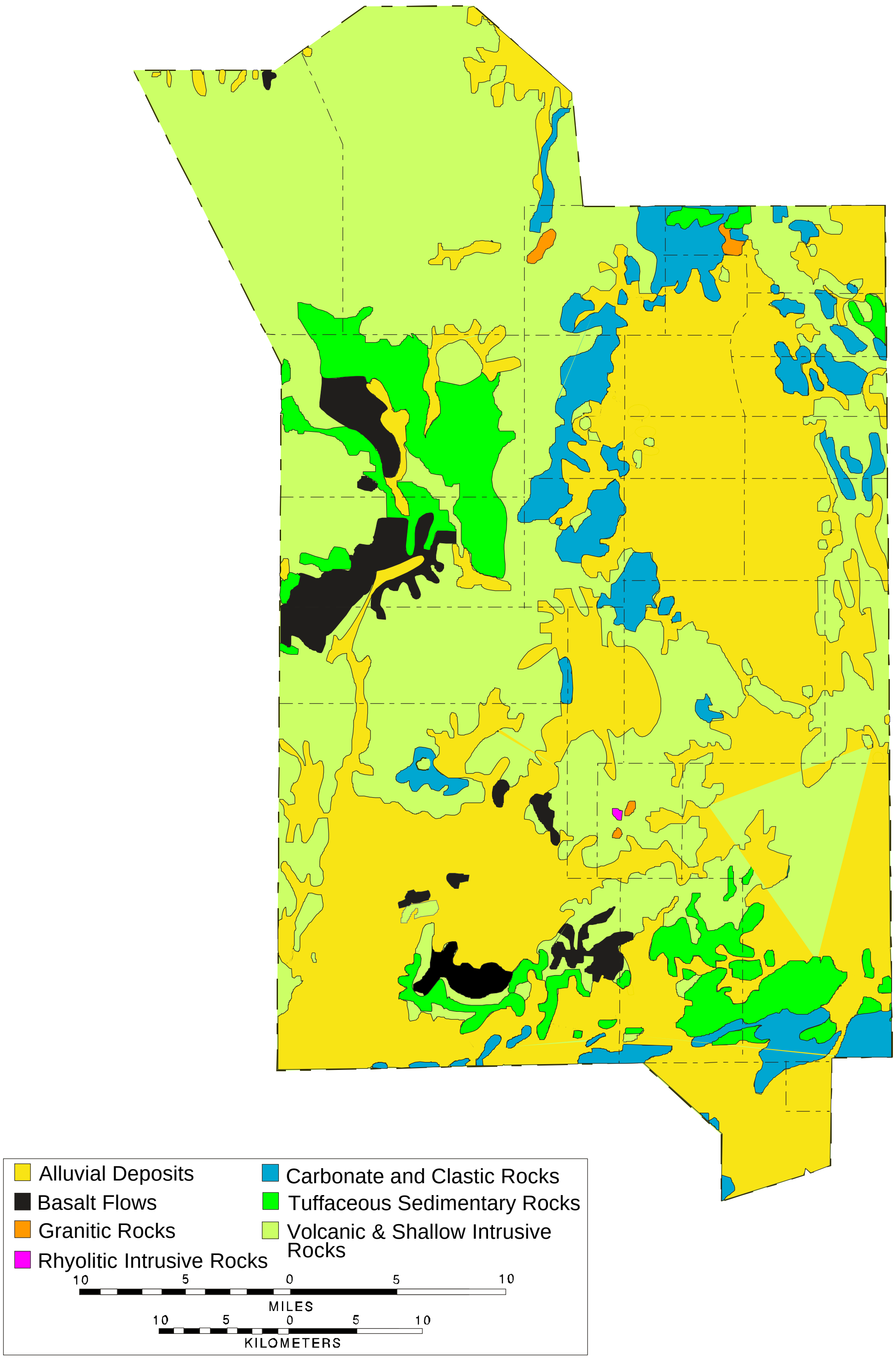


Figure 2.5 Basic Lithologic Structure of the NTS

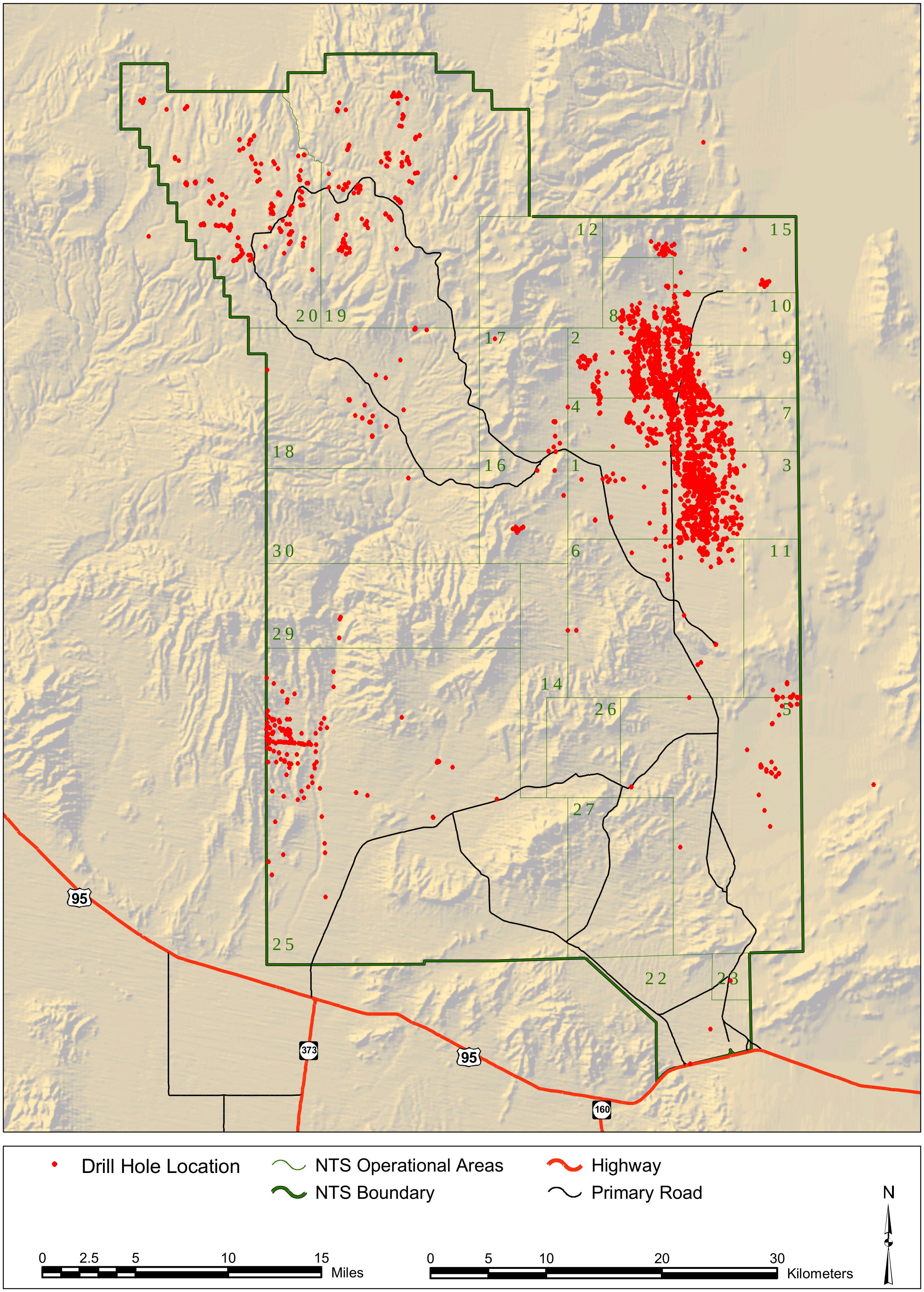


Figure 2.6 Drill Hole Locations on the NTS - 1999

unsaturated zone sources via groundwater, greatly limiting the potential for the transport of radioactivity to offsite areas. Some historic nuclear tests were conducted below the groundwater table; others were at varying depths above the groundwater table. Nuclear tests below the groundwater table have a greater potential for offsite migration. However, the great distance to offsite water supply wells or springs makes it unlikely that contaminants will be transported in significant quantities.

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, in the western portions, it occurs predominantly in volcanic rocks. The flow in the shallower parts of the groundwater is generally toward the major valleys (Yucca and Frenchman), where it may deflect downward to join the regional drainage to the southwest in the carbonate aquifer.

The hydrogeology of the underground nuclear testing areas on the NTS (Figure 2.7) has been summarized by the Desert Research Institute, University of Nevada System and the USGS (Russell 1990 and Laczniak et al., 1996). Yucca Flat is situated within the Ash Meadows groundwater subbasin. Groundwater occurs within the valley-fill, volcanic and carbonate aquifers, and in the volcanic and clastic aquitards. The depth to water generally ranges from 210 m (690 ft) to about 580 m (1,900 ft) below the ground surface. The tuff aquitard forms the principal Cenozoic hydrostratigraphic unit beneath the water table in the eastern two-thirds of the valley and is unconfined over most of its extent. The valley-fill aquifer is saturated in the central part of the valley and is unconfined (Winograd and Thordarson 1975).

Some underflow, past all of the subbasin discharge areas, probably reaches springs in Death Valley. Recharge for all of the subbasins most likely occurs by precipitation at higher elevations and infiltration along ephemeral stream courses and in playas. Regional groundwater flow is from the upland recharge areas in the north and east, towards discharge areas at Ash Meadows and Death Valley, southwest of the NTS. Due to the large topographic changes across the area and the importance of fractures to groundwater flow, local flow directions can be radically different from the regional trend.

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 currently used for DOE activities. South of the NTS, private and public supply wells are completed in a valley-fill aquifer.

Frenchman Flat is also within the Ash Meadows subbasin. Regional groundwater flow in this valley occurs within the major Cenozoic and Paleozoic hydrostratigraphic units at depths ranging from 210 to 350 m (690 to 1,150 ft) below the ground surface. Perched water is found as shallow as 20 m (66 ft) within the tuff and lava-flow aquitards in the western part and older Tertiary sedimentary rocks in the southwestern part of the valley. In general, the depth to water is at least 210 m (690 ft) beneath Frenchman playa and increases to nearly 360 m (1,180 ft) near the margins of the valley (Winograd and Thordarson 1975). The water table beneath Frenchman Flat is considerably shallower than beneath Yucca Flat. Consequently, the extent of saturation in the valley-fill and volcanic aquifers is correspondingly greater.

Winograd and Thordarson (1975) hypothesized that groundwater within the Cenozoic units of Yucca and Frenchman Flats probably cannot leave these basins without passing through the underlying and surrounding tuff confining unit. In addition,

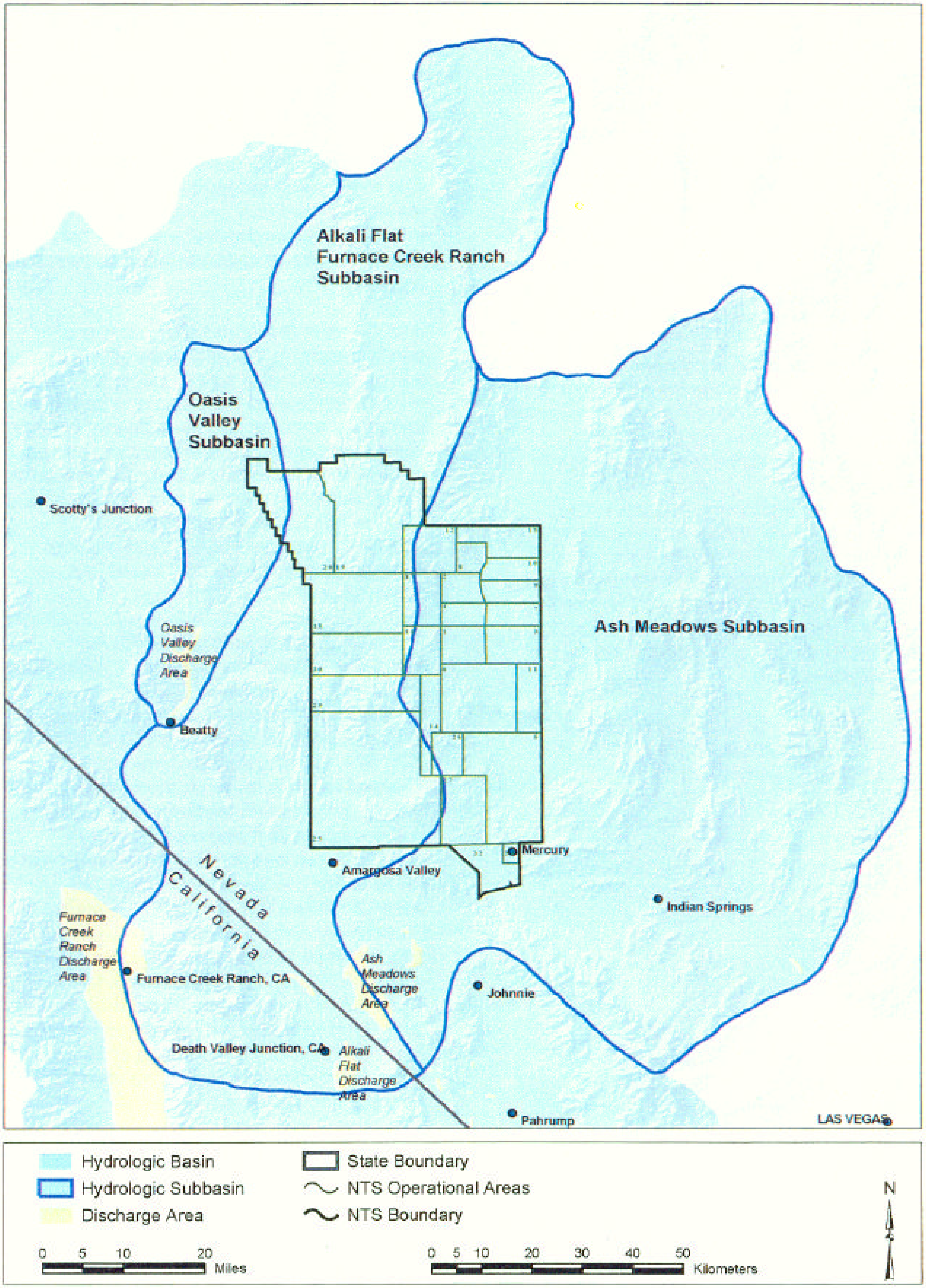


Figure 2.7 Groundwater Hydrologic Units of the NTS and Vicinity

lateral gradients within the saturated volcanic units exist and may indicate groundwater flow toward the central areas of Yucca and Frenchman Flats prior to vertical drainage.

The only hydrostratigraphic units encountered at Pahute Mesa are the volcanic aquifers and aquitards. Pahute Mesa is thought to be a part of both the Oasis Valley and Alkali Flat/Furnace Creek Ranch subbasins (Figure 2.7). The location of the inter-basin boundary is uncertain. Groundwater is thought to move towards the south and southwest, through Oasis Valley, Crater Flat, and western Jackass Flats. Points of discharge are thought to include the springs in Oasis Valley, Alkali Flat, and Furnace Creek. The amount of recharge to Pahute Mesa and the amount of underflow, which moves to the various points of discharge, are not accurately known. Vertical gradients within Pahute Mesa suggest that flow may be downward in the eastern portion of the mesa but upward in the western part (Blankennagel and Weir 1973). The hydrostratigraphic units beneath Rainier Mesa consist of the welded and bedded tuff aquifer, tuff confining unit, the lower carbonate aquifer, and the lower clastic aquitard. The volcanic aquifer and aquitards support a semiperched groundwater lens. Nuclear testing at Rainier Mesa was conducted within the tuff aquitard. Work by Thordarson (1965) indicates that the perched groundwater is moving downward into the underlying regional aquifer. Depending on the location of the subbasin boundary, Rainier Mesa groundwater may be part of either the Ash Meadows or the Alkali Flat/Furnace Creek Ranch subbasin. The regional flow from the mesa may be directed either towards Yucca Flat or, because of the intervening upper clastic aquitard, towards the Alkali Flat discharge area in the south. The nature of the regional flow system beneath Rainier Mesa requires further investigation.

CLIMATE AND METEOROLOGY

The climate at the NTS is characterized by low precipitation, low humidity, and large diurnal temperature ranges. The lower elevations are characterized by hot summers and mild winters, which are typical of other Great Basin areas. As elevation increases, precipitation increases and temperatures decrease.

Annual precipitation at higher NTS elevations is about 23 cm (9 in), which includes snow accumulations. The lower elevations receive approximately 15 cm (6 in) of precipitation annually, with occasional snow accumulations lasting only a few days. Winter precipitation is usually associated with transitory low-pressure systems originating from the west and occurring in uniform storms over large areas. These storms are rarely accompanied by lightning and are typically of more than a day's duration. Summer precipitation occurs predominantly as convective storms, often accompanied by lightning, originating from the south or southeast, where storm intensity varies widely among locations (Winograd and Thordarson 1975). Snowfall is rare below elevations of approximately 1,500 m (4,900 ft).

Elevation influences temperatures on the NTS. At an elevation of 2,000 m (6,560 ft) on Pahute Mesa, the average daily maximum and minimum temperatures are 4 °C to -2 °C (40 °F to 28 °F) in January and 27 °C to 17 °C (80 °F to 62 °F) in July. In the Yucca Flat basin at an elevation of 1,195 m (3,920 ft), the average daily maximum and minimum temperatures are 11 °C to -6 °C (51 °F to 21 °F) in January, and 36 °C to 14 °C (96 °F to 57 °F) in July. Elevation at Mercury is 1,314 m (4,310 ft), and the extreme temperatures are 21 °C to -11 °C (69 °F to 12 °F) in January and 43 °C to 15 °C (109 °F to 59 °F) in July. 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. Average relative humidity ranges from 11 percent in June to 55 percent in January and December.

Average annual wind speeds and direction vary with location. At higher elevations on Pahute Mesa, the average annual wind speed is 16 kph (10 mph). The prevailing wind direction during the winter months is north-northeasterly, and during the summer months winds are southerly. In the Yucca Flat basin, the average annual wind speed is 11 kph (7 mph). The prevailing wind direction during the winter months is north-northwesterly, and during the summer months is south-southwesterly. At Mercury, the average annual wind speed is 13 kph (8 mph), with northwesterly prevailing winds during the winter months, and southwesterly prevailing winds during the summer months. Wind speeds in excess of 97 kph (60 mph), with gusts up to 172 kph (107 mph), may be expected to occur once every 100 years (Quiring 1968). Additional severe weather in the region includes occasional thunderstorms, lighting, tornadoes, and sandstorms. Severe thunderstorms may produce high precipitation that continues for approximately one hour and may create a potential for flash flooding (Bowen and Egami 1983). Few tornadoes have been observed in the region and are not considered a significant event. The estimated probability of a tornado striking a point at the NTS is extremely low (3 in 10 million years) (Ramsdell and Andrews 1986).

The multli-year climatological 10-m wind roses for the NTS are shown in Figure 2.8.

FLORA AND FAUNA

The vegetation on most of the NTS includes various associations of desert shrubs typical of the Mojave or Great Basin Deserts or the zone of transition between these two. Extensive floral collection has yielded 711 taxa of vascular plants within or near the boundaries of the NTS (O'Farrell and Emery 1976). Associations of creosote bush, *Larrea tridentata*, which are characteristic of the Mojave Desert, dominate the vegetation mosaic on the bajadas of the southern NTS. Between 1,220 and 1,520 m (4,000 and 5,000 ft) in elevation in Yucca Flat, transitional associations are dominated by *Grayia spinosa-Lycium andersonii* (hopsage/desert thorn) associations, while the upper alluvial fans support *Coleogyne* types. Above 1,520 m (5,000 ft), the vegetation mosaic is dominated by sagebrush associations of *Artemisia tridentata* and *Artemisia arbuscula* subspecies *nova*. Above 1,830 m (6,000 ft), piñon pine and juniper mix with the sagebrush associations, where there is suitable moisture for these trees. No plant species located on the NTS is currently on the federal endangered species list; however, the state of Nevada has placed *Astragalus beatleyae* on its critically endangered species list.

Most mammals on the NTS are small and secretive (often nocturnal in habitat), hence 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, over 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.

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.

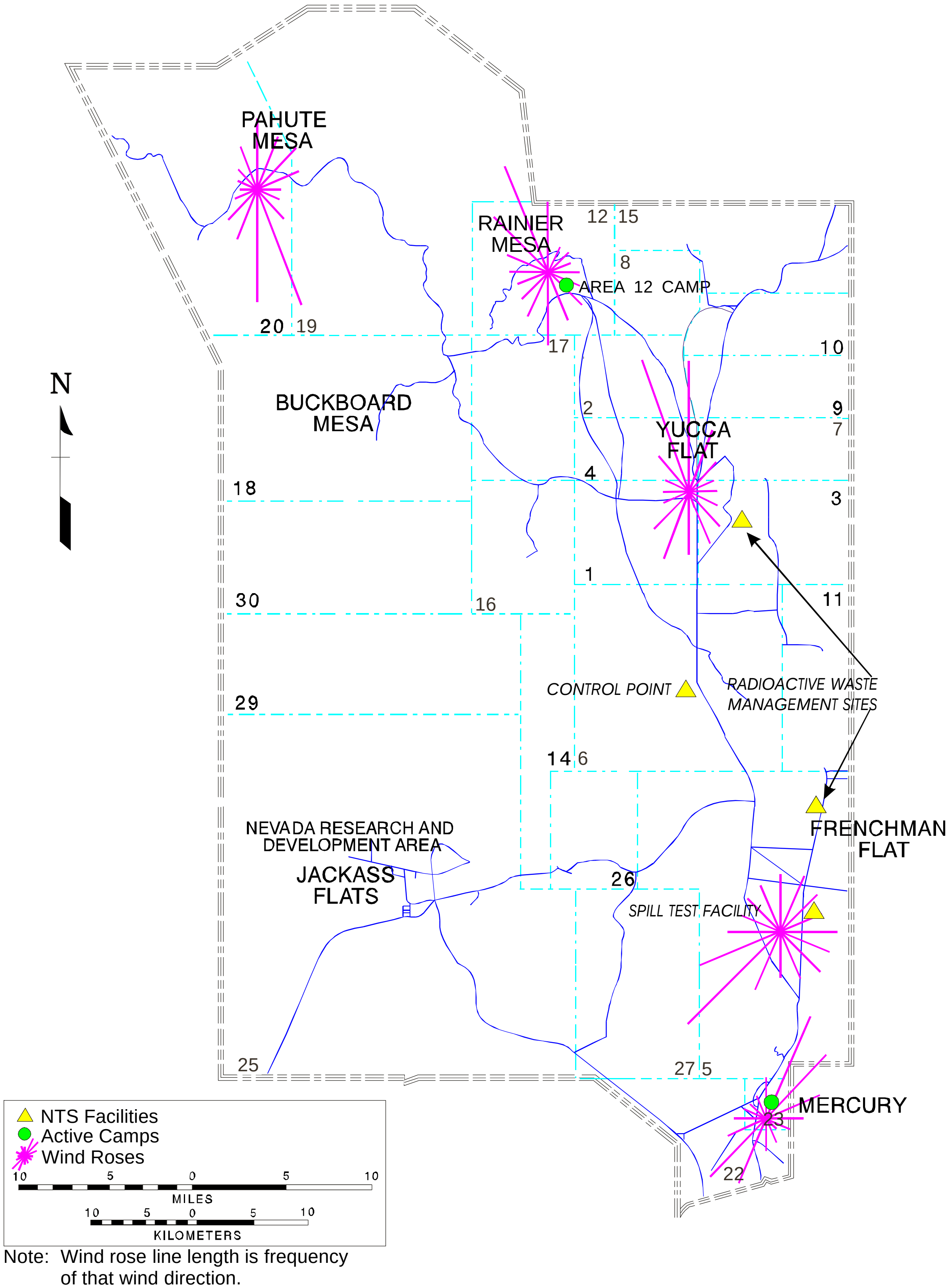


Figure 2.8 Multi-Year Climatological Wind Rose Patterns for the NTS

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. 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.

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. Very few locations associated with this time period have been identified. In 1950, the NTS was selected as the continental nuclear testing ground. Surveys have located and recorded many structures associated with nuclear testing. These structures are significant because of the importance of the nuclear testing program in the history of the United States, as well as its effects on the rest of the world.

DEMOGRAPHY

The population of the area surrounding the NTS has been estimated based on the 1990 Bureau of Census estimates (U.S. Department of Commerce 1990) and population estimates by the Nevada Small Business Development Center. Excluding Clark County, the major population center (over 1,300,000 in 1999), the population density within a 150-km (90-mi) radius of the NTS is about 0.4 persons/km^2. In comparison, the 48 contiguous states (1990 census) had a population density near 29 persons/km^2. The offsite area within 80 km (50 mi) of the NTS Control Point (CP) is predominantly rural. CP-1 (a building at the Control Point) is located near the center of the NTS. Several small communities are located in the area, the largest being in the Pahrump Valley. This growing rural community, with an estimated population of nearly 23,000, is about 50 mi (80 km) south of CP-1. The Amargosa Farm area, which has a population of about 1,200, is approximately 50 km (30 mi) southwest of CP-1. The largest town in the near offsite area is Beatty, which has a population of about 1,600 and is approximately 65 km (40 mi) to the west of CP-1.

The Mojave Desert of California, which includes Death Valley National Monument, lies along the southwestern border of Nevada. The National Park Service estimated that the population within the boundaries ranges from 200 permanent residents during the summer months to as many as 5,000 tourists and campers on any particular day during holiday periods in the winter months. The largest nearby population in this desert is in the Ridgecrest-China Lake area about 190 km (118 mi) southwest of the NTS, containing about 28,000 people. The next largest is in the Barstow area located 265 km (165 mi) south-southwest of the NTS with a population of 24,000. The Owens Valley, where many small towns are located, lies west of Death Valley. The largest town in Owens Valley is Bishop, 225 km (140 mi) west-northwest of the NTS, with a population of 3,500.

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 29,000. The next largest town, Cedar City, with a population of 14,000, is located 280 km (174 mi) east-northeast of the NTS.

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.

SURROUNDING LAND USE

Figure 2.9 is a map of the offsite area showing a wide variety of land uses such as farming, mining, grazing, camping, fishing, and hunting within a 300-km (180-mi) radius of the CP-1. West of the NTS, elevations range from 85 m (280 ft) below MSL in Death Valley to 4,400 m (14,500 ft) above MSL in the Sierras, including parts of the Owens and San Joaquin agricultural valleys. The areas south of the NTS are more uniform, since the Mojave Desert ecosystem (mid-latitude desert) comprises most of this portion of Nevada, California, and Arizona.

The areas east of the NTS are primarily mid-latitude steppe with some of the older river valleys, such as the Virgin River and Moapa Valleys, supporting irrigation for small-scale but intensive farming of a variety of crops. Grazing is also common in this area, particularly towards the northeast. The area north of the NTS is also mid-latitude steppe where the major agricultural activity is grazing of cattle and sheep, and a minor agricultural activity is the growing of alfalfa hay. Many of the residents cultivate home gardens.

Recreational areas lie in all directions around the NTS and are used for such activities as hunting, fishing, and camping. In general, the camping and fishing sites to the north of the NTS are not utilized in the winter months. Camping and fishing locations to the south are utilized throughout the year. The peak hunting season is from September through January.

2.2 NON-NTS FACILITIES

Under a contract with DOE/NV, BN has several offsite operations that support activities at the NTS. Each of these facilities is located in a metropolitan area.

City, county, and state regulations govern emissions, waste disposal, and sewage. No independent BN systems exist for sewage disposal or for supplying drinking water, and hazardous waste is moved off the facility sites for disposal. Radiation sources are sealed, and no radiological emissions above a small fraction of federal guidelines are expected during normal facility operations.

LIVERMORE OPERATIONS (LO)

The LO Facility occupies a 5,520-m^2 (59,445-ft^2) two-story combination office/laboratory building. LO is located near the Lawrence Livermore National Laboratory (LLNL) in Livermore, California, to simplify logistics and communications associated with BN support of LLNL programs. Although most of the work has been in support of NTS underground weapons testing, LO also supports LLNL with optical alignment systems and a variety of mechanical and electrical engineering activities associated with energy research and development programs. Areas of environmental interest include two small chemical cleaning operations.

SPECIAL TECHNOLOGIES LABORATORY (STL)

STL is located in Santa Barbara, California. The current facilities occupy approximately 4,608 m^2 (49,600 ft^2) and consist of combination office/laboratory areas, used primarily for engineering and electronic research. The research is conducted to

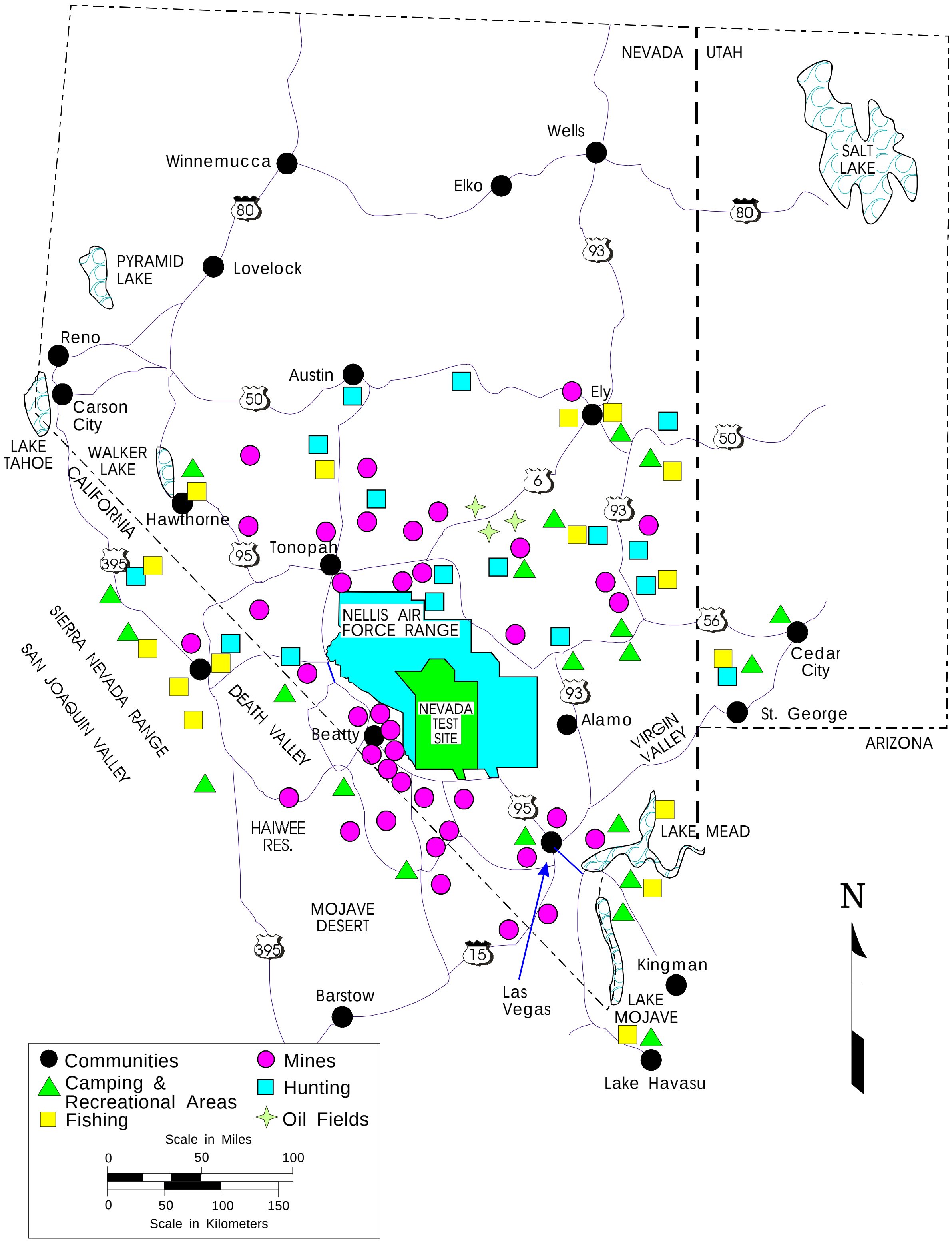


Figure 2.9 Land Use Around the NTS

develop a suite of sensor systems for testing and field deployment in support of DOE Headquarters and DOE/NV. Areas of environmental interest include a small printed circuit board operation, minor solvent cleaning operations, neutron activation, and pulsed X-ray system experiments.

NORTH LAS VEGAS FACILITY (NLVF)

The NLVF provides technical support for DOE/NV activities and includes multiple structures totaling about 53,820 m^2 (585,000 ft^2). There are numerous areas of environmental interest at the NLVF, including a machine shop using cutting fluids, a radiation source range, an X-ray laboratory, solvent and chemical cleaning operations, small amounts of pesticide and herbicide application, and hazardous waste generation and accumulation.

REMOTE SENSING LABORATORY - NELLIS (RSL-NELLIS)

The RSL-Nellis is an 11,000-m^2 (118,000-ft^2) facility located on a 14-ha (35-acre) site within the confines of Nellis Air Force Base. The facility includes space for aircraft maintenance and operations, mechanical and electronics assembly, computer operations, photo processing, a light laboratory, warehousing, and emergency operations. Areas of environmental interest are photo processing, aircraft maintenance, and operations.

LOS ALAMOS OPERATIONS (LAO)

The LAO resides in an engineering and laboratory office complex of approximately 4,645 m^2 (50,000 ft^2). It is located near the Los Alamos National Laboratory (LANL) facility to provide local support for LANL's programs. The work performed includes direct support to the LANL Science-Based Stockpile Stewardship program, the DOE Research and Development Program, and miscellaneous DOE cash-order work. LAO's primary activities are twofold: the design, fabrication, and fielding of data acquisition systems used in underground and above ground testing diagnostics and the analysis of data from prior experiments. Areas of environmental interest include small solvent cleaning operations, metal machining, operations, and a small photo laboratory.

REMOTE SENSING LABORATORY - ANDREWS (RSL-ANDREWS)

The RSL-Andrews (formerly called WAMO), located at Andrews Air Force Base, consists of five buildings: a 186-m^2 (2,000-ft^2) Butler Building used as office space; a 1,110-m^2 (12,000-ft^2) hangar, combination electronics laboratory, aircraft maintenance, and office complex; a 37-m^2 (400-ft^2) equipment service and storage building; and 186 m^2 (2,000 ft^2) in each of two other joint tenant buildings. A new 24,000 square foot building was completed during the latter part of 1999. Because of weather and other factors, the acceptance date will most likely be delayed until late spring or early summer 1999. This building consolidate operations from Buildings 3802, 3812, 1792, and the deployment shed. RSL-Andrews provides an effective east coast emergency response capability and an eastern aerial survey capacity to the DOE/NV. Areas of environmental interest include minor solvent cleaning operations, used fuels, and oils.

2.3 ENVIRONMENTAL MONITORING PROGRAM FOR THE NEVADA TEST SITE

Environmental monitoring of the Nevada Test Site and surrounding land is described in the December 1998 Routine Radiological Environmental Monitoring Plan (RREMP). This radiological monitoring plan, prepared on behalf of the NTS landlord, brings together site-wide environmental surveillance, site-specific effluent monitoring, and operational monitoring conducted by various missions, programs, and projects on the NTS. The plan provides an approach to identifying data and conducting routine radiological monitoring on and off the NTS, based on integrated technical, scientific, and regulatory compliance data requirements for various media (air, water, soil, biota, and direct radiation sources).

The RREMP describes the objectives and design elements of all media following a technical design process to develop this integrated, multimedia program and was styled after the EPA Data Quality Objective process (EPA 1994). The detailed steps of the process for each media are presented in the Appendices of the RREMP. During the RREMP design process, existing and historical site information and regulatory requirements were reviewed. A summary of the site characteristics, transport and exposure pathways, regulatory requirements, and historical data is presented to support the monitoring designs with detailed Quality Assurance, Analysis, and Sampling Plans. The RREMP will be reviewed annually and updated biannually as required.

3.0 COMPLIANCE SUMMARY

Environmental compliance activities at the Nevada Test Site (NTS) during calendar year (CY) 1999 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 1999 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 1999.

Compliance activities at non-NTS facilities of DOE Nevada Operations Office (DOE/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” [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, DOE/NV has had full delegation of authority from DOE Headquarters (DOE/HQ) for Categorical Exclusion Determinations (CXs), Environmental Assessments (EAs), issuing Findings of No Significant Impact, and floodplain and wetland action documentation related to DOE/NV proposed actions.

DOE 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 a proposed action and alternatives and the potential environmental effects to determine if an EIS is necessary; and (3) a Categorical Exclusion (CX) is used for classes of action which have been found to have no adverse environmental impacts, based on similar previous activities. DOE/NV activities involved only CXs and EAs during 1999.

Completion of a NEPA Environmental Evaluation Checklist is required under the DOE/NV Work Acceptance Process Procedural Instructions (DOE 1997a) for all proposed projects or activities. The Checklist is reviewed by the DOE/NV NEPA Compliance Officer to determine whether the project or activity is included in the NTS/EIS and record of decision (ROD) or other previously completed NEPA analysis. During calendar year (CY) 1999, checklists were completed for 60 proposed projects or activities at the NTS. Nineteen of these 60 were exempted from further NEPA analyses by being a CX; 37 were exempted due to previous analysis in the NTS/EIS and ROD; four were exempted due to previous NEPA analysis and determinations in EA's; and three were exempted based on previous NEPA determinations. The EA for Intermodal Transportation of Low-Level Radioactive Waste to the NTS was canceled on May 6, 1999. The Nellis Air Force Range (NAFR) EIS, in which DOE/NV was a cooperating agency, was completed, and on October 5, 1999, Congress renewed withdrawal of the NAFR for another 20 years.

Still pending are the following documents developed by or with DOE/NV involvement:

- Kistler Aerospace Corporation in Areas 18 and 19 EA.

- Withdrawal of public lands for range safety and training purposes at the Naval Air Station in Fallon, Nevada EIS.

- Desert Rock Sky Park in Area 22, EA. Throughout CY 1999, the staff of the DOE Environment, Safety, and Health Division (ESHD) continued to maintain and update the NEPA Compliance Guide (Volume III), a quick reference handbook containing procedures, formats, and guidelines for those personnel responsible for NEPA compliance activities. The staff of the DOE ESHD prepared Volume III to supplement the NEPA Compliance Guides, Volumes I and II, prepared and distributed by the Office of NEPA Policy and Assistance, DOE/HQ.

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 pollutant 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) requires 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. Notifications are also required to be made to the U.S. Environmental Protection Agency (EPA) Region 9 for projects which disturb greater than 260 linear ft or 160 ft^2 of asbestos-containing material, in accordance with Title 40 Code of Federal Regulations 61.145-146 (CFR 1989).

During 1999, there were no projects that required state of Nevada notifications be made. The annual estimate for non-scheduled asbestos demolition/renovation for FY 2000 was sent to EPA Region 9 on December 23, 1998.

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.

There are two locations on the NTS where airborne radioactive effluents may be emitted from permanent stacks: (1) the tunnels in Rainier Mesa, and (2) the analytical laboratory hoods in the community of Mercury. Based on the amount of radioactivity handled, the exhaust from the analytical laboratories is considered negligible compared to other sources on the NTS and the tunnels have been sealed (although water still seeps from one). Present sources are evaporation of tritiated water (HTO) from containment ponds, diffusion of HTO vapor from the Area 5 Radioactive Waste Management Site (RWMS-5), the SEDAN test in Area 10, the SCHOONER test in Area 20, and resuspension of plutonium contaminated soil from nuclear device safety test and atmospheric test locations.

In the 1999 NTS NESHAP report for airborne radioactive effluents (Grossman 2000), airborne emission of HTO vapor from the containment ponds was conservatively reported as if all the liquid discharge into the ponds had evaporated and become airborne. For HTO vapor diffusing from the RWMS-5, SEDAN, and SCHOONER, plutonium particulate resuspension from Areas 3 and 9, and various other areas on and near the NTS, the airborne effluents were conservatively estimated as follows. For those HTO sources with nearby monitoring stations, the station with the maximum annual average concentration of HTO was selected from among the surrounding sampling stations. An effective dose equivalent (EDE) was then calculated for that concentration. EPA's Clean Air Package 1988 (CAP88-PC [DOE 1997c]) software program was used to determine what total emission from the geometric center of the region in question would be required in order to produce that EDE. Resuspended radioactivity was estimated by employing a published formula and confirming the estimate with offsite air sampling data.

Using these conservative estimates of air emissions in 1999 as input to the CAP88-PC computer model, the EDE was calculated to be only 0.12 mrem (1.2×10^{-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 through permit reporting and renewal and ongoing verification of operational compliance with permit-specified limitations. A summary of NTS permits is in Table 3.1. (See Chapter 4 for a listing of active permits.) 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 1998, approximately 23 tons of pollutants were estimated to be emitted from permitted operations at the NTS. The 1998 Air Quality Permit Data Report was sent to the state of Nevada on February 18, 1999.

On June 16, 1999, the state inspected the permitted facilities/equipment associated with the Underground Testing Area (UGTA) project which has operations on NAFR and on the NTS. The UGTA is regulated under Class II Air Quality Operating Permit AP9711-0785. On June 17, 1999, the state inspected the permitted facilities/equipment associated with the Hazardous Materials Spill Center (HSC) and the Tactical Demilitarization Development (TaDD) project located in Areas 5 and 11, respectively. The HSC is regulated under Class II Air Quality Operating Permit AP9711-0556, and the TaDD project is regulated under Class II Air Quality Operation Permit AP9711-0814. There were no findings as a result of the inspections.

NON-NTS OPERATIONS

Under normal conditions, the six non-NTS facilities operated by the DOE/NV do not produce radioactive effluents. The six are the North Las Vegas Facility (NLVF) and Remote Sensing Laboratory (RSL) in North Las Vegas; Special Technologies Laboratory (STL) in Santa Barbara, California; Livermore Operations (LO) in Livermore, California; Los Alamos Operations (LAO) in Los Alamos, New Mexico; and Washington Aerial Measurements Operations (WAMO) in Washington, D.C.

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 DOE/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 summary of NTS permits is displayed in Table 3.1, and a separate list of applicable permits appears in Chapters 4, 5, and 6. 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 of Nevada 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, 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 (5) years on December 7, 1999. The permit was structured to allow DOE more flexibility in bringing new industrial processes on line. There were no significant changes to permit parameters.

Downsizing of NTS operations has resulted in low flow conditions at sewage lagoon systems servicing the Area 5 RWMS, Area 12, and the Area 25 Central Support Facility. Automated flow meters are subject to incorrect flow measurements at low flows; therefore, a system was tested this year which incorporated a tipping bucket and timer. This system proved effective for accurate flow measurements in low flow situations. The use of this measuring system was noted in the Quarterly Discharge Monitoring Reports submitted to the state.

In the first and second quarters of 1999, the Area 25 Central Support sewage lagoon exceeded the organic load and flow compliance requirements. A modification to the organic load and flow requirements was initiated in November 1998 and approved in 1999. This modification appeared in the new permit on December 7, 1999.

During the third Quarter of 1999, the Area 5 RWMS sewage lagoon exceeded the mean daily Biological Oxygen Demand limit. After investigation, it was determined that a calculation error had been made and the amended loading (which was below the regulatory limit) was resubmitted to the state.

There were no formal state inspections of the sewage lagoons in 1999. During an informal visit to the Area 25 Central Support sewage lagoon, the state issued a finding of alleged violation for “disposal of portable toilet wastes” into this system. Area 25 Central Support is not permitted to receive this type of waste. Upon investigation, it was determined that the state had mistakenly assumed that wastewater in the primary lagoon was from portable toilet discharge. The situation was discussed and resolved with the DOE, the state, and Bechtel Nevada (BN).

In May of 1999, DOE and BN inspected Area 25 facilities to meet the “administrative controls” requirements for industrial discharges. All facilities and operations were determined to be in compliance with the permit.

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. No wastewater permits were required for the LO, LAO, or RSL-Andrews facilities in 1999.

The Wastewater Contribution Permit for NLVF was renewed in 1999, with an effective date of January 1, 2000.

SAFE DRINKING WATER ACT (SDWA)

NTS OPERATIONS

The SDWA primarily addresses quality of potable water supplies through sampling and monitoring requirements for drinking water systems. The state of Nevada has enacted and enforces SDWA regulations including system management such as operation and maintenance, water haulage, operator certification, permitting, and sampling requirements. A list of state potable water permits is shown in Chapter 5.

As required under state health regulations (NAC 445A 1996), potable water distribution systems at the NTS are monitored for residual chlorine content and coliform bacteria. NTS potable water distribution systems are also monitored for volatile organic compounds, inorganic compounds, synthetic organic compounds, and other water quality parameters.

During 1999, lead was found above the acceptable level in the Area 1 and the Area 2-12 systems. Corrective action was initiated in 1999 to resolve this problem. All other monitoring results for 1999 were within regulatory limits and are discussed in Chapter 5.

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 1999, the NTS maintained three permitted water hauling trucks. Water hauling permits are renewed annually at the same time as the regular water system permits. Water hauling trucks are sampled monthly for coliform bacteria. There were no positive coliform bacteria sample results in 1999.

NON-NTS OPERATIONS

All non-NTS operations are on municipal water systems and have no compliance activities under the SDWA.

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 DOE/NV facilities. The Federal Facilities Compliance Act (FFCAct) 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 1995, DOE/NV received a RCRA Hazardous Waste Operating Permit for the Area 5 Hazardous Waste Storage Unit (HWSU) and the Area 11 Explosive Ordnance Disposal (EOD) Unit. In addition, the Part B Permit application was revised to include the Mixed Waste Storage Pad (now under interim status) and updated information concerning general facility conditions. During 1996, the permit was modified to include the change in contractor and operational changes concerning the EOD and HWSU. The permit application modification for the Pit 3 Mixed Waste Disposal Unit was completed and submitted to the state in 1997 (NAC 1982). Several other minor modifications were made to the permit during 1997 and 1998, mostly relating to updated personnel and training records. The current permit expires in May 2000, and DOE/NV submitted an application for reissuance of the permit to the state in November 1999. The state is currently reviewing the application.

In 1999, DOE/NV received a RCRA Research Development and Demonstration Permit for the construction and operation of the TaDD facility. This facility will develop treatment methods for deactivating waste missiles.

On January 5, 1994, the state of Nevada and DOE/NV entered into a Mutual Consent Agreement that allowed low-level radioactive mixed wastes generated on the NTS to be moved into storage at the RWMS-5 TRU pad. This was amended in June 1994 to include mixed waste generated in Nevada via environmental restoration work. Waste in storage at this facility will continue to be held in storage until a final determination of the proper treatment and disposal technology is established by the EPA. A FFACO (FFACO 1996) was signed, effective March 27, 1996, requiring compliance with a Site Treatment Plan (DOE 1996a), which was also finalized in March 1996. Compliance with the FFACO exempts the NTS from potential enforcement action resulting from the mixed waste storage prohibition under RCRA.

The NDEP conducted its annual Compliance Evaluation Inspection (CEI) from May to June 1999. Only a few minor areas of concern were identified in the report, and NDEP did not pursue any formal enforcement actions as a result of the CEI.

HAZARDOUS WASTE REPORTING FOR NON-NTS OPERATIONS

The 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 continues to meet regulatory compliance schedules for the reporting, upgrading, or removal of documented USTs. Efforts are continuing to identify undocumented USTs at the NTS. Once identified, undocumented USTs are reported to the NDEP to satisfy state regulatory reporting requirements. During 1999, there were no regulated USTs removed or upgraded, as all requirements had been satisfied in 1998. In 1999, there was one nonregulated heating oil UST removed from the Area 6 decontamination Facility.

The DOE/NV operates one deferred UST and three excluded USTs at the Device Assembly Facility. The DOE/NV also maintains a fully-regulated UST that is not currently in service at the Area 6 heli-pad. There are no other known USTs at the NTS.

NON-NTS OPERATIONS

The RSL operates three fully-regulated USTs, one deferred UST, and two excluded USTs. All are in compliance with the regulations.

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

In April 1996, the DOE/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 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.

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

Compliance with this Act (EO 1986, CFR 1986) is discussed in the paragraphs below and summarized in the following checklist:

SARA Title III Reports

EPCRA Section	NTS Compliance Yes	No	Not Required
302-302: Planning Notification	x		
304: EHS Release Notification			x
311-312: Material Safety Data Sheet/Chemical Inventory	x		
313: TRI Reporting			x

Additional compliance activities under CERCLA/SARA for 1999 included the Nevada Combined Agency Report, which combines reporting under SARA Section 312, Tier II and Nevada Chemical Catastrophe Prevention Program requirements. The latter program covers extremely hazardous substances (EHSs).

The 1999 Nevada Combined Agency Hazardous Substances Reports for the NTS, NLVF, and RSL were submitted to the state as required and included chemical categories and mixtures and single constituents. The report also included the EHSs present.

A separate Nevada Combined Agency Report was submitted for the Area 5 HSC as required.

In compliance with EO 12856 (EO 1986), 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 1998, no thresholds were exceeded, so no report was required in 1999.

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.

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 DOE for nitrogen dioxide, sulfur dioxide and thionyl chloride in July 1999. These substances were stored and released as part of HSC operations in 1998.

There were no reportable EHS chemicals at other DOE facilities (NTS, RSL, NLVF) in 1999.

TOXIC SUBSTANCES CONTROL ACT (TSCA)

State of Nevada regulations implementing the TSCA require submittal of an annual report describing polychlorinated biphenyl (PCB) control activities. The 1998 NTS PCB annual report was transmitted to DOE/NV in May 1999. During 1999, there was one offsite shipment of PCBs consisting of capacitors and PCB oil.

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 1999.

On April 14, 1999, representatives of EPA Region 9 conducted a Federal Facility Inspection of the FIFRA program at the NTS. The inspection was requested by the Nevada Department of Business and Industry-Agriculture Division. No violations of federal laws were noted during the site inspection.

HISTORIC PRESERVATION

The NHPA (CFR 1966; EO 1971), as amended, requires federal agencies to inventory and manage the cultural resources under their stewardship. In 1999, the Cultural Resources Management Plan for the NTS was completed to facilitate compliance with these responsibilities. This plan provides DOE/NV, the state of Nevada, contractors, and the public with the appropriate information regarding cultural resources requirements and their implementation on the NTS.

Towards meeting the goal of inventorying cultural resources, a survey of the atmospheric nuclear testing remains in and near Frenchman Lake was conducted in 1999. More than 150 historic structures were identified and deemed worthy of inclusion in a proposed Frenchman Flat historic district. The technical report for this task is in preparation.

Prior to all undertakings that may affect cultural resources, DOE/NV conducts cultural resources surveys and historical evaluations in order to determine what, if any, impact of their actions may have on archaeological sites, historic sites, historic structures, and traditional cultural properties. In 1999, seven cultural resource surveys were conducted to determine if significant sites or structures were within proposed project areas. Although seven archaeological sites were identified, only one was determined to be eligible for listing in the National Register of Historic Places (NRHP). This location contains the remnants of Camp Desert Rock, the camp where the military troops that participated in atmospheric testing exercises resided during their stay at the NTS. The proposed actions associated with the Desert Rock Sky Park were modified to avoid affecting the Camp Desert Rock remains. Consultation with the appropriate American Indian tribes was also conducted for this location. No remedial actions were needed for any of the other proposed projects. Additionally, a historic evaluation of the train engine used in the 1960s at the Nuclear Research and Development Station was completed and the train engine was determined eligible for listing in the NRHP. An agreement was reached with the Nevada State Historic Preservation Office to move the engine to the train museum in Boulder City. A technical report on the archaeological study of a site near the proposed Kistler Launch Facility was finalized and issued in 1999.

The NHPA also requires that federal agencies curate the archaeological collections from the lands under their jurisdiction. DOE/NV continued to maintain a curatorial facility with security and environmental controls that houses more than a half million artifacts and associated records. In 1999, a long-term project to consolidate and coordinate the various artifact databases was completed with data verification in progress.

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 be associated funerary items, human remains, sacred objects, or objects of cultural patrimony. The NAGPRA consultations for the main DOE/NV collection were completed in 1997. However, three small collections from DOE/NV lands that were added to the collection recently were the focus of a new round of NAGPRA consultations in 1999. A subgroup representing the Western Shoshone, Southern Paiute, and Owens Valley Paiute Tribes viewed the items and made recommendations for repatriation that were adopted by the Consolidated Group of Tribal Organizations meeting sponsored by DOE/NV.

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 DOE/NV. The terms and conditions, which were implemented in 1999, included (1) tortoise clearance surveys for 12 projects, (2) onsite monitoring of construction for 14 projects when heavy equipment was being used, (3) periodic monitoring of tortoise-proof fencing around the ER-5-2 Well and at sewage treatment ponds in Areas 6 and 23, and (4) preparation of an annual compliance report for the USFWS of NTS activities that were conducted in CY 1999. Project activities conducted in CY 1999 resulted in the loss of 25.38 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 168.57 acres of desert tortoise habitat has been disturbed as a result of NTS activities.

In September 1999, a team of volunteer biologists, led by the Biological Resources Division of the U.S. Geological Survey, 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 1999, 16 tortoises, including one new hatchling, 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 site-wide 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 1999.

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 1999 that required consultation for floodplain management.

EXECUTIVE ORDER (EO) 11990 PROTECTION OF WETLANDS

There were no projects in 1999 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 1999 to further characterize the biological and physical conditions at the five new wetlands discovered during 1998.

3.2 AGREEMENTS WITH STATES AND AGENCIES

During 1999, 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 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 Tonopah Test Range.
- a FFACO with the state of Nevada on environmental restoration activities.
- a FFCAct Site Treatment Plan and Consent Order with the state of Nevada regarding legacy 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 on storing 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 1999. 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 that are sufficient to cover costs of state 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 TaDD and UGTA projects, must pay an annual fee of $250. Maintenance and emissions fees of $3,500 were paid to the NDEP on June 23, 1999.

The NTS Class II Air Quality Operating Permit AP9711-0549 was revised once during 1999. Modifications included the reassignment of generators to different groupings within the permit and the transfer of a conveyor, hopper, and storage silos from the NTS permit to the UGTA air permit. A modification package for the NTS air permit was submitted to the state in November 1999. The main purpose of the modification was to add smaller "insignificant" fuel-burning sources to the permit with an annual limit on the number of hours the sources could operate. Fuel burning sources include generators, compressors, boilers, and miscellaneous equipment such as pumps. The modification was necessary due to the "potential to emit" nitrogen oxide, one of the criteria pollutants, approaching the 100-ton limit that is the cut off between being designated a minor (Class II) or a major (Class I) source. The potential emission nitrogen oxides on the NTS is approximately 85 tons.

One open burn permit was renewed by the state in 1999, which included Permit 99-13 for the Area 27 burn box. This permit was issued in February 1999. The NTS open burn permit for fire training exercises expired in October 1998. DOE ESHD was initially informed that annual "blanket" permits would no longer be issued and that an individual Burn Variance would need to be obtained prior to each burn. However, the state reversed this policy and issued a blanket NTS open burn permit, 99-25, in March 1999.

The NTS has a Nevada Hazardous Materials Storage Permit 13-99-0034-X, and the HSC has Permit 13-99-0037-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 3.1 contains a summary of the permits issued for NTS activities and for offsite activities that support the NTS.

NON-NTS AIR QUALITY PERMITS

The UGTA General Air Quality Permit was modified twice in 1999: (1) to add a conveyor, hopper, and storage bin, and (2) to add several diesel generators as rental units. With the addition of the equipment, the status of the permit was changed to a Class II air quality operating permit.

Six 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 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 1998 Emissions Inventory was submitted by BN to the APCD on May 27, 1999.

CLEAN WATER ACT (CWA)

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

Site utilization by new projects will result in increased permitting activities for existing septic systems. In the past, the state regulated septic tanks and leachfields by issuing a "permit to construct" after review of percolation test data and engineering drawings. New regulations (NAC 444 Sections 1-119, 756, 774, 800, 802, 812, 814, 816, 830, 832, 834, 836, 838, and 840) adopted by the State Board of Health effective March 25, 1999, require application for an operating permit covering existing and new septic systems. The permits do not require renewal and are good for the life of the system. Several existing systems will be permitted in 2000.

SAFE DRINKING WATER ACT (SDWA)

The Operations and Maintenance Manual for the NTS water distribution systems was updated to incorporate some recent revisions to state regulations.

The Nevada Bureau of Health Protection Services (BHPSs) conducted a sanitary survey of the water distribution systems in May 1999. Monitoring results for secondary standards showed that all supply wells met the standards. The BHPSs also issued 16 survey findings, mostly relating to the reservoir storage tanks, with the final report of the survey. DOE/NV resolved all but one of those findings in 1999. The remaining finding, a pinhole leak in a storage tank, will be addressed in 2000.

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.

HISTORIC PRESERVATION

In 1999, a formal consultation with Native Americans was conducted in regard to the area proposed for the NTS Development Corporation's Desert Rock Sky Park.

Under the NHPA, all DOE/NV cultural resources reports and plans are reviewed by the Nevada State Historic Preservation Office (NSHPO) for compliance with the NHPA. All consultations with the NSHPO were completed successfully, permitting proposed projects to proceed and documents to be finalized for distribution to the Nevada State Cultural Resources Archives.

The American Indian Religious Freedom Act of 1978 affirms Native Americans right to religious freedom and defines the responsibility of federal agencies to consult with Native Americans in developing policies and procedures to protect and preserve cultural and spiritual traditions and sites. Executive Order 13007 of 1996 obligates federal agencies to accommodate the access to and ceremonial use of Native American sacred sites and to maintain their integrity. In 1999, a draft technical report of NTS rock art sites was completed, complementing a previous ethnographic study of the area. Both reports recommend protection for the rock art and emphasize the religious importance of the sites.

In 1999, the Cultural Resources Management Plan for the NTS was completed for the purpose of facilitating compliance with DOE/NV's legal responsibilities. This plan provides DOE/NV, the state of Nevada, contractors, and the public with appropriate information regarding cultural resources requirements and their implementation on the NTS.

POLLUTION PREVENTION (P2) AND WASTE MINIMIZATION

The 1999 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 DOE/NV P2 program establishes a process to reduce the volume and toxicity of hazardous 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 DOE/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 energy efficiency, and promote 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.

Section 6.3 provides a summary of the P2 program, P2 accomplishments achieved during CY 1999, notable activities that achieved reduction in volume and toxicity of waste, and recycling activities and quantities.

SOLID/SANITARY WASTE

During 1999, landfills were operated in Areas 6, 9, and 23. The amount of waste disposed of in each is shown in Chapter 6.0, and their operating permits are in Table 3.1.

The NTS Cleanup Project, initiated in 1994, is an activity devised to remove and dispose of or recycle, where applicable, nonhazardous debris and material and readily identify hazardous debris and material. In 1999, some cleanup activities were completed at inactive facilities throughout the NTS. During this cleanup, solid wastes were disposed of in the U10c Landfill, and reusable materials were delivered to the NTS Salvage Yard for recycling and reclamation.

FEDERAL FACILITIES AGREEMENT AND CONSENT ORDER (FFACO)

REMEDIAL ACTIVITIES - SURFACE AREAS

Environmental restoration activities continued at the NTS and TTR in 1999. These activities followed the agreements specified in the FFACO signed between the DOE/NV and the NDEP.

These activities follow a formal work process beginning with a Data Quality Objectives (DQO) meeting between DOE, 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 identified for analysis that best provides site closure. In some instances, additional site characterization may be required before the CADD can be prepared. The CADD may also include a risk assessment to better define the risk to humans and the environment.

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 document 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 DOE/NV of the progress made.

Some small sites are closed under the Streamlined Approach for Environmental Restoration (SAFER) process. These sites typically have small amounts of contamination and can be remediated by simple excavation and sampling to verify that the remediation level has been reached. A SAFER plan is prepared providing the methods to be used to close the site. After closure, a SAFER closure report is prepared documenting the work performed.

During 1999 all FFACO deadlines were met and actions taken are summarized below:

- The Area 6 Decontamination Pond (CAU 92) RCRA Closure Unit design and field testing for the engineered cover was completed in 1998. Closure activities started in 1998 were completed in early 1999. The Closure Report was prepared and sent to the NDEP in 1999.

- 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 LLNL Post Shot Containment Building Injection Wells (CAU 90), Area 23 Landfill Hazardous Waste Trenches (CAU 112), and the U3fi Injection Well (CAU 91) RCRA Closure Units.

- Closure of the Area 12 Fleet Operations Steam Cleaning Discharge Area (CAU 339) was completed and a Closure Report was submitted in 1998. During 1999 NDEP initiated a quarterly monitoring requirement for the next six years of undisturbed impacted areas to evaluate whether or not sufficient degradation of the petroleum hydrocarbons has been demonstrated. Two reports were completed and sent in 1999.

- The contents of the aboveground tanks located at the Area 23 Fire Training Pit (AU 340D) were characterized and disposed of as a RCRA hazardous waste (approximately 3,000 gal [11.4 m^3]).

- The SAFER Closure Plan for the Area 5 and 6 aboveground tanks (CAU 120) was prepared, completed, and approved by the NDEP. Closure activities were completed in 1998. In 1999 the Closure Report was prepared and sent to NDEP.

- Characterization activities were completed for the TTR Area 3 Landfill Complex (CAU 424) and Area 9 UXO Landfill (CAU 453). The CADD and CAP were prepared and transmitted to the NDEP for concurrence during 1998. Remedial activities were completed in 1999 and the Closure Report was prepared and sent to NDEP.

- Characterization activities were started at the TTR Building 360 Underground Discharge Point (CAU 427) and Areas 2 and 6 Septic Systems (CAU 423). The Corrective Action Decision Document and Corrective Action Plan were prepared and transmitted to the NDEP for concurrence during 1998. During 1999, the closure was accomplished, and the Closure Report was prepared and sent to NDEP.

- In 1998, the Building A-1 (Atlas) tritium decontamination was completed. All decontaminated areas have been free-released with the condition that a weekly long-term monitoring program be conducted for a least one year. This monitoring began during 1998 and was completed during 1999.

- The draft Characterization report for the U3ax/bl Subsidence Crater (CAU 110) was prepared and sent to the NDEP in 1999.

- The draft CAP for the DOUBLE TRACKS radiological safe area, (CAU 486) Nellis Air Force Range was prepared and sent to the NDEP.

- The Area 25 sewage Lagoons (CAU 232), Area 25 Building 4839 Leachfield (CAU 263), Area 25 Building 3124 Leachfield (CAU 266), and Area 25 Test Cell A Septic Systems (CAU 500) were characterized and Best Management Practices were used to close all but (CAU 263) in 1999.

- The ROLLER COASTER radiological safe area (CAU 407) in TTR was characterized. Preparation of the draft Closure Plan began.

- The Area 25 Waste Dumps (CAU 143) were characterized.

- The Area 25 Storage Tanks (CAU 135) were removed from an underground vault and the tank contents and vault were characterized.

- The Area 25 Vehicle Washdown Sites (CAU 240) were characterized and the draft CAP began.

- The TTR Unconfirmed Joint Test Assembly Sites (CAU 461) were closed and a SAFER Closure Report prepared and sent to the NDEP.

- The U2bu Subsidence Crater (CAU 109) was characterized, the Closure Plan prepared, and the site closed. The Closure Report was prepared and sent to the NDEP.

- The NTS Pesticide Release Site (CAU 340) was characterized and a CAP prepared and sent to the NDEP. The site was clean closed and preparation of the Closure Report began.

- The Draft Facility Disposition Process: Surveillance and Maintenance Activities Master Plan was prepared for the D & D Facilities.

- The Housekeeping Report for the Area 25 E-MAD Vacuum Pump Oil Recovery Housekeeping Closure was sent to NDEP. The closure was completed in 1999.

- Housekeeping activities at the E-MAD yard were done. Approximately 426,000 pounds of material was sent to salvage and 396,000 pounds of debris were sent to a landfill for disposal.

RADIATION PROTECTION

NTS OPERATIONS

Results of monitoring during 1999 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 0.25 percent of the DOE Order 5400.5 guidelines for HTO in air to 5.0 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 did not exceed 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 1999 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, RSL-Andrews (formerly called WAMO), 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 TLDs are placed at the fence line of these facilities or where non-project personnel could be for limited periods and are exchanged quarterly. Additional control TLDs accompanying the exchanged TLDs are kept in a shielded safe. The TLD results were consistent with previous data indicating no exposures to the public from any of the monitored facilities, except for the TLDs placed in a hanger at RSL-Andrews. Here the TLDs were placed around a radiation source cage near a walk-way in the hanger. Although the readings for these TLDs were higher than normal background, non-project personnel were just passing by and not residing near the source cage. During the latter part of 1999, the sources in the cage were moved to a location more removed from areas frequented by non-project personnel when construction of a new laboratory building was completed.

ENVIRONMENTAL COMPLIANCE AUDITS

There were eight Environmental Compliance Management Assessments of specific operations, facilities, or project for calendar year 1999. These assessments focused, in most cases, on one or two major areas of Environmental Compliance, e.g. 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 O232.1A, "Occurrence Reporting and Processing of Operations Information," (DOE 1997b). The 15 reportable environmental occurrences for 1999 on NTS facilities appear in Table 3.2.

LEGAL ACTIONS

No legal actions were filed against DOE/NV during 1999.

3.4 PERMIT SUMMARY

For facilities used in the operation and maintenance of the NTS and non-NTS facilities, the contractors providing such operation and support activities for the DOE/NV have been granted numerous permits by the appropriate regulatory authorities. To facilitate management of environmental compliance and save costs, several operating permits have been combined into general permits. This reduced the number of permits, but all facilities remain regulated and permitted. In addition to the existing number of permits in 1999 (Table 3.1), the EOD Facility and the Area 5 Storage Facility of the RCRA Part B permit application were permitted, while the other units in the application are in various stages of the NDEP review for permission to construct or operate. The TaDD facility was also granted a RCRA Research Development and Demonstration permit in 1999 under the same NTS generator number.

Table 3.1 Environmental Permit Summary - 1999

	Air Pollution	Wastewater	Drinking Water	Waste Disposal	Number of EPA Generator User IDs	Hazardous Materials Storage Permit	Endangered Species Act
NTS	5	7	7	3	1[a]	2[c]	2
NAFR	1						
Las Vegas Area Operations Office	13[b]	1			1[a]	2[d]	
Livermore Operations	1				1		
Los Alamos Operations					1		
Special Technologies Laboratory (Santa Barbara)		2			2	1	
TOTAL	20	10	7	3	6	5	2

(a) Biennial Report Required.
(b) Routine Monitoring of Emissions is Not Required.
(c) Includes the HSC.
(d) NLVF and RSL.

Table 3.2 Off-Normal Occurrences at NTS Facilities - 1999

Date	Report Number	Description	Status
01/11/1999	NVOO-BNLV-NTS-1999-0001	Sewage lagoon permit violation when sewage vacuum discharged propylene glycol into active lagoon.	Closed
01/21/1999	NVOO-BNLV-NTS-1999-0003	Historical hydrocarbon spill discovered at E-MAD Facility from a closed vacuum pump oil recovery System.	Closed
01/27/1999	NVOO-BNLV-NTS-1999-0004	Samples were transported from TTR to the NTS without the proper DOT shipping papers.	Closed
02/08/1999	NVOO-BNLV-NTS-1999-0005	Site Specific Health & Safety Plan violated when excavation exceeded two feet without having EOD personnel on site.	Open
02/08/1999	NVOO-BNLV-DECN-1999-0001	Approximately six yards of soil were contaminated from a leaking underground heating oil storage tank at the Area 6 Waste Handling Facility.	Closed
02/22/1999	NVOO-BNLV-NTS-1999-0006	Violation of Air Quality Operating Permit when opacity limit at the Area 1 Aggregate Plant was exceeded and no written notice to state was made.	Closed
02/25/1999	NVOO-BNLV-NTS-1999-0007	Operations at the Waste Examination Facility were suspended due to the inability to complete the Limiting Conditions of Operation checklist.	Closed
03/23/1999	NVOO-BNLV-NTS-1999-0010	Grease trap at Area 23 Cafeteria loading dock backed up causing a spill of 20 gallons of waste water.	Closed
05/13/1999	NVOO-BNLV-NTS-1999-0012	Approximately 70 gallons of hydraulic oil leaked from a Dover-Rotary Hoist.	Closed
06/23/1999	NVOO-BNLV-NTS-1999-0015	A Limiting Condition of Operation at the WEF was violated when a backup generator was disabled for maintenance during WEF operations.	Closed
07/06/1999	NVOO-BNLV-NTS-1999-0016	Non-PCB transformer oil leaked from drums being stored at the Area 6 Linemen Yard, causing about 15 yards of soil contamination.	Closed
07/06/1999	NVOO-BNLV-NTS-1999-0017	Non-PCB transformer oil leaked from transformers being moved at the Area 6 Linemen Yard, causing about 5 yards of soil contamination.	Open

Table 3.2 (Off-Normal Occurrences at NTS Facilities - 1999, cont.)

Date	Report Number	Description	Status
09/27/1999	NVOO-BNLV-BNNTS-1999-0001	An abandoned five-gallon open-top container was discovered at Building 3152 in Area 25 that had radiation readings above background.	Open
11/10/1999	NVOO-BNLV-BNNLV 1999-0001	Low level tritium contamination discovered in a source storage vault located in Building A-1 at the North Las Vegas Facility.	Open
12/16/1999	NVOO-BNLV-NTS-1999-0025	Hydrocarbon spill discovered in the Area 6 Utilities Yard affecting an area of soil about 10 ft by 15 ft. Source of the spill is unknown.	Open

4.0 AIR SURVEILLANCE ACTIVITIES

The air surveillance activities consist of monitoring and compliance programs for the Nevada Test Site (NTS), near offsite areas, and support facilities. These activities include radiological and nonradiological monitoring and environmental permit and operations compliance. There are both onsite and offsite radiological monitoring programs associated with the NTS. The onsite program is conducted by Bechtel Nevada (BN), the operations and maintenance contractor for the NTS. BN is responsible for NTS air surveillance, effluent monitoring, and ambient gamma radiation monitoring. Beginning July 1999, BN air sampling was expanded to six offsite locations to confirm compliance with National Emission Standards for Hazardous Air Pollutants (NESHAPs) regulations. The offsite air and ambient gamma radiation monitoring program is conducted by the U.S. Environmental Protection Agency's (EPA's) Center for Environmental Restoration, Monitoring and Emergency Response of the Radiation and Indoor Environments National Laboratory in Las Vegas, Nevada (R&IE-LV). Non-radiological air monitoring is primarily for permit compliance.

4.1 ONSITE RADIOLOGICAL MONITORING

At the NTS, radiological effluents may originate from tunnels, underground test sites (at or near surface ground zeros), radiological waste disposal sites, resuspension of surface deposits, and facilities where radioactive materials are either used or processed. All of these sources have the potential to, or are known to, discharge radioactive effluents into the environment. Two types of monitoring operations are used for these sources: (1) effluent monitoring, which measures radioactive material collected at the point of discharge; and (2) environmental surveillance, which measures radioactivity in the general environment.

Table 4.1 is a summary of the routine air surveillance program, as of the end of 1999. Air sampling was conducted for radioactive particulates and tritiated water (HTO) vapor. The air sampling locations are shown in Figure 4.1, and Figure 4.2 shows the locations where ambient gamma radiation monitoring is conducted on the NTS using thermoluminescent dosimeters (TLDs).

CRITERIA

Title 40, Code of Federal Regulations (CFR) Part 50, "National Primary and Secondary Ambient Air Quality Standards" (CFR 1971) and Title 40 CFR 61," NESHAPs," Subpart H, "Emission of Radionuclides Other Than Radon from Department of Energy Facilities" (CFR 1989) issued by the EPA are the primary drivers for air monitoring programs. In turn, the U.S. Department of Energy (DOE) published DOE Order 5400.1, "General Environmental Protection Program," (DOE 1990a), which establishes environmental protection program requirements, authorities, and responsibilities for DOE operations. These mandates require compliance with applicable federal, state, and local environmental protection regulations. Other DOE directives applicable to environmental monitoring include DOE Order O 231.1, "Environment, Safety, and Health Reporting" (DOE 1996d), DOE Order 5480.1B, "Environment, Safety, and Health Program for DOE Operations" (DOE 1990c); DOE Order 5484.1, "Environmental Protection, Safety, and Health Protection

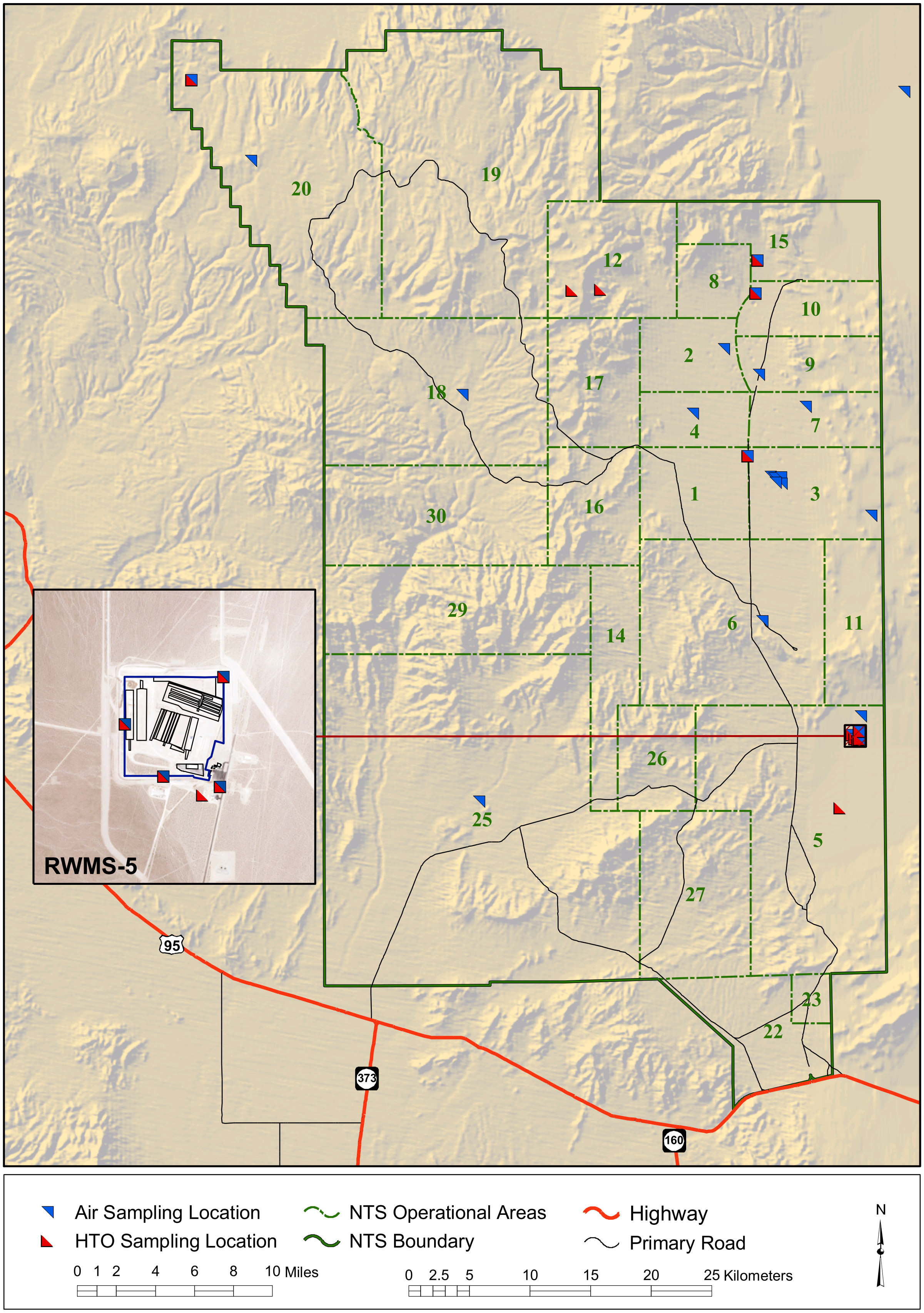


Figure 4.1 Air Sampling Stations on the NTS - 1999

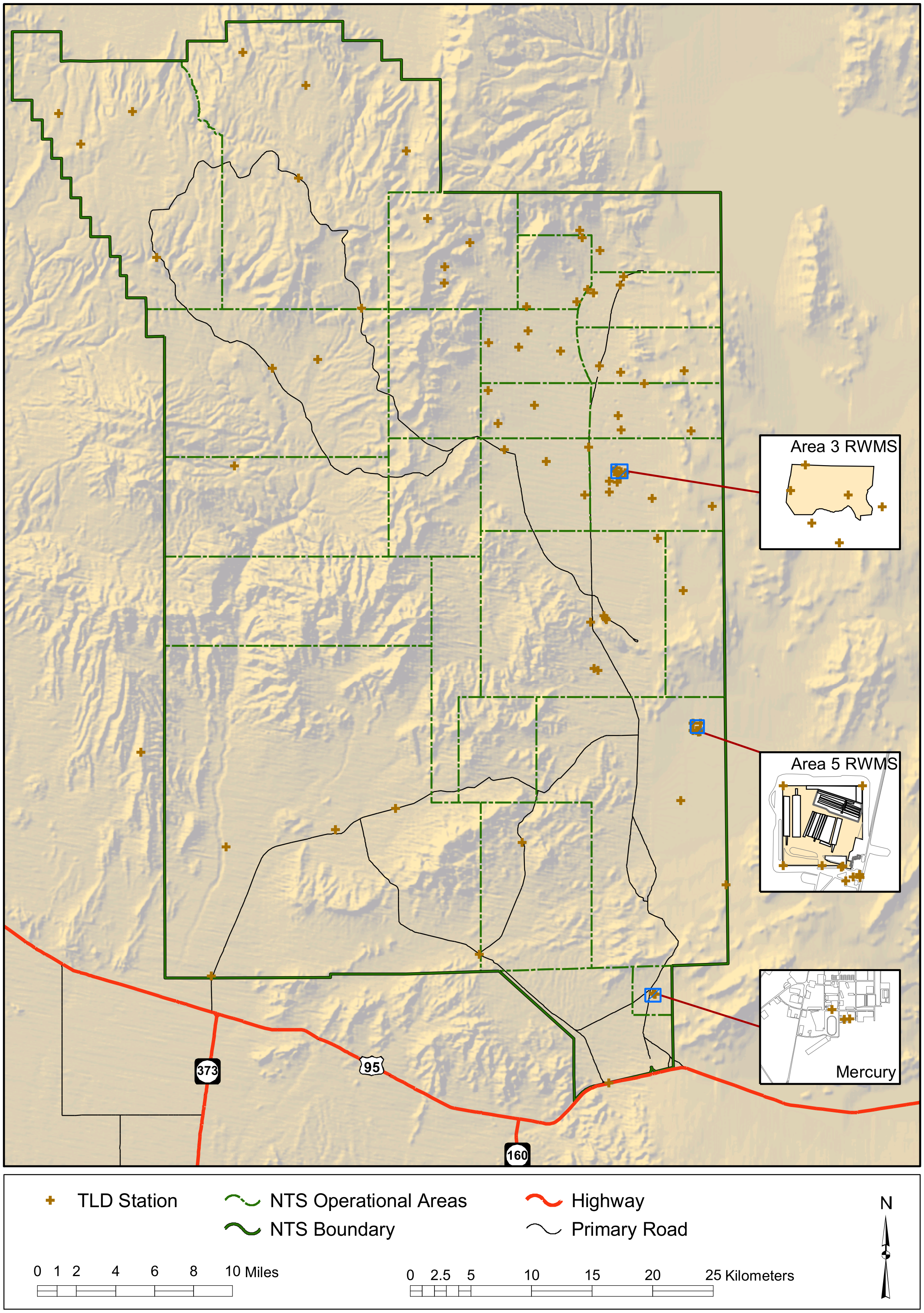


Figure 4.2 TLD Stations on the NTS - 1999

Information Reporting Requirements" (DOE 1990e); DOE Order 5400.5, "Radiation Protection of the Public and the Environment" (DOE 1990b); and DOE/EH-0173T, "Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance" (DOE 1991c).

AIRBORNE EFFLUENT MONITORING

Airborne radioactive effluents are the emissions on the NTS with the greatest potential for reaching members of the public. For all activities on the NTS, the estimated effective dose equivalent to any member of the public offsite from all airborne emissions continues to be much less than one mrem/yr (<10 percent of the guideline) (Grossman 2000). Compliance with the regulations listed above requires periodic measurements of effluents to confirm the low emission levels. The estimated effluents for 1999 are shown in Table 4.5 and include measured and calculated effluents, evaporated liquids, and resuspension of contaminated soils.

An increase in efforts to monitor radioactive air emissions at the NTS began in November 1988 as a result of requirements in DOE Order 5400.1. Known and potential effluent sources throughout the NTS were assessed for their potential to contribute to public dose and were considered in designing the “Site Effluent Monitoring Plan”, which forms part of the “Environmental Monitoring Plan, Nevada Test Site and Support Facilities” published in November 1991 (DOE 1991b). This plan was updated in 1992 and 1993, but has been superseded by a “Routine Radiological Environmental Monitoring Plan” (DOE 1998a).

ENVIRONMENTAL SURVEILLANCE

Air surveillance was conducted onsite throughout the NTS. Equipment at fixed locations continuously sampled the ambient air to monitor for radioactive material content. Ambient gamma exposures were measured with TLDs placed at fixed locations.

AIR MONITORING

The air surveillance program operated samplers that were designed to detect airborne radioactive particles and ^3H, as water vapor in the form of $^3H^3HO$ or ^3HHO. The low-volume air sampling units used to measure radioactive particulates were operated at 25 stations on the NTS (Figure 4.1) and 4 on the Nellis Air Force Range (NAFR) during 1999. These stations included 10 at radioactive waste management facilities. Access, worker population, geographical coverage, presence of radioactivity, and availability of electrical power were considerations in site selection for air samplers. During 1996, air samplers powered by solar photovoltaic/ battery systems were acquired for operation near contaminated areas where commercial power was not available and were in use at 14 locations in 1999.

In July 1999, high-volume air samplers for the collection of airborne particulates were installed at six offsite locations for the purpose of confirming compliance with NESHAPs regulations and to replace the R&IE-LV stations that were terminated at the end of FY 1999.

The low-volume air sampling unit consisted of a constant volume pump drawing approximately 85 L/min (3 cfm) of air through a 9-cm (3.5-in) diameter Whatman GF/A glass-fiber filter that trapped air particulates. Due to the moratorium on nuclear explosives testing, charcoal cartridges are no longer used in the air sampler. The particulate filter was mounted in a plastic, cone-shaped sample holder that faced downward at a height of 1.5 m (5 ft) above ground. A run-time clock measured the operating time. The time on the clock, multiplied by 85 L/min yields the volume of air sampled, which was about 860 m^3 (30,000 ft^3) during a typical seven-day sampling period.

A high-volume air sampler draws air at a constant rate of 68 m^3 per hour through a 20 x 25 cm (8 x 10 inch) glass-fiber filter, type FPAE-810. The filter is positioned upward and is covered to protect it from the wind and rain. The total volume sampled and the elapsed time is summed by a microprocessor, which also maintains a constant flow rate through the filter.

The 9-cm diameter filters were analyzed for gross alpha and gross beta radioactivity no sooner than 5 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 plutonium isotopes.

The 20 x 25 cm filters were analyzed by gamma spectroscopy at least five days after collection, composited over an approximate one-month period, and analyzed for plutonium.

Airborne HTO vapor was monitored at 12 locations throughout the NTS. For this monitoring, a pump continuously drew air into the sampler at approximately 0.6 L/min, the total volume being measured with a dry-gas meter. The HTO vapor was removed from the air stream by two molecular sieve columns connected in series. These columns were exchanged biweekly. Beginning in July 1999, the samplers were replaced with constant flow units which were controlled by microprocessors, which summed the total volume sampled and the elapsed time.

The analytical procedures used on all these air samples are summarized in Table 4.2.

AMBIENT GAMMA MONITORING

Ambient gamma monitoring was conducted at 85 stations on the NTS (Figure 4.2) by use of TLDs. The dosimeter used was the Panasonic UD-814AS environmental dosimeter, consisting of four elements housed in an air-tight, water-tight, ultraviolet-light-protected case. One element, made of lithium borate, was only slightly shielded in order to measure low-energy radiation. The other three elements, made of calcium sulfate, were shielded by 1,000 mg/cm^2 of plastic and lead and were used to monitor penetrating gamma radiation. TLDs were deployed in a holder placed about one meter above the ground and were exchanged quarterly. Locations were chosen at the site boundary, at locations where historical monitoring has occurred, or where operations or ground contamination have occurred.

WASTE MANAGEMENT SITE MONITORING

Environmental surveillance on the NTS included monitoring of the radioactive waste management sites (RWMSs). These sites are used for the disposal of low-level radioactive waste from the NTS and other DOE facilities. Shallow-land disposal in trenches and pits was done at the Area 5 RWMS (RWMS-5) and in subsidence craters at the Area 3 RWMS (RWMS-3).

During 1999, there were six air particulate sampling stations, four HTO vapor sampling stations, and 10 TLD stations placed around RWMS-5.

Monitoring at RWMS-3 during 1999 included four air particulate sampling stations and five TLD stations.

4.2 OFFSITE RADIOLOGICAL MONITORING

Under the terms of an Interagency Agreement between DOE and EPA's Office of Radiation and Indoor Air, the R&IE-LV conducted the Offsite Environmental Monitoring Program (OEMP) around the NTS. The primary activity of the OEMP is routine monitoring of potential human exposure pathways. Secondary activities include maintaining readiness to monitor during nuclear testing, emergency response, public information, and community assistance.

Maintaining readiness was exercised during three subcritical experiments conducted in 1999: CLARINET, OBOE I, and OBOE II. For each of the experiments, R&IE-LV senior personnel served on the Test Controller's Scientific Advisory Panel and on the EPA offsite radiological safety staff.

R&IE personnel continued to perform routine offsite environmental monitoring to assist the DOE in documenting compliance with NESHAPs and with DOE orders 5400.1 and 5400.5 throughout 1999.

Environmental monitoring networks, described in this and following Chapters, measure radioactivity in air (this chapter) and groundwater (Chapter 5). These networks monitor the major potential pathways for transfer of radionuclides to man. Ambient gamma radiation levels are monitored using Reuter-Stokes pressurized ion chambers (PICs) and Panasonic TLDs. Data from these networks are used to calculate an annual exposure to the offsite residents.

The Community Technical Liaison Program (CTLP) grew to 19 stations during 1999, operating in communities around the NTS and extending into southern Utah. The CTLP stations are managed by local residents and consist of air samplers, PICs, and TLDs. The Desert Research Institute (DRI) was a cooperator with R&IE-LV in the CTLP during calendar year (CY) 1999 and will assume full management of the DOE offsite program beginning with CY 2000. Transition of the program from R&IE-LV to DRI began during the third quarter of 1999.

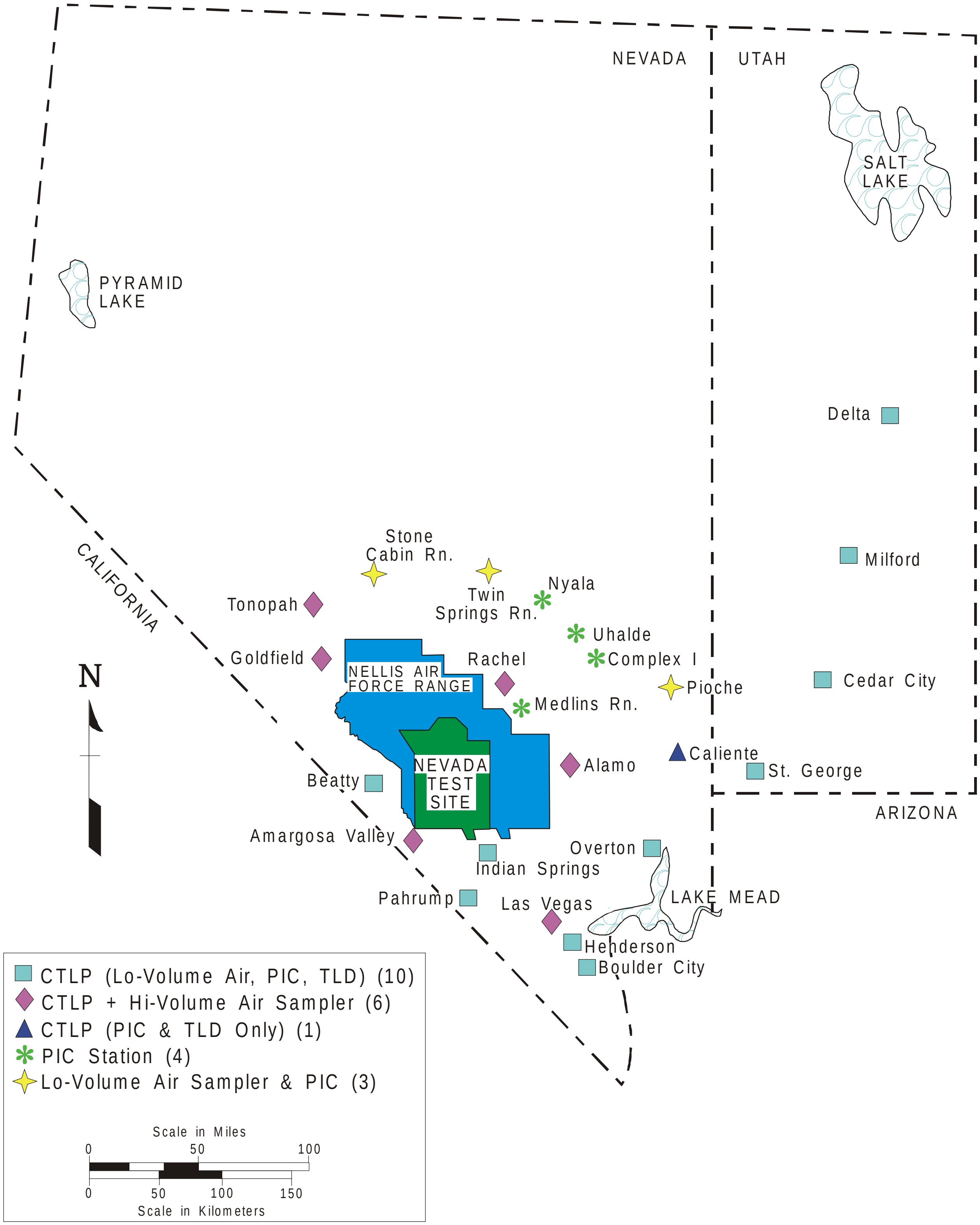
AIR SURVEILLANCE NETWORK (ASN)

The inhalation of radioactive airborne particles can be a major pathway for human exposure to radiation. The atmospheric monitoring networks detect environmental radioactivity from both NTS and non-NTS activities. 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 man.

The R&IE-LV ASN is currently designed to monitor the areas within approximately 130 km (80 mi) of the NTS. During CY 1999, the ASN consisted of 20 continuously operating sampling stations. High-volume air samplers were operational at six of the stations. The high-volume samplers were removed from the network after the December 1999 sample was collected. The current network is shown in Figure 4.3. Station location depends in part on the availability of electrical power and a resident willing to operate the equipment.

The low-volume air samplers at each station are equipped to collect particulate radionuclides on 5-cm (2.0-in) diameter glass-fiber filters at a flow rate of about 80 m^3 (2,800 ft^3) per day. Filters are changed weekly (approximately 560 m^3 or 20,000 ft^3 of air sampled). High-volume air samplers collect particulates on 20 x 25 cm (8 x 10 in) glass-fiber filters at a flow rate of approximately 1,600 m^3 (58,000 ft^3) per day. High-volume samples are collected monthly (approximately 48,000 m^3, or 1.7 million ft^3 of air sampled). 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 then moved to new locations. One duplicate high-volume sampler is operated in the same manner as the duplicate low-volume samplers.

At the R&IE-LV, the glass-fiber filters are analyzed by high-resolution gamma spectrometry. Each of the glass-fiber filters is then analyzed for gross alpha and gross beta activity 7 to 14 days after sample collection to allow time for the decay of naturally occurring radon progeny. Filters from high-volume air samplers are analyzed using high-resolution gamma spectrometry and are then analyzed for plutonium isotopes using wet chemistry methods.



Note: Real time data transmittal.

Figure 4.3 CTLP, PIC, and Air Sampling Locations Around the NTS - 1999

THERMOLUMINESCENT DOSIMETRY (TLD) NETWORK

An essential component of environmental radiological assessments is external dosimetry, which is used to determine both individual and population exposure to ambient radiation, natural or otherwise.

The primary purpose of EPA's offsite environmental dosimetry program is to establish dose estimates to populations living in the areas surrounding the NTS. Panasonic Model UD-814 TLDs are used for environmental monitoring. The UD-814 consists of one element of $Li_2B_4O_7$:Cu and three elements of $CaSO_4$:Tm phosphors. The $CaSO_4$:Tm elements are behind a filter of approximately 1,000 mg/cm^2. An average of the corrected values for the latter three elements gives the total exposure for each TLD. For quality assurance purposes, two UD-814 TLDs are deployed at each fixed environmental station location. The TLDs are exchanged quarterly.

In addition to a fixed environmental TLD, EPA deploys personnel TLDs to individual volunteers, predominantly CTLP station managers and their alternates, living in areas surrounding the NTS.

Panasonic Model UD-802 TLDs are used for personnel monitoring. The UD-802 consists of two elements, each of $Li_2B_4O_7$:Cu and $CaSO_4$:Tm phosphors. The phosphors are behind filters of approximately 17,300,300 and 1,000 mg/cm^2 respectively. With the use of different phosphors and filtrations, a dose algorithm can be applied to ratios of the different element responses. This process defines the radiation type and energy and provides data for assessing an absorbed dose equivalent to the participating individuals. These TLDs are also exchanged quarterly.

An average daily exposure rate was calculated for each quarterly exposure period and the average of the four values was multiplied by 365.25 to obtain the total annual exposure for a station.

In 1999, the TLD program consisted of 38 fixed environmental monitoring stations and 19 offsite personnel, as shown in Figure 4.4. At the end of the first quarter in 1999, Furnace Creek was discontinued as an environmental station and at the end of the third quarter the offsite personnel TLDs were discontinued due to funding.

PRESSURIZED ION CHAMBER (PIC) NETWORK

The PIC network uses Reuter-Stokes models 1011, 1012, and 1013 PICs. The PIC is a spherical shell filled with argon gas at 25 times atmospheric pressure. In the center of the shell is a spherical electrode with an electrical charge opposite to the shell. When gamma radiation penetrates the sphere, ionization of the gas occurs and the negative ions are collected by the center electrode. The current generated is proportional to the radiation exposure.

The PIC measures gamma radiation exposure rates and because of its sensitivity, may detect low-level exposures not detected by other monitoring methods. 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 naturally differ among locations as they may change with altitudes (cosmic radiation), with radioactivity in the soil (terrestrial radiation), and may vary slightly within a location due to weather patterns.

Seventeen PICs are located at the CTLP stations in communities around the NTS, and seven PICs are located at ranches and other non-CTLP locations. Meteorological data are collected from stations in Las Vegas, Boulder City, and Henderson. Additional stations are being updated with meteorological monitoring hardware during the final months of 1999. The locations of the PIC stations around the NTS are shown in Figure 4.3.

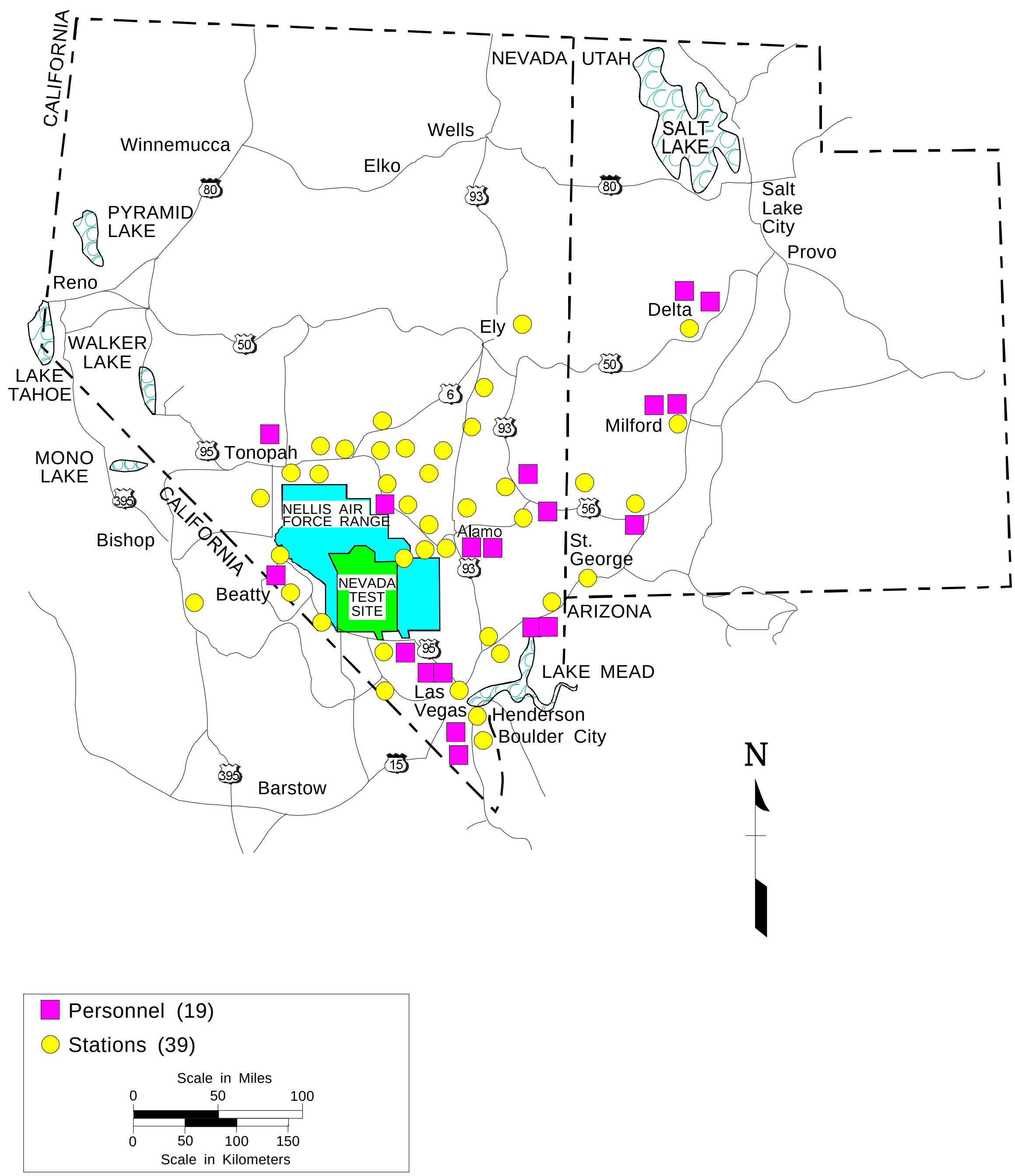


Figure 4.4 Locations of Offsite Station and Personnel TLDs - 1999

During the first two months of 1999, data from the PIC network were collected and displayed via satellite telemetry through the Los Alamos National Laboratory NEWNET system. Availability of the PIC telemetry data through this system was discontinued at the end of February 1999. During the remainder of CY 1999, PIC data were monitored by non-telemetry means, including magnetic media and chart recorders. Transition of the PIC network to the DRI began in July 1999 and was completed during December 1999. Data collection by way of telemetry resumed with equipment upgrades made to each station during the transition period. Current data were displayed on the DRI Western Regional Climate Center website as each station was upgraded. At the time of this writing, the PIC network data collected by DRI was unavailable in a format that could be summarized for reporting.

COMMUNITY TECHNICAL LIAISON PROGRAM (CTLP)

Because of the successful experience with the Citizen's Monitoring Program during the purging of the Three Mile Island containment in 1980, the Community Radiation Monitoring Program (CRMP) was begun. In 1999, there were 17 monitoring stations located in Nevada and Utah. The CTLP is a cooperative project of the DOE, EPA, and DRI. DOE/NV sponsors the program. DRI administers the program by hiring the local station managers and alternates, securing rights-of-way, providing utilities, distributing data reports, and performing additional quality assurance checks of the data. During the third and fourth quarter of 1999, the EPA began to transfer responsibility for technical and scientific direction, maintenance of the instrumentation and sampling equipment, sample analysis, data summary, and reporting, to DRI. The locations of the CTLP stations are shown in Figure 4.3.

Each station is operated by a local resident. In most cases, this resident is a high-school science teacher. Sixteen of the CTLP stations had one of the samplers for the ASN. In addition, some stations had a PIC and recorder for immediate readout of external gamma exposure and some had a TLD. A recording barograph was located at all stations. All of the equipment is mounted on a stand at a prominent location in each community so the residents can become aware of the surveillance and, if interested, can check the data. During 1999, standby noble gas and tritium monitoring equipment was removed from all stations.

4.3 NONRADIOLOGICAL MONITORING

The 1999 nonradiological monitoring program for the NTS included onsite sampling of various environmental media and substances for compliance with federal and state regulations or permits and for ecological studies as discussed in Chapters 5 and 6. Air quality monitoring is not required for the NTS. The air permits issued by the state of Nevada do require opacity and material throughput measurements. Nonradiological monitoring was conducted for eight series of tests conducted at the Hazardous Materials Spill Center (HSC) on the NTS.

MONITORING OF NTS OPERATIONS

ROUTINE MONITORING

As there were no industrial-type production facility operations on the NTS, there was no significant production of nonradiological air emissions or liquid discharges to the environment. Sources of potential contaminants were limited to construction support and NTS operational activities. These included motor pool facilities; large equipment and drill rig maintenance areas; cleaning, warehousing, and supply facilities; and general worker support facilities (including lodging and administrative offices) in the Mercury Base Camp, Area 12 Camp, and to a lesser extent in Area 20 and the NTS Control Point (CP) Complex in Area 6.

The HSC in Area 5 is a source of potential release of nonradiological contaminants to the environment, depending on the individual tests conducted. In 1999, the eight test series conducted there, involved 23 different chemicals.

Routine nonradiological environmental monitoring on the NTS in 1999 was limited to Nevada operating permit requirements and asbestos sampling in conjunction with asbestos removal and renovation projects and in accordance with occupational safety and NESHAP compliance.

NTS AIR QUALITY PERMIT COMPLIANCE

Monthly visible emissions 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 the limit is 10 percent. Certification of personnel to perform valid visible emission opacity evaluations is required by the state, with recertification required every six months. During 1999, one employee of BN's Environmental Compliance Department and two Construction Department employees were recertified. In 1999, several visible emission evaluations of permitted air quality point sources were conducted. When visual evaluations determine that an emission exceeds the opacity requirement, corrective action is initiated. The opacity limit was not exceeded in 1999.

OFFSITE MONITORING

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. 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 1999, no monitoring was required.

NON-NTS FACILITY MONITORING

Under normal conditions, the operations at the six non-NTS facilities operated by BN for DOE/NV do not produce radioactive effluents. The six are: (1) the North Las Vegas Facility (NLVF), (2) the Remote Sensing Laboratory (RSL), (3) the Special Technologies Laboratory (STL), (4) Livermore Operations (LO), (5) Los Alamos Operations (LAO), and (6) RSL-Andrews.

AIR QUALITY PERMITS

The permits required for 1999 are listed in Table 4.3. The permits required for the NTS in 1999 for non-NTS facilities that support the work of DOE/NV are listed in Table 4.4.

Thirteen air quality operating permits, issued by the Clark County Health District in Las Vegas, Nevada, were required for operations at the NLVF and the RSL during 1999. 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 1999.

4.4 AIR SURVEILLANCE PROGRAM RESULTS

ONSITE RADIOLOGICAL MONITORING

AIRBORNE EFFLUENTS

During 1999, the monitoring of airborne radioactive emissions at the NTS involved several operational facilities and some inactive locations. Due to the continuation of the moratorium on nuclear testing throughout 1999, the monitoring of emissions from nuclear tests was not required. The results of other effluent monitoring, calculated or measured, are set forth in Table 4.5. The total curies of tritium emissions (338 Ci airborne) included in Table 4.5 are more than that reported in the 1998 Annual Site Environmental Report (192 Ci). The increase is attributed to an improvement in the air sampling collection efficiency for tritium. From field tests conducted in 1998, the tritium in air concentrations measured with the use of molecular sieve were found to be a factor of 2.3 times the concentrations measured with silica gel. Therefore beginning in July 1999, molecular sieve was used in place of silica gel, which resulted in the measurement of higher concentrations of tritium at all sampling locations during the last six months of 1999. As these concentrations were used with CAP88-PC software to estimate emissions, the higher concentrations resulted in higher estimated emissions.

AIR SAMPLING RESULTS

GROSS ALPHA

The annual average gross alpha results for each air sampling station are shown in Table 4.6. The annual average for the network was 2.5×10^{-15} µCi/mL (96 µBq/m^3), which was slightly higher than the median minimum detectable concentration (MDC). This average was slightly higher than the 1998 value. The samples from the NAFR were all about the same as the NTS average at 2.5×10^{-15} µCi/mL (93 µBq/m^3).

The samples collected from the air samplers at the low-level radioactive waste disposal facility in RWMS-3 and in RWMS-5 had gross alpha levels near the NTS average.

GROSS BETA

The annual average gross beta results for each air sampling station are shown in Figures 4.5 and 4.6 which also indicate the distribution of this radioactivity. The NTS average this year at 2.1×10^{-14} µCi/mL (0.78 mBq/m^3) was slightly higher than the 1998 value. The air samples from the NAFR had an average value slightly less at 1.7×10^{-14} µCi/mL (0.63 mBq/m^3). This is consistent with the results for the past few years. The basic data are in Table 4.6. Figure 4.7 depicts the trend in concentration for the past few years (a much longer trend is shown in Figure 1.1, Chapter 1), but expressed as percent Derived Concentration Guide (DCG), set by the EPA as 10 mrem per year for inhaled radioactivity. Note that the levels are only about 2 percent of the DCG. This guide is for public exposure and is based on ^{90}Sr, once a common beta-emitting isotope in the environment.

Air samples from both RWMS-3 and RWMS-5 had average gross beta levels that were near the NTS average.

PLUTONIUM

The annual average ^{238}Pu result of 1.4×10^{-18} µCi/mL (52 nBq/m^3) is less than the median MDC for this isotope and slightly greater than the 1998 average. The results from the NAFR were about half of the MDC. None of the stations had results greater than the MDC, except for Bunker 9-300. The annual averages for ^{238}Pu and for $^{239+240}$Pu are also included in Table 4.6.

The $^{239+240}$Pu network average of 1.0×10^{-16} µCi/mL (3.7 µBq/m^3) was about ten times the MDC and about twice the 1998 average value. To indicate the distribution of this nuclide over the NTS, the annual average concentration for each station is plotted in Figure 4.8 (see Figure 4.6 for RWMS-5). The highest annual average concentration was for Area 9 9-300, 1.3×10^{-15} µCi/mL. Of the NAFR samples, the set from Project 57 had the highest concentration of any station offsite. The trend of the NTS site-wide $^{239+240}$Pu concentration with time for the past few years is shown on Figure 4.9. There the data are plotted as a percent of the DCG for the general population as was done for the gross beta data above. The peak in the curve in 1992 was due to increased concentrations in Areas 3 and 9, probably related to increased vehicular travel and construction activities. The peak this year is mainly due to the Bunker 9-300 results.

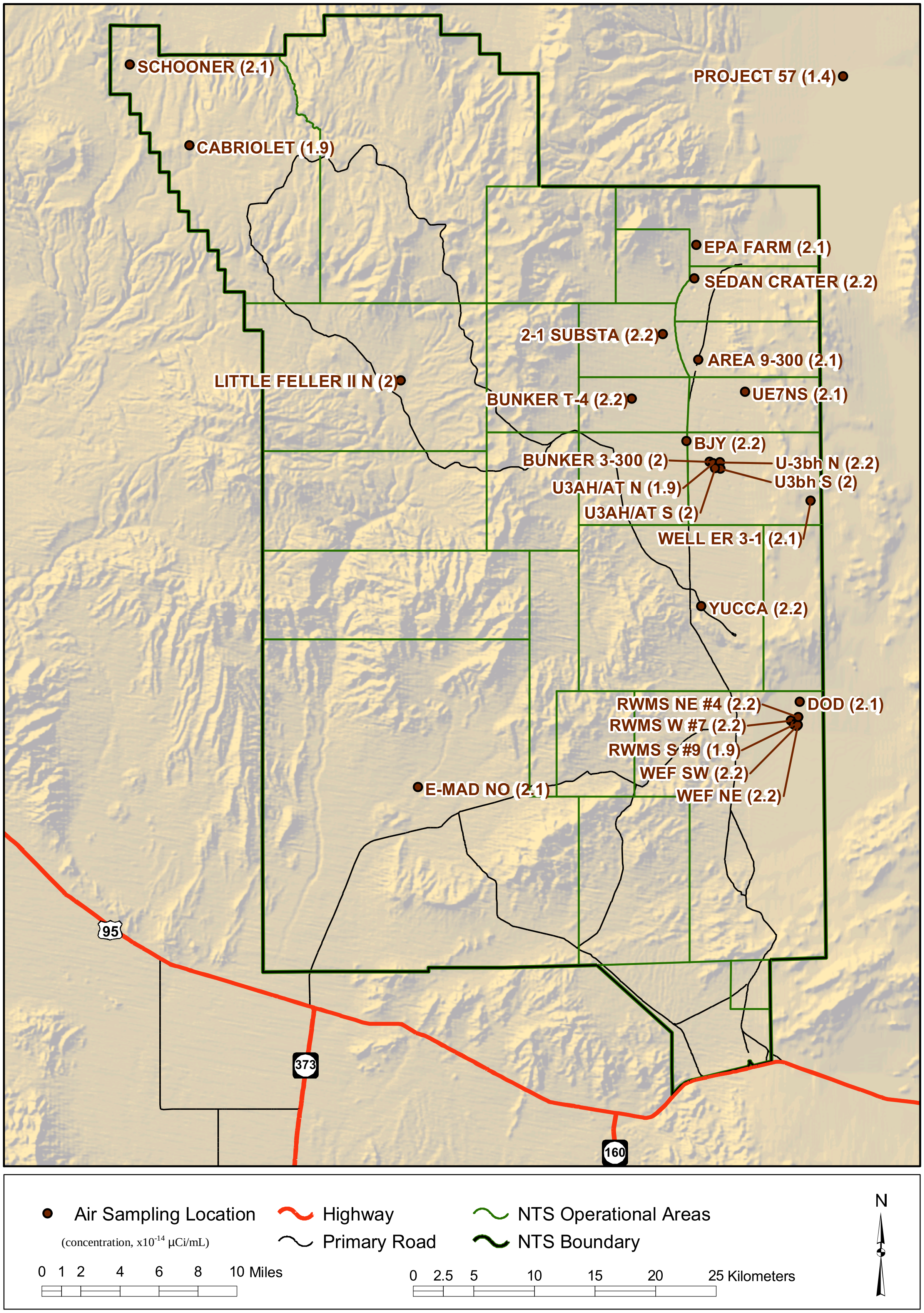


Figure 4.5 Annual Average Gross Beta from Air Sampling - 1999

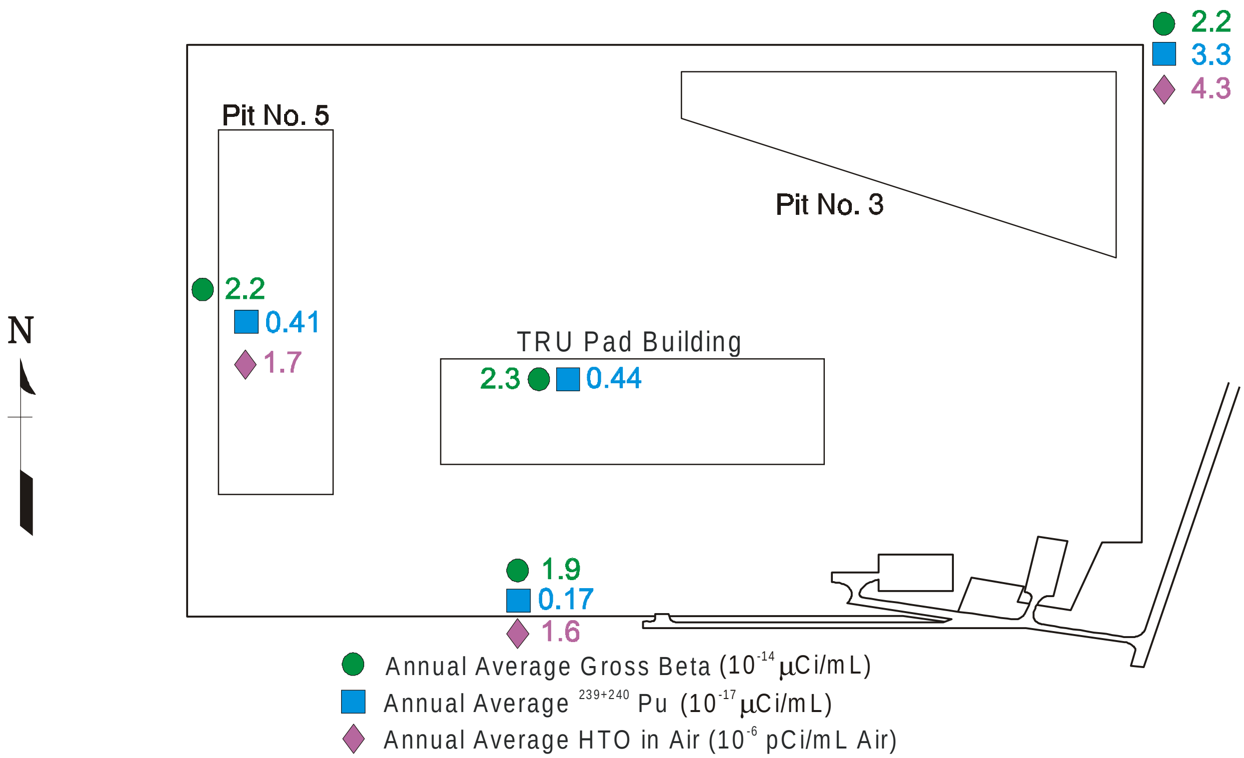


Figure 4.6 Air Monitoring Results for RWMS-5 - 1999

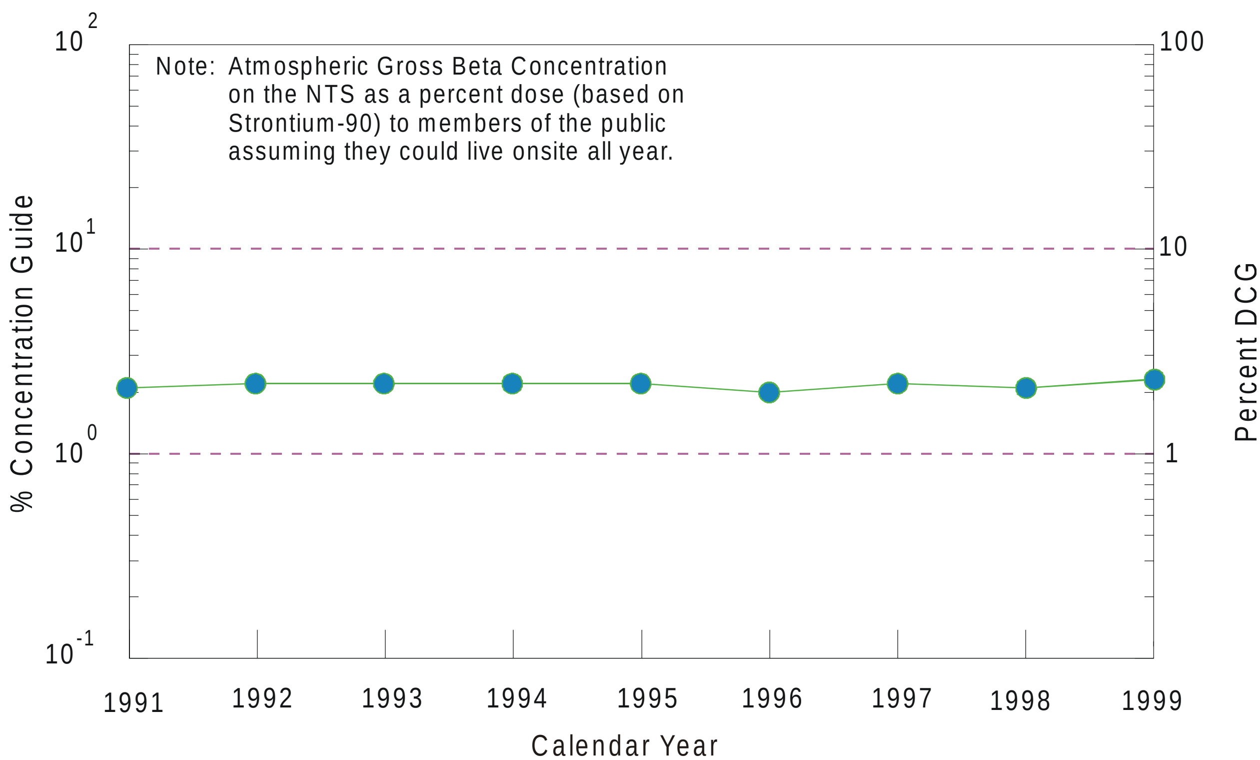


Figure 4.7 Trend in Annual Average Gross Beta Concentration in Air on the NTS

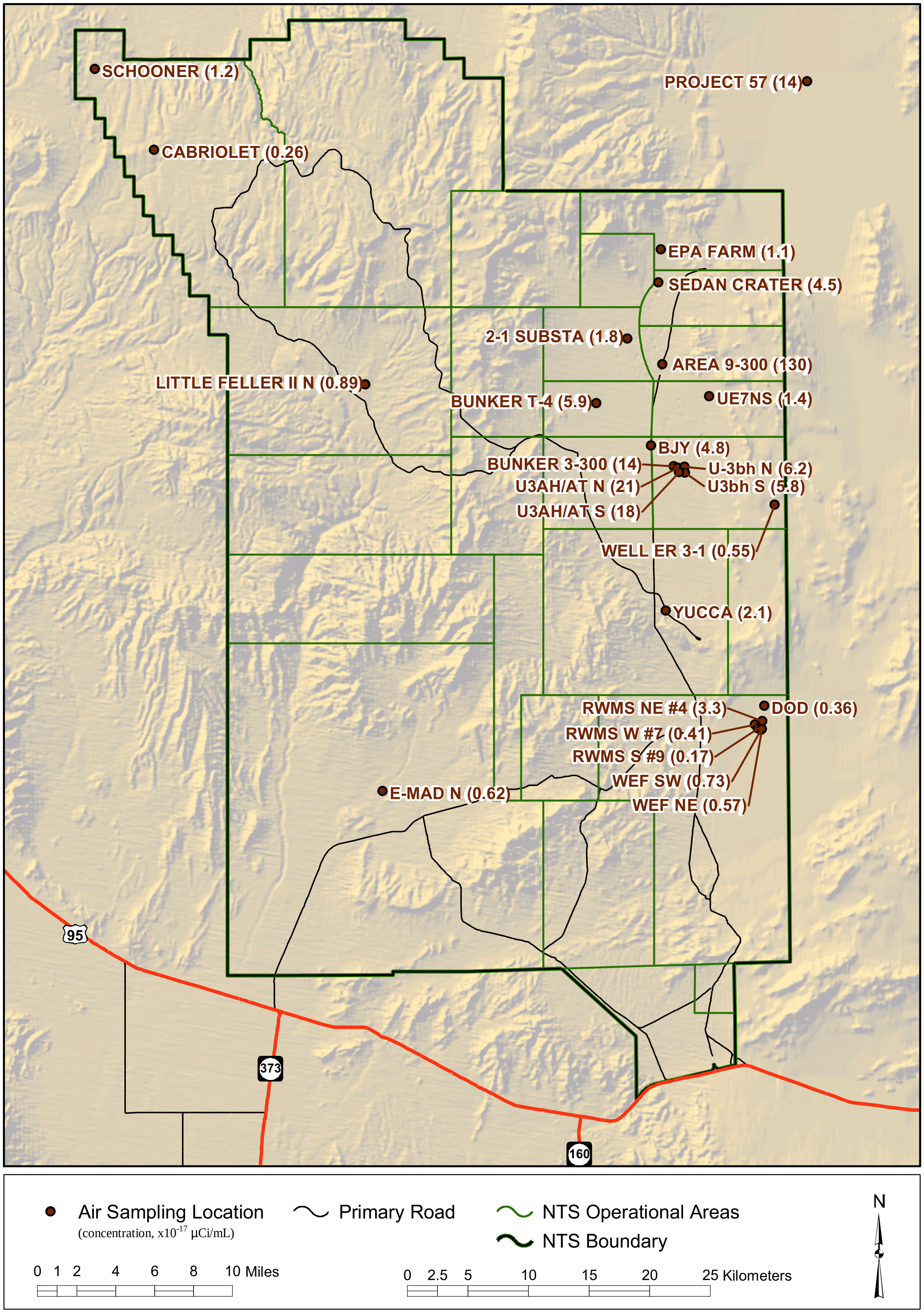


Figure 4.8 Annual Average $^{239+240}$Pu in Air on the NTS - 1999

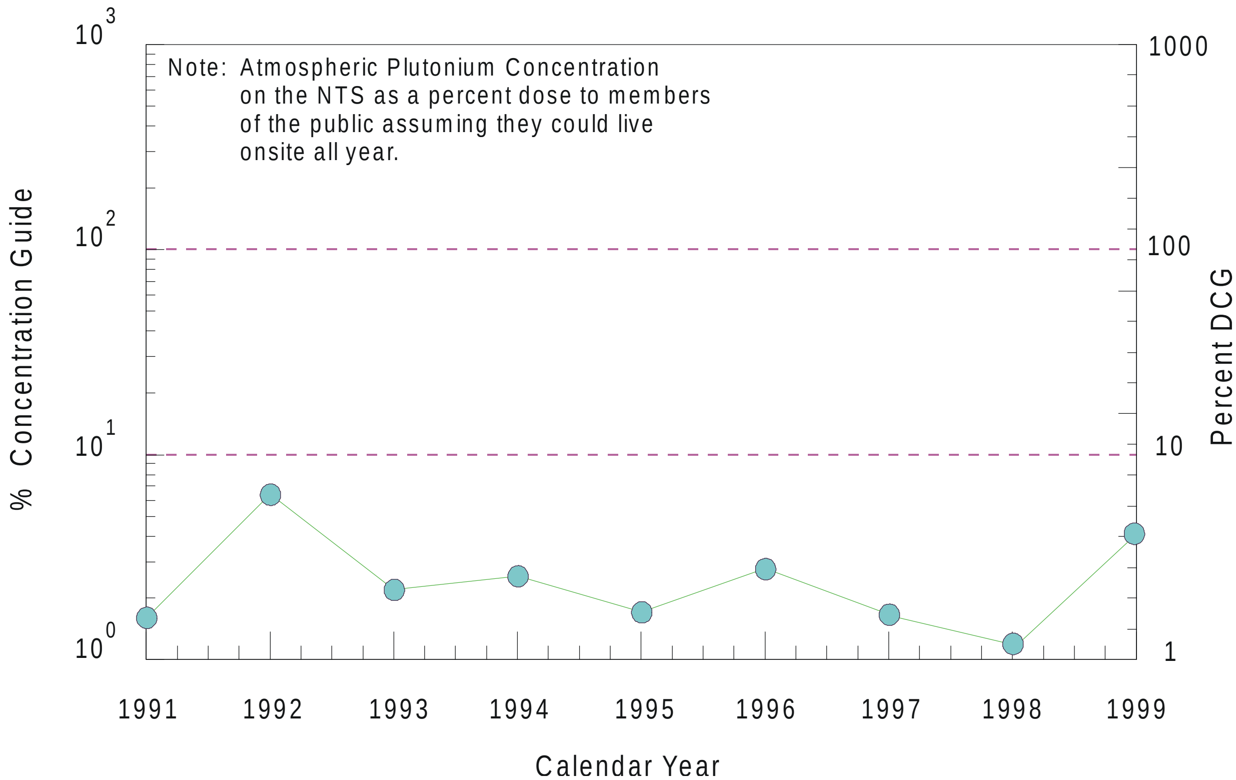


Figure 4.9 Trend in Annual Averages for Plutonium Concentration on the NTS

Air samples from RWMS-3 generally have concentrations of plutonium above the NTS average, while those from RWMS-5 are generally lower than the NTS average.

GAMMA

Gamma spectral analyses of the glass-fiber filters indicated only naturally occurring radioactive materials. The predominant one was ^{7}Be formed by cosmic ray interaction with nitrogen in the atmosphere. The annual average values for this isotope are shown in Table 4.6 and the NTS average of 2.1×10^{-13} µCi/mL (7.8 mBq/m^3) is similar to the value for 1998. The concentrations in samples from the NAFR were 24 percent lower, on the average, at 1.6×10^{-13} µCi/mL (5.9 mBq/m^3).

TRITIATED WATER VAPOR (HTO)

The annual average value for the 12 stations in this network was 25×10^{-6} pCi/mL (0.85 Bq/m^3). This concentration is 35 percent higher than it was in 1998 due to higher concentrations in 1999 at SCHOONER, which had an average concentration of 200×10^{-6} pCi/mL. The other locations which had annual averages above the median MDC were BJY, RWMS 4 NE, WEF NE, EPA Farm, SEDAN crater, Decon Pad, and E Tunnel Pond 2. All of the data are displayed in Table 4.7 and are plotted as a trend over the last several years in Figure 4.10. The data plotted in Figure 4.10 are the network average concentration of HTO in each year expressed as a percent of the DCG for the general offsite population. There has been a slight downward trend over the period plotted, until 1998; however, all values are less than 2 percent of the DCG. The increase in the network average is attributed to: (1) the elimination over the last two years of several sampling locations that previously measured tritium concentrations near and below the MDC; and (2) the use of a more efficient desiccant (molecular sieve instead of silica gel) in the tritiated atmospheric moisture samplers.

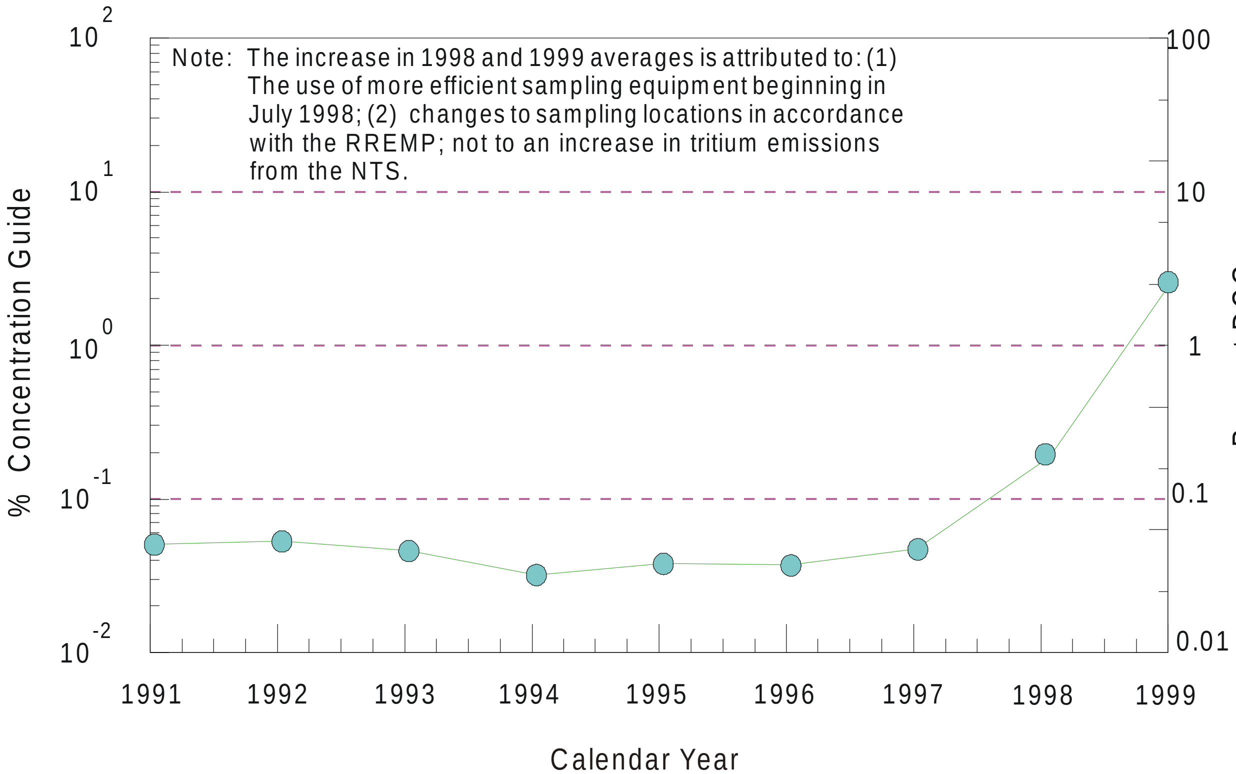


Figure 4.10 Trend in Annual Averages for HTO Concentration on the NTS

TREND AT THE WASTE MANAGEMENT SITES

The annual average air concentrations of plutonium and HTO as atmospheric moisture at RWMS-3 and RWMS-5 are set forth in Tables 4.8 and 4.9, respectively. No average for HTO is shown for RWMS-3, because that sampling was terminated at the beginning of 1998. The annual average HTO concentrations have been less than the median MDC for several years at RWMS-3.

ONSITE TLD RESULTS

The 1999 average exposure for the 13 boundary monitoring stations was 119 mR/year, the same as the average value for these stations in 1998 (see Table 4.10). Also, the 1999 average exposure for the nine historically monitored stations was 0.25 mR/day (91 mR/yr), as shown in Table 4.11. The results for these stations for the last six years have been almost identical. Both sets of results indicate that external radiation measured by TLDs has not changed to any measurable extent, at least for the last few years.

OFFSITE RADIOLOGICAL RESULTS

AIR SAMPLING RESULTS

The ASN measures the major radionuclides which could potentially be emitted from activities on the NTS, as well as naturally occurring radionuclides. The ASN results represent the possible inhalation exposure pathway for the general public.

Gamma spectrometry was performed on all samples from the ASN high and low volume air samplers. The majority of the samples were gamma-spectrum negligible (i.e., no gamma-emitting radionuclides detected). Naturally occurring ^{7}Be was detected occasionally by the low-volume network of samplers. It was detected consistently by the high-volume sample method with an average annual activity of 1.6 x 10^{-13} µCi/mL.

GROSS ALPHA

Gross alpha analysis was performed on all low-volume network samples. The average annual gross alpha activity was 2.1 x 10^{-15} µCi/mL (80 µBq/m^3). Summary results for the ASN are shown in Table 4.12.

GROSS BETA

As in previous years, the gross beta results from the low-volume sampling network consistently exceeded the analytical MDC. The annual average gross beta activity was 1.6 ± 0.6 x 10^{-14} µCi/mL (5.9 ± 2.2 x 10^{-4} Bq/m^3). Summary gross beta results for the ASN are in Table 4.13.

PLUTONIUM

High-volume samples were collected monthly and analyzed for plutonium isotopes. Due to a low limit of detection for high-volume sampling and analysis methods, environmental levels of $^{239+240}$Pu were consistently detected at all six of the sampling sites. Sixty-eight samples were analyzed during CY 1999. The overall average annual activity was 0.13 x 10^{-18} µCi/mL (4.8 nBq/m^3) for ^{238}Pu. Only 7 of the 68 samples analyzed for ^{238}Pu had result values greater than the analysis MDC. The average activity for these seven samples was 0.51 x 10^{-18} µCi/mL (18 nBq/m^3). Six of these samples were from the Rachel, Nevada sampling location, and the other sample was collected in Alamo, Nevada. Fifty-four of the 68 samples were above the detection limit for $^{239+240}$Pu. The average activity for this group of samples was 2.9 x 10^{-18} µCi/mL (107 nBq/m^3) for $^{239+240}$Pu. If you exclude the one high sample of 52 x 10^{-18} from Rachel, Nevada, the group average activity drops to 2.0 x 10^{-18} µCi/mL (74 nBq/m^3) for the remaining 53 samples. Summary results of the high-volume data are shown in Table 4.14.

TLD RESULTS FOR STATIONS

Total annual exposure for 1999 ranged from 46 mR (0.46 mSv) per year at Las Vegas, Nevada, to 147 mR (1.47 mSv) per year at Queen City Summit, Nevada, with a mean annual exposure of 28 mR (0.28 mSv) per year for all operating locations. All results are shown in Table 4.15 and are consistent with previous years results.

TLD RESULTS FOR PERSONNEL

Annual whole body dose equivalents ranged from a low of 51 mrem (0.51 mSv) to a high of 175 mrem (1.8 mSv) with a mean of 108 mrem (1.8 mSv) for all monitored personnel during 1999. A summary of the results is shown in Table 4.16. These results are consistent with previous years results. The result for Furnace Creek was not used because it was for one quarter only.

PRESSURIZED ION CHAMBER (PIC) NETWORK

The PIC data presented in this section are based on daily averages of gamma exposure rates from each station. Table 4.17 contains the maximum, minimum, mean, standard deviation, and median of the daily averages for the periods where telemetry data was available during 1999. The table shows the total mR/yr and the average gamma exposure rate for each station during the year. The mean ranged from 72 to 152 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). The annual exposure levels observed at each PIC station are well within these United States background levels. Data for the remainder of 1999 when telemetry information was unavailable, were collected using chart media. Charts for each station were reviewed weekly for irregularities or increases above normal background levels. No trends or anomalous data were observed in the chart data. Magnetic tape and electronic cartridge data quality have seriously deteriorated during the last several years and do not meet data quality requirements for this report.

NON-NTS BN FACILITY MONITORING

BN facilities that use radioactive sources or radiation-producing equipment with the potential to expose the general population outside the property line to direct radiation are the STL, during operation of the Sealed Tube Neutron Generator and operation of the Febetron; RSL-Andrews, during storage of sealed sources; and Atlas NLVF A-1 Source Range. Sealed sources are tested every six months to ensure there is no leakage of radioactive material. The data from sealed source testing are kept in the BN Radiation Protection Records. Operation of radiation generating devices is controlled by BN procedures. Fence-line radiation monitoring at STL and NLV was conducted during 1999 using Panasonic Type UD-814 TLDs. At least two TLDs were placed at the fence line at a location which would be the closest to radiation sources at these facilities. At RSL-Andrews, all the boundary TLD stations were terminated during fourth quarter 1998. TLDs were exchanged on a quarterly basis with additional control TLDs kept in a shielded safe. The TLD results are given in Table 4.18. The range of results, 45 to 65 mR/yr, is within the background range in the continental United States.

Table 4.1 Summary of the NTS Air and Direct Radiation Surveillance Program - 1999

Sample Type	Description	Collection Frequency	Number of Locations	Type of Analysis
		Onsite Monitoring		
Air	Sampling through Whatman GF/A glass fiber filter, 85 L/min .	Weekly	29	Gross alpha and beta, (Gamma spectroscopy, $^{238,239+240}$Pu, monthly composite).
	High-volume sampling	Weekly	6	Gamma spectroscopy, $^{238,239+240}$Pu, monthly composite.
	Low-volume sampling through molecular sieve	Biweekly	12	HTO (tritiated water)
External Gamma Radiation Levels	UD-814AS thermoluminescent dosimeters	Quarterly	85	Total quarterly exposure
		Offsite Monitoring		
Air	Sampling through 5-cm glass-fiber filter	Weekly	20	Gamma spectroscopy, gross α & ß
	Sampling through 500-cm^2 glass-fiber filter at 1,100 L/min	Monthly	6	Gamma spectroscopy $^{238,239+240}$Pu
External Gamma Radiation Levels	UD-814AS thermoluminescent dosimeters	Quarterly	38	Quarterly exposure at deployed location
	UD-802 thermoluminescent dosimeters	Quarterly	19	Quarterly exposure of offsite personnel
External Gamma Radiation Rate	Reuter-Stokes Pressurized Ion Chambers	Continuous	17	Continuous rate recording summarized hourly

Table 4.2 Analytical Procedures, Air and TLD - 1999

Analysis	Sample Type Nominal Size	Analytical Procedure	Equipment	Count Time (min)	Estimated MDC
		BN Analytical Procedures			
Gross α	Air, 860 m^3	After 5 - 7 days, place in planchet	Gas-flow proportional counter	20	74 µBq/m^3 (2 x 10^{-3} pCi/m^3)
Gross β	Air, 860 m^3	Continue count.	Gas-flow proportional counter	20	150 µBq/m^3 (4 x 10^{-3} pCi/m^3)
Gamma spectrometry composite	Air, 3,400 m^3	Filters placed on planchet, that is placed on crystal	HpGe, calibrated 1 keV per channel,	20	370 µBq/m^3 (1 x 10^{-2} pCi/m^3) for ^{137}Cs
$^{238,239+240}$Pu Monthly Composite	Air, 3,400 m^3	Acid dissolution, ion-exchange, ppt with ^{242}Pu tracer, collect on filter	Alpha spectrometer with solid-state PIP detector	333	0.41 µBq/m^3 (11 x 10^{-6} pCi/m^3)
Tritium	Air, 8 m^3	Moisture trapped on molecular sieve, heat to remove	5 mL in cocktail counted in liquid scintillation counter	70	0.11 Bq/m^3 (3 pCi/m^3)
Ambient gamma	TLD, UD-814AS	Expose in field, 3 months	Automatic TL reader		10 mR per quarter
		EPA Analytical Procedures			
Gross α	Air, 560 m^3	After 7-14 days place in planchet	Gas-flow proportional counter	30	30 µBq/m^3 (8 x 10^{-4} pCi/m^3)
Gross β	Air, 560 m^3	After 7-14 days place in planchet	Gas-flow proportional counter	30	90 µBq/m^3 (2.5 x 10^{-3} pCi/m^3)
Gamma spectrometry	Air, 560 m^3 Low-vol 10,000 m^3 High-vol	Place on detector, has online analytical program	HpGe detector, calibrated 0.5 keV/channel from 40 to 2,000 keV	30	2 mBq (0.05 pCi)/m^3 20 µBq (5 x 10^{-4} pCi) per m^3 (Hi-vol), ^{137}Cs
$^{238,239+240}$Pu Monthly Composite	Air, 40,000 m^3	Acid dissolution, ion-exchange, electrodeposition on stainless steel disc with ^{242}Pu tracer	Alpha spectrometer with solid-state PIP detector	1,000	0.02 µBq/m^3 (5.0 x 10^{-7} pCi/m^3)

Table 4.3 NTS Active Air Quality Permits - 1999

Permit	Description	Expiration Date	Annual Reporting
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 Equip. (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)	03/09/2001	None
00-26	Burn Variance, NTS (EM Drill)	03/21/2001	None
	Non-BN Operated NTS Air Permits		
00-10	Burn Variance Area 27 (LLNL)	02/05/2001	None
	BN Operated Off-NTS Air Permits (TTR and NAFR)		
AP9711-0785	UGTA Class II Air Quality Permit	04/16/04	February 1

Table 4.4 Active Air Quality Permits for Non-NTS Facilities - 1999

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	Water Heater, No. 2 Natl. 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
A38702	Hamada Offset Press (C-1)	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 4.5 NTS Radionuclide Emissions - 1999

Onsite Liquid Discharges

Containment Ponds	Curies[a]				
	^{3}H	^{90}Sr	^{137}Cs	^{238}Pu	$^{239+240}Pu$
Area 12, E Tunnel	1.53×10^{1}	3.2×10^{-5}	4.1×10^{-3}	5.5×10^{-6}	4.8×10^{-5}
Area 20, U-20n PS No.1	9.43×10^{0}				
TOTAL	2.47×10^{1}	3.2×10^{-5}	4.1×10^{-3}	5.5×10^{-6}	4.8×10^{-5}

Airborne Effluent Releases - Curies[a]

Facility Name	^{3}H[b]	$^{239+240}Pu$
Laboratories	5.7×10^{0}	
SCHOONER	6.5×10^{1}	
Area 5, RWMS[d]	7.1×10^{0}	
SEDAN Crater [d]	2.6×10^{2}	
Areas 3 and 9[c]		4.0×10^{-2}
Other Areas[c]		2.0×10^{-1}
TOTAL	3.38×10^{2}	2.4×10^{-1}

(a) Multiply by 3.7×10^{10} to obtain Bq. Calculated releases from laboratory spills and losses are included in Table 1.1.
(b) In the form of tritiated water vapor, primarily HTO.
(c) Resuspension from known surface deposits.
(d) Calculated from air sampler data.

Table 4.6 Summary Data (µCi/mL) for Gross Alpha/Beta, ^{7}Be, and Plutonium in Air - 1999

Onsite Air Sampling

Location	Gross α (x 10^{-15})	Gross β (x 10^{-14})	^{7}Be (x 10^{-13})	^{238}Pu (x 10^{-18})	$^{239+240}Pu$ (x 10^{-18})
Area 1, BJY	2.4	2.2	2.1	0.27	48
Area 2, 2-1 Substation	2.3	2.2	2.1	0.26	18
Area 3, Bunker 3-300	2.5	2.0	2.0	1.9	140
Area 3, U-3AH/AT N	2.4	1.9	1.9	2.4	210
Area 3, U-3AH/AT S	2.4	2.0	2.1	1.6	180
Area 3, U-3BH N	2.8	2.2	2.1	-0.51	62
Area 3, U-3BH S	2.3	2.0	2.0	0.04	58
Area 3, Well ER 3-1	2.3	2.1	2.1	-0.66	5.5
Area 4, Bunker T-4	2.4	2.2	2.2	8.3	59
Area 5, DOD	2.1	2.1	2.0	0.22	3.6
Area 5, RWMS 4 Northeast	2.5	2.2	2.1	0.07	33
Area 5, RWMS 7 West	2.8	2.2	2.0	-0.43	4.1
Area 5, RWMS 9 South	1.8	1.9	2.1	-0.68	1.7
Area 5, RWMS TRU Bldg N	2.5	2.3	1.9	-0.65	4.4
Area 5, WEF Northeast	2.3	2.2	2.1	-0.09	5.7
Area 5, WEF Southwest	2.3	2.2	2.1	0.10	7.3
Area 6, Yucca	2.2	2.2	2.2	0.23	21
Area 7, UE7NS	2.0	2.1	2.1	-0.40	14
Area 9, Bunker 9-300	4.6	2.1	2.2	14.00	1300
Area 10, SEDAN Crater	2.4	2.2	2.2	3.50	45
Area 15, EPA Farm	2.5	2.1	2.1	-0.12	11
Area 18, LITTLE FELLER 2 N	2.1	2.0	2.0	-0.37	8.9
Area 20, CABRIOLET	2.1	1.9	2.0	0.99	2.6
Area 20, SCHOONER	2.1	2.1	2.0	2.10	12
Area 25, E-MAD N	2.3	2.1	2.1	-0.37	6.2
Average	2.5	2.1	2.1	1.4	100

Near Offsite Air Sampling

Location	Gross α (x 10^{-15})	Gross β (x 10^{-14})	^{7}Be (x 10^{-13})	^{238}Pu (x 10^{-18})	$^{239+240}Pu$ (x 10^{-18})
Area 13, PROJECT 57	2.1	1.4	1.4	1.93	140
Area 52, CLEAN SLATE II	2.8	1.8	1.5	0.75	120
Area 52, CLEAN SLATE III	3.3	2.2	1.7	-0.52	7.2
Area 52, DOUBLE TRACKS	2.1	1.7	1.7	0.31	1.5
Average	2.5	1.7	1.6	0.82	84
Median MDC	1.8	0.40	0.22	11.	11

Offsite Air Sampling

Location	Gross α (x 10^{-15})	Gross β (x 10^{-14})	^{7}Be (x 10^{-13})	^{238}Pu (x 10^{-18})	$^{239+240}Pu$ (x 10^{-18})
Alamo	--	--	1.6	0.40	2.5
Amargosa Center	--	--	1.7	0.02	1.3
Beatty	--	--	1.7	0.04	2.7
Goldfield	--	--	1.6	0.08	0.96
Indian Springs	--	--	1.5	0.03	2.3
Rachel	--	--	1.6	0.41	28
Average	--	--	1.6	0.16	6.2
Median MDC	--	--	0.035	0.92	0.92

Table 4.7 Airborne Tritium Concentrations on the NTS - 1999

	^{3}H Concentration (10^{-6} pCi/mL)					
	Onsite					
Location	Number	Maximum	Minimum	Arithmetic Mean	Standard Deviation	Mean as %DCG
Area 1, BJY	30	20	-1.3	3.0	4.5	0.030
Area 5, RWMS NE (4)	25	15	0.66	4.3	3.7	0.043
Area 5, RWMS S (9)	31	10	-0.92	1.6	2.5	0.016
Area 5, RWMS W (7)	32	12	-1.8	1.7	3.0	0.017
Area 5, WEF NE	30	52	-0.61	3.2	9.5	0.032
Area 5, Well 5B	31	1.9	-2.3	0.12	0.89	<0.01
Area 6, Decon Pad	3	4.2	2.2	3.4	1.0	0.034
Area 10, SEDAN Crater	31	41	1.5	16	12	0.16
Area 12, E Tunnel Pond No. 2	21	54	2.6	20	15	0.20
Area 12, Stake T-18	20	2.3	-2.1	0.28	0.88	<0.01
Area 15, EPA Farm	32	27	3.8	11	4.2	0.11
Area 20, Schooner	31	750	12	200	233	2.0
All Stations	322	750	-2.3	25	88	0.25
	Offsite					
Amargosa Valley	8	29	-0.58	3.8	10	0.038
Indian Springs	8	11	-0.53	3.9	5.3	0.039

Median MDC was 2.5 x 10^{-6} pCi/mL

Table 4.8 Mean Air Monitoring Results for Various Radionuclides at the RWMS-3, 1995 - 1999

Year	$^{239+240}Pu$ (x 10^{-17} µCi/mL)	^{238}Pu (x 10^{-17} µCi/mL)	Tritium (x 10^{-12} µCi/mL)
Arithmetic Mean 1999	13	0.09	(a)
Arithmetic Mean 1998	4.2	0.08	(a)
Arithmetic Mean 1997	3.8	0.06	1.2
Arithmetic Mean 1996	16	0.25	0.5
Arithmetic Mean 1995	8.8	0.16	(a)
Mean MDC	1.1	0.99	2.8
Derived Concentration Guide	200	300	10,000

(a) Sampling for tritium was stopped at the end of 1997 due to concentrations less than the MDC.

Table 4.9 Mean Air Monitoring Results for Various Radionuclides at the RWMS-5, 1995 - 1999

Year	$^{239+240}Pu$ (x 10^{-17} µCi/mL)	^{238}Pu (x 10^{-17} µCi/mL)	Tritium (x 10^{-12} µCi/mL)
Arithmetic Mean 1999	1.0	-0.02	2.7
Arithmetic Mean 1998	1.3	0.03	4.0
Arithmetic Mean 1997	0.23	0.03	3.7
Arithmetic Mean 1996	0.51	0.02	3.2
Arithmetic Mean 1995	0.6	0.01	5.7
Mean MDC	1.1	0.99	2.9
Derived Concentration Guide	200	300	10,000

Table 4.10 NTS Boundary Gamma Monitoring Results - 1999

Location	First Quarter (mR/day)	Second Quarter (mR/day)	Third Quarter (mR/day)	Fourth Quarter (mR/day)	Annual Average (mR/d)	Annual Average (mR/yr)
U-15E Substation	0.24	0.25	0.25	0.24	0.25	90
Stake J-41	0.34	0.35	0.36	0.35	0.35	130
Stake LC-4	0.42	0.44	0.44	0.41	0.43	160
Stake A-118	0.37	0.40	0.40	0.39	0.39	140
Papoose Lake Road	0.21	0.21	0.21	0.21	0.21	76
Gate 19-3P	0.43	0.41	0.42	0.40	0.42	150
Army Well No. 1	0.21	(a)	0.20	0.20	0.20	75
3.3 Miles SE of Aggregate Pit	0.16	0.15	0.15	0.15	0.15	57
Guard Station 510	0.33	(a)	0.32	0.31	0.32	120
Yucca Mountain	0.37	(a)	0.35	0.33	0.35	130
Cat Canyon/Buggy Rd	0.47	0.45	0.47	0.47	0.47	170
Gold Meadows	0.34	0.35	0.37	0.34	0.35	130
Well ER 3-1	0.32	0.34	0.33	0.31	0.33	120

(a) Results lost due to human error.

Table 4.11 NTS Historical TLD Station Comparisons, 1992-1999

Area	Station	Exposure Rate (mR/day) 1993	1994	1995	1996	1997	1998	1999
5	Well 5B	0.39	0.34	0.30	0.30	0.30	0.29	0.29
6	CP-6	0.30	0.19	0.19	0.21	0.20	0.19	0.25
6	Yucca Oil Storage	0.37	0.27	0.26	0.28	0.28	0.26	0.31
23	Building 650 Dosimetry	0.26	0.15	0.15	0.14	0.16	0.15	0.15
23	Building 650 Roof	0.25	0.14	0.15	0.14	0.16	0.14	0.14
23	Post Office	0.30	0.21	0.20	0.18	0.20	0.18	0.18
25	HENRE Site	0.45	0.32	0.33	0.34	0.32	0.32	0.31
25	NRDS Warehouse	0.46	0.33	0.36	0.32	0.33	0.32	0.31
27	Cafeteria	0.46	0.33	0.33	0.34	0.37	0.34	0.35
Network Average		0.36	0.25	0.25	0.25	0.26	0.24	0.25

Table 4.12 Gross Alpha Results for the Offsite Air Surveillance Network - 1999

Sampling Location	Number	Concentration (10^{-15} µCi/mL [37 µBq/m^3]) Maximum	Minimum	Mean	Standard Deviation
Alamo	52	7.6	0.1	2.6	1.7
Amargosa Center	52	4.7	0.2	1.5	0.9
Beatty	51	7.6	0.9	2.5	1.6
Boulder City	52	5.5	0.0	1.8	1.1
Caliente	49	5.2	0.3	1.9	1.0
Cedar City	49	7.6	0.9	3.4	1.5

Mean MDC = 7.6 x 10^{-16} µCi/mL   Standard Deviation of Mean MDC = 2.3 x 10^{-16} µCi/mL

Table 4.12 (Gross Alpha Results for the Offsite Air Surveillance Network - 1999, cont.)

Sampling Location	Concentration (10^{-15} µCi/mL [37 µBq/m^3]) Number	Maximum	Minimum	Mean	Standard Deviation
Delta	51	6.4	0.5	1.8	1.1
Goldfield	52	6.6	0.2	2.3	1.9
Henderson	50	9.5	0.8	2.8	1.7
Indian Springs	51	5.4	-0.1	1.4	0.9
Las Vegas	51	4.9	0.4	1.7	1.0
Milford	51	7.0	0.6	2.3	1.3
Overton	52	5.3	0.2	2.6	1.3
Pahrump	51	3.2	0.3	1.3	0.6
Pioche	45	3.0	-0.2	1.3	0.8
Rachel	52	5.3	-0.4	2.0	1.2
St. George	51	10.5	0.6	3.2	2.2
Stone Cabin	51	7.6	0.2	2.4	1.2
Tonopah	52	8.2	0.4	2.2	1.7
Twin Springs	52	5.5	0.3	1.9	1.2

Mean MDC = 7.6 x 10^{-16} µCi/mL Standard Deviation of Mean MDC = 2.3 x 10^{-16} µCi/mL

Table 4.13 Gross Beta Results for the Offsite Air Surveillance Network - 1999

Sampling Location	Concentration (10^{-14} µCi/mL [0.37 mBq/m^3]) Number	Maximum	Minimum	Mean	Standard Deviation
Alamo	52	2.8	0.5	1.4	0.4
Amargosa Center	52	3.5	0.3	1.5	0.6
Beatty	51	3.4	0.5	1.7	0.6
Boulder City	52	4.3	0.7	1.6	0.7
Caliente	49	5.2	0.1	1.9	0.8
Cedar City	49	2.7	0.4	1.5	0.4
Clark Station	51	3.0	0.4	1.6	0.5
Delta	51	3.9	0.2	1.7	0.7
Goldfield	52	2.8	0.3	1.4	0.5
Henderson	50	3.0	0.8	1.6	0.4
Indian Springs	51	2.6	-0.2	1.5	0.5
Las Vegas	51	2.6	0.5	1.5	0.5
Milford	51	4.1	0.3	1.8	0.8
Overton	52	3.4	0.5	1.7	0.6
Pahrump	51	2.5	0.6	1.5	0.3
Pioche	45	3.1	0.6	1.6	0.5
Rachel	52	3.2	-0.1	1.6	0.6
St. George	51	3.8	0.2	1.7	0.7
Tonopah	52	2.4	0.5	1.3	0.4
Warm Springs	52	3.5	0.2	1.7	0.7

Mean MDC = 2.41 x 10^{-15} µCi/mL Standard Deviation of Mean MDC = 0.31 x 10^{-15} µCi/mL

Table 4.14 Plutonium Results for the Offsite Hi-Volume Air Surveillance Network - 1999

^{238}Pu Concentration (10^{-18} μCi/mL)

Sampling Location	Number	Maximum	Minimum	Mean	Standard Deviation	%DCG[a]
Alamo	12	0.40	-0.06	0.15	0.16	[b]
Amargosa Center	9	0.18	0.00	0.07	0.07	[b]
Goldfield	11	0.38	-0.11	0.11	0.17	[b]
Las Vegas	11	0.19	-0.07	0.06	0.08	[b]
Rachel	12	1.1	0.01	0.33	0.30	[b]
Tonopah	12	0.21	-0.07	0.06	0.09	[b]

Mean MDC = 0.40 x 10^{-18} μCi/mL   Standard Deviation of Mean MDC = 0.17 x 10^{-18} μCi/mL

(a) Derived Concentration Guide; Established by DOE Order as 2 x 10^{-15} μCi/mL.
(b) Not applicable, result less than MDC.
Note: To convert μCi/mL to Bq/m^3 multiply by 3.7 x 10^{10} (e.g., [0.43 x 10^{-18}] x [3.7 x 10^{10}] = 52 nBq/m^3).

$^{239+240}$Pu Concentration (10^{-18} μCi/mL)

Sampling Location	Number	Maximum	Minimum	Mean	Standard Deviation	%DCG[a]
Alamo	6	7.0	0.28	1.6	1.8	0.05
Amargosa Center	9	3.2	0.54	1.7	0.92	0.06
Goldfield	11	2.6	0.44	1.1	0.75	0.04
Las Vegas	11	9.1	0.17	1.5	2.6	0.05
Rachel	12	52	0.12	7.7	14	0.26
Tonopah	12	1.5	-0.05	0.64	0.51	0.02

Mean MDC = 0.44 x 10^{-18} μCi/mL   Standard Deviation of Mean MDC = 0.20 x 10^{-18} μCi/mL

(a) Derived Concentration Guide; Established by DOE Order as 3 x 10^{-15} μCi/mL.
Note: To convert μCi/mL to Bq/m^3 multiply by 3.7 x 10^{10} (e.g., [1.4 x 10^{-18}] x [3.7 x 10^{10}] = 52 nBq/m^3).

Table 4.15 TLD Monitoring Results for Offsite Stations - 1999

Station Name	Daily Exposure (mR) Min	Max	Mean	Total (mR) Exposure
Alamo, NV	0.20	0.42	0.29	106
Amargosa Center, NV	0.18	0.35	0.26	95
Beatty, NV	0.23	0.44	0.33	119
Blue Jay, NV	0.26	0.54	0.36	113
Boulder City, NV	0.17	0.38	0.24	88
Caliente, NV	0.19	0.43	0.30	109
Cedar City, UT	0.15	0.34	0.24	87
Complex I, NV	0.22	0.52	0.30	109
Coyote Summit, NV	0.28	0.58	0.38	137
Delta, UT	0.17	0.38	0.27	100
Furnace Creek, CA	0.16	0.28	0.05	18
Goldfield, NV	0.20	0.42	0.29	107
Groom Lake, NV	0.18	0.44	0.27	97
Henderson (CCSN), NV	0.20	0.36	0.27	99
Hiko, NV	0.15	0.35	0.23	84
Indian Springs, NV	0.16	0.35	0.23	84

Table 4.15 (TLD Monitoring Results for Offsite Stations - 1999, cont.)

Station Name	Daily Exposure (mR) Min	Max	Mean	Total (mR) Exposure
Las Vegas, NV (UNLV)	0.13	0.26	0.13	46
Lund, NV	0.21	0.52	0.30	110
Lund, UT	0.22	0.46	0.34	125
Medlins Ranch, NV	0.23	0.52	0.35	127
Mesquite, NV	0.15	1.82	0.22	80
Milford, UT	0.24	0.50	0.35	129
Moapa, NV	0.19	0.37	0.28	102
Nyala, NV	0.17	0.42	0.27	99
Overton, NV	0.15	0.34	0.22	79
Pahrump, NV	0.12	0.25	0.18	65
Pioche, NV	0.18	0.44	0.27	97
Queen City Summit, NV	0.29	0.66	0.40	147
Rachel, NV	0.23	0.49	0.35	127
Sacorbatus Flats, NV	0.23	0.49	0.35	128
St. George, UT	0.13	0.28	0.20	72
Stone Cabin, NV	0.03	0.54	0.33	120
Sunnyside, NV	0.16	0.37	0.24	87
Tonopah Test Range, NV	0.25	0.55	0.37	135
Tonopah, NV	0.24	0.58	0.36	131
Twin Springs, NV	0.24	0.43	0.34	125
Uhaldes Ranch, NV	0.11	0.51	0.17	62
Warm Springs No. 1, NV	0.20	0.43	0.24	86

Table 4.16 TLD Monitoring Results for Offsite Personnel - 1999

Personnel ID No.	Associated Station Name	Number of Days	Daily Deep Dose Exposure (mrem) Min	Max	Mean	Total Annual Exposure
022	Alamo, NV	274	0.20	0.35	0.28	102
038	Beatty, NV	274	0.40	0.56	0.48	175
293	Pioche, NV	274	0.18	0.26	0.22	80
344	Delta, UT	274	0.28	0.29	0.28	102
345	Delta, UT	274	0.27	0.47	0.36	132
346	Milford, UT	274	0.25	0.46	0.35	128
347	Milford, UT	274	0.21	0.46	0.35	128
348	Overton, NV	274	0.20	0.36	0.27	99
427	Alamo, NV	274	0.21	0.36	0.29	106
592	Rachel, NV	183	0.14	0.14	0.14	51
593	Cedar City, UT	274	0.21	0.33	0.26	95
595	Las Vegas, NV	274	0.14	0.30	0.23	84
596	Las Vegas, NV	274	0.11	0.28	0.22	80
607	Tonopah, NV	274	0.37	0.50	0.43	157
608	Logandale, NV	274	0.18	0.33	0.25	91
610	Caliente, NV	274	0.34	0.41	0.37	135
621	Indian Springs, NV	274	0.17	0.31	0.24	88
655	Boulder City, NV	274	0.25	0.33	0.28	102
656	Henderson, NV	274	0.23	0.42	0.30	110

Table 4.17 Summary of Gamma Exposure Rates as Measured by PIC - 1999

Station	Max	Min	Standard Deviation	Average	mR/yr
	Gamma Exposure Rate (µR/hr)				
Alamo	14.5	10.4	0.51	12.5	110
Amargosa	14.7	6.5	0.58	10.7	94
Beatty	19.6	15.3	0.35	16.3	143
Boulder City	15.0	10.7	0.26	11.4	100
Caliente	16.9	13.4	0.45	14.5	127
Cedar City	14.0	8.6	0.34	9.7	85
Complex I	No data - discontinued in fall of 1998				
Delta	14.3	10.0	0.57	11.6	102
Furnace Creek	No data - discontinued in fall of 1998				
Henderson	16.1	12.2	0.31	13.2	116
Goldfield	21.6	13.5	0.54	15.2	133
Indian Springs	14.9	9.9	0.48	11.1	97
Las Vegas	10.8	8.9	0.22	9.6	84
Medlin's	No data - discontinued in fall of 1998				
Milford	19.8	14.6	0.62	17.2	151
Nyala	No data - discontinued in fall of 1998				
Overton	11.3	6.5	0.56	9.0	79
Pahrump	14.5	5.5	0.35	8.2	72
Pioche	No data - discontinued in fall of 1998				
Rachel	22.8	14.5	0.63	16.6	146
St. George	10.4	7.5	0.37	8.3	73
Stone Cabin	No data - discontinued in fall of 1998				
Terrel's	No data - discontinued in fall of 1998				
Tonopah	19.4	15	0.80	17.3	152
Twin Springs	No data - discontinued in fall of 1998				
Uhalde's	No data - discontinued in fall of 1998				

Table 4.18 BN Offsite Boundary Monitoring Data - 1999

Station ID No.	Description	1st Qtr (mR)	2nd Qtr (mR)	3rd Qtr (mR)	4th Qtr (mR)	1999 (mR)
	North Las Vegas Facility					
LV-100	North Fence of Bldg. A-1	12.4	14.4	15.3	19.5	61.6
LV-101	North Fence of Bldg. A-1	12.4	14.9	14.8	19.8	61.9
LV-C1	Control	7.95	9.79	11.6	15.8	45.1
LV-C2	Control	8.25	10.4	11.0	16.0	45.7
	Special Technologies Laboratory					
ST-122	Bldg. 5540, Room 117, CF Well	17.0	(b)	(b)	(b)	(c)
ST-123	Bldg. 5540, Room 114, North Wall	16.7	(b)	(b)	(b)	(c)

Table 4.18 (BN Offsite Boundary Monitoring Data - 1999, cont.)

Station ID No.	Description	1st Qtr (mR)	2nd Qtr (mR)	3rd Qtr (mR)	4th Qtr (mR)	1999 (mR)
			Special Technologies Laboratory (cont.)			
ST-124	Bldg. 5540, Room 114, North Wall	16.4	(b)	(b))	(b)	(c)
ST-125	Bldg. 5540, Room 114, East Wall	17.8	(b)	(b)	(b)	(c)
ST-126	Bldg. 5540, Room 114, East Wall	19.0	(b)	(b)	(b)	(c)
ST-127	Bldg. 5540, Room 114, East Wall	19.0	(b)	(b)	(b)	(c)
ST-128	Bldg. 5540, Corridor Ceiling, Room 110	16.7	(b)	(b)	(b)	(c)
ST-129	Bldg. 5540, Corridor Ceiling, Room 110	16.4	(b)	(b)	(b)	(c)
ST-130	Bldg. 5540, Corridor Ceiling, Room 110	16.7	(b)	(b)	(b)	(c)
ST-131	Bldg. 5540, Room 117, East Wall	18.4	(b)	(b)	(b)	(c)
ST-132	Bldg. 5540, Room 117, East Wall	18.7	(b)	(b)	(b)	(c)
ST-133	Bldg. 5540, Room 117, East Wall	18.4	(b)	(b)	(b)	(c)
ST-134	Bldg. 5540, Room 114, Overhead	17.0	(b)	(b)	(b)	(c)
ST-135	Bldg. 5540, Room 114, Overhead	17.5	(b)	(b)	(b)	(c)
ST-136	Bldg. 5540, Room 114 Overhead	17.5	(b)	(b)	(b)	(c)
ST-137	Bldg. 5540, Room 114, CF Well&Vaults	21.1	20.2	(a)	19.2	60.5(d)
ST-141	Bldg. 227, Rear on Fence	21.4	18.7	(a)	24.8	64.9(d)
ST-199	Bldg. 229-C, Left Side of Sliding Gate	18.4	17.8	(a)	24.0	60.2(d)
ST-200	Bldg. 229-C, Left Side of Sliding Gate	18.4	18.6	(a)	23.6	60.6(d)
ST-209	Bldg. 227, Behind CF Shed	17.0	16.9	(a)	22.2	56.1(d)
ST-210	Bldg. 227, Behind CF Shed	17.8	16.9	(a)	22.0	56.7(d)
ST-215	Bldg. 228, Crime Lab Window Sill	15.8	15.4	(a)	22.0	53.2(d)
ST-216	Bldg. 228, Crime Lab Window Sill	17.3	16.0	(A)	22.0	55.3(d)
ST-C1	Control 1	13.4	13.6	(a)	17.5	44.5(d)
ST-C2	Control 2	12.8	14.2	(a)	16.3	43.3(d)

(a) Results lost due to procedural error.
(b) Station terminated.
(c) Annual sum not possible due to missing quarterly results.
(d) Sum of only three quarters.

5.0 WATER SURVEILLANCE ACTIVITIES

The Nevada Test Site (NTS) has a history of underground nuclear testing and continues to operate radioactive waste storage sites, environmental restoration sites, and a hazardous material testing facility. Groundwater surveillance is particularly important because of the potential for groundwater contamination from some of these activities and the scarcity of water supplies in this desert region. The water surveillance program includes a combination of effluent controls, groundwater protection, monitoring, restoration, and permit compliance. Groundwater quality monitoring is conducted both onsite and offsite by Bechtel Nevada (BN) for the Routine Radiological Environmental Monitoring Plan (RREMP) and the U.S. Environmental Protection Agency's (EPA's) Radiation & Indoor Environments National Laboratory-Las Vegas (R&IE-LV) for the Long Term Hydrological Monitoring Program (LTHMP). In 1999, there was a transition from the LTHMP to the RREMP (DOE 1998a). Results from both programs are reported for 1999.

Groundwater quantity monitoring continues to be conducted by the U.S. Geological Survey (USGS) and BN. No significant water level changes were detected associated with groundwater pumping, and water usage on the NTS continued to decline. The NTS potable water supply system continues to be free of any detectable man-made radionuclides.

The Nevada Environmental Restoration Project (ERP) goals are to safeguard the public's health and safety and to protect the environment. This involves the assessment and cleanup of contaminated sites and facilities to meet standards required by federal and state environmental laws. In 1996, the U.S. Department of Energy Nevada Operations Office (DOE/NV) formalized an agreement with the state for implementing corrective actions based on public health and environmental considerations in a cost-effective and cooperative manner. Investigation and cleanup activities continued on the NTS and the adjacent Nellis Air Force Range. Particular emphasis was directed at the Pahute Mesa, and Oasis Valley (adjacent offsite) areas.

Beginning in 1999, activities at non-NTS sites in other states including the two in Central Nevada (SHOAL and FAULTLESS sites) will not be reported in the NTS Annual Site Environmental Report (ASER). These monitoring and remedial activities will be addressed in separate reports (e.g. the "Annual Water Sampling and Analysis Calendar Year 1999", Davis 1999, available from R&IE-LV). The term "offsite" in this ASER will refer to adjacent, or proximal areas to the NTS. Also included in this ASER are the administratively related North Las Vegas Facility (NLVF) and the Remote Sensing Laboratory (RSL) at Nellis Air Force Base in North Las Vegas.

5.1 WATER MONITORING PROGRAM INFORMATION

Water monitoring activities conducted in the past on the NTS and related facilities involve surveillance of surface and groundwaters, drinking water systems, sewage treatment ponds, and actions protective of groundwater resources. During 1999, the sampling of onsite surface waters (reservoirs and natural springs) was terminated in accordance with the "Routine Radiological Environmental Monitoring Plan", published in December 1998 (DOE 1998a). The past concentrations of radionuclides in the reservoirs have consistently been below the Derived Concentration Guides (DCGs), and the supply wells, the source of water for the reservoirs, are routinely sampled. Likewise, the radionuclide concentrations in samples of spring water have also been consistently below the DCGs, and none of the onsite springs are hydrologically connected to the aquifers that may have been radioactively contaminated by underground nuclear tests.

REGULATORY DRIVERS FOR ONSITE ENVIRONMENTAL MONITORING

DOE Order 5400.1, "General Environmental Protection Program," establishes environmental protection program requirements, responsibilities, and authorities for DOE operations. These mandates require compliance with applicable federal, state, and local environmental protection regulations. Other DOE directives applicable to environmental monitoring include 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." Nevada Administrative Code (NAC) 445A.453 - 445A.459 “Public Water Systems” provides standards for sampling and monitoring of potable water systems.

WATER EFFLUENT MONITORING

Radiologically contaminated water continued to be discharged from E Tunnel in Rainier Mesa (Area 12) despite efforts to seal that tunnel. A grab sample was collected quarterly from the tunnel's effluent discharge point and from the tunnel's containment pond. These samples were analyzed for tritium (^{3}H), gross alpha, gross beta, ^{238}Pu, $^{239+240}Pu$, and gamma emitters. In addition, one quarterly sample was analyzed for ^{90}Sr, and one quarterly sample was analyzed for ^{137}Cs. Tritium was the radionuclide most consistently detected at the tunnel sites. Other radionuclides were detected at lower concentrations. Flow data obtained from the Defense Threat Reduction Agency (formerly the Defense Special Weapons Agency) were used to calculate the total volume discharged. Annual average radioactivity concentrations were calculated from the quarterly measurements. From these, the total amount of radioactivity in the effluent was obtained.

Seven new wells were drilled in the vicinity of the NTS during 1999 (one onsite and six offsite, located just west of the NTS). Water pumped from the wells during drilling and to obtain characterization water samples was discharged into lined and/or unlined containment ponds depending upon proximity to source areas (e.g., on Pahute Mesa). No man-made radionuclides were detected in the drilling or predevelopement characterization fluids produced from these wells.

WATER ENVIRONMENTAL MONITORING

Environmental monitoring was conducted onsite throughout the NTS and the near offsite area. Groundwater samples were routinely collected at preestablished locations and analyzed for radioactivity.

Water samples were collected from selected potable tap water points, water supply wells, monitoring wells, sewage lagoons, and containment ponds. The frequency of collection and types of analyses done for these types of samples are shown in Tables 5.1, 5.2, 5.3, and 5.4. Sampling locations are shown on Figures 5.1 (supply wells), 5.2 (surface water), and 5.3 (monitoring wells).

5.2 NTS HYDROLOGICAL MONITORING PROGRAMS

Until implementation of the LTHMP in 1972, monitoring of ground and surface waters was done by the U.S. Public Health Service,

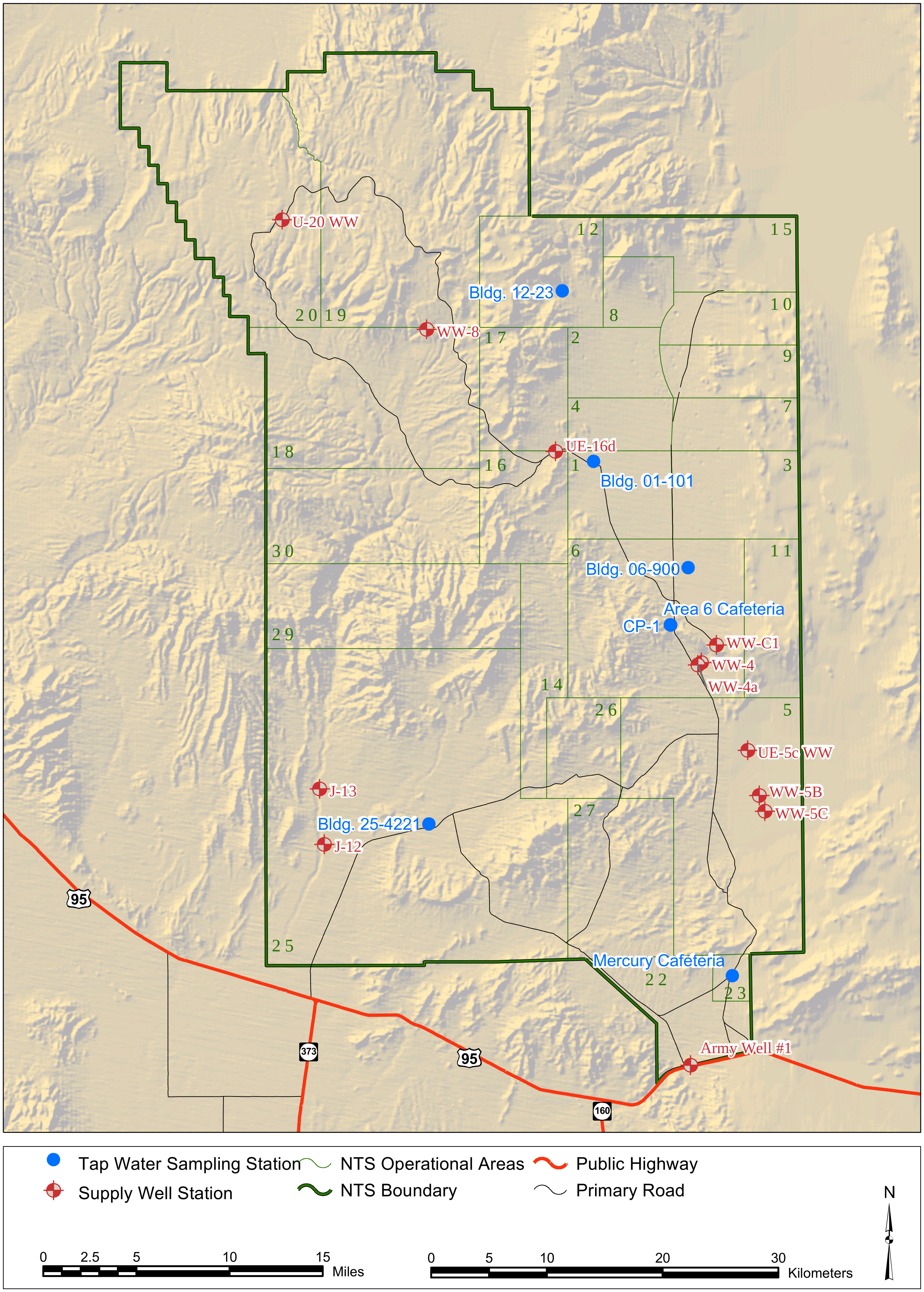


Figure 5.1 Supply Well and Potable Water Sampling Stations on the NTS - 1999

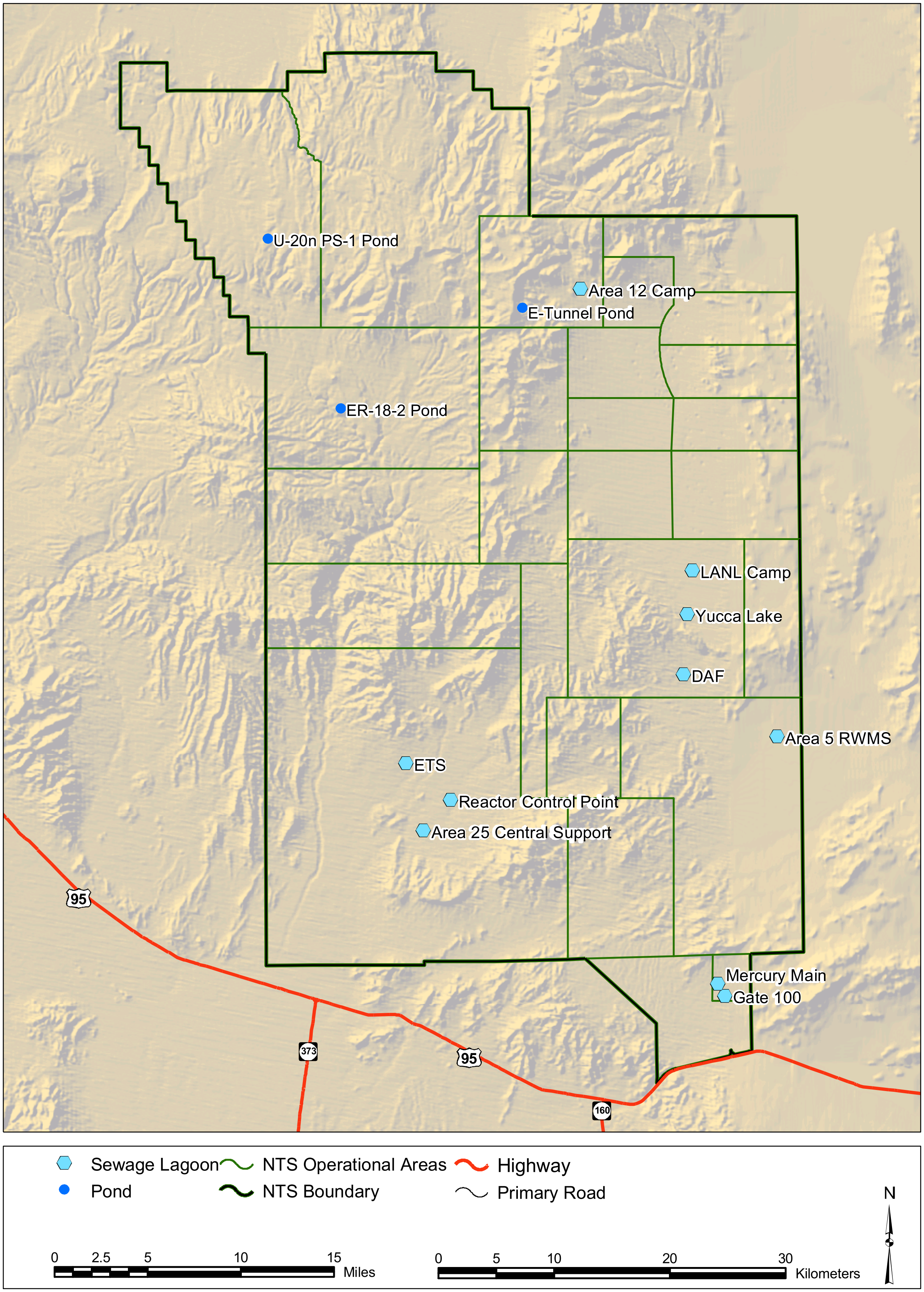


Figure 5.2 Surface Water Sampling Locations on the NTS - 1999

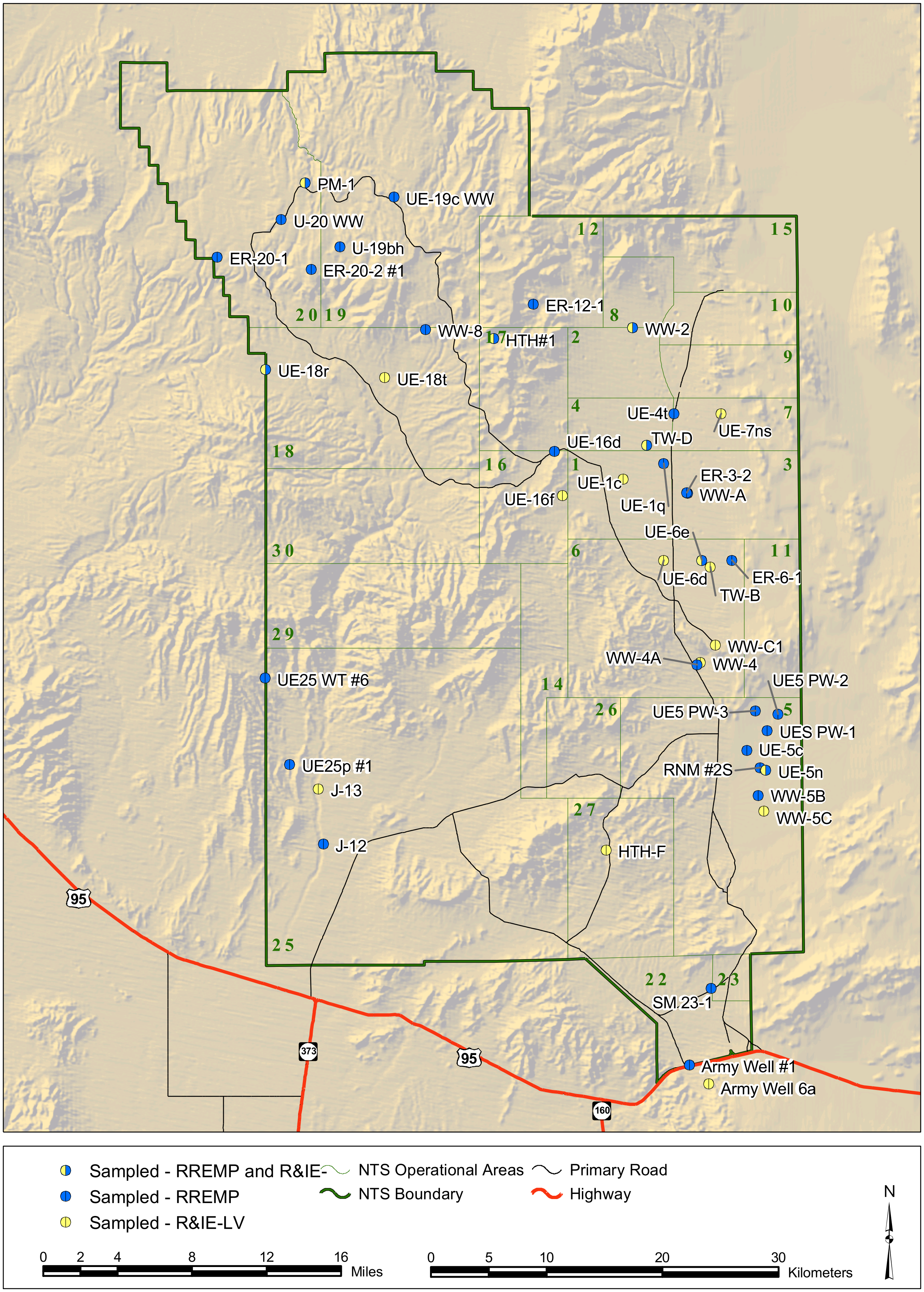


Figure 5.3 NTS Groundwater Radiological Monitoring Sites (RREMP, R&IE-LV) - 1999

the USGS, and the U.S. Atomic Energy Commission contractor organizations. The EPA's R&IE-LV has been responsible for operation of the LTHMP. In 1998, BN was tasked by the DOE/NV to establish and manage the NTS RREMP, a single integrated and comprehensive monitoring program. In 1999, there was a transition from the LTHMP to the RREMP (DOE 1998a). A brief summary of each program is provided below.

LONG-TERM HYDROLOGICAL MONITORING PROGRAM (LTHMP)

The EPA's R&IE-LV is responsible for operation of the LTHMP, including sample collection, analysis, and data reporting. The LTHMP consists of routine radiological monitoring, analysis, and reporting of samples collected from specific wells on the NTS and of wells, springs, and surface waters in the offsite area around the NTS.

The present R&IE-LV sampling locations on the NTS, or immediately outside its borders on federally owned land are shown in Figure 5.3. All sampling locations are selected by DOE and primarily represent potable water supplies. R&IE-LV samples onsite wells without pumps and, for quality assurance purposes, collects samples from some potable wells sampled by BN. In 1999, a total of 21 onsite wells was sampled in support of the LTHMP. All samples were analyzed by gamma spectrometry and for tritium.

Summaries of the 1999 sampling results for the onsite sampling program are provided in Section 5.5.

SAMPLING AND ANALYSIS PROCEDURES

The procedures for the analysis of water samples, used by EPA's R&IE-LV, are described by Johns et al., 1979 and are summarized in Table 5.1. These include gamma spectral analysis and radiochemical analysis for tritium. The procedures are based on a standard methodology for the stated analytical procedures. Two methods for tritium analysis were performed; these were conventional and electrolytic enrichment. The samples were initially analyzed for tritium by the conventional method followed by enrichment analysis if the results were less than 800 pCi/L (30 Bq/L). In late 1995, it was decided that only 25 percent of the samples would be analyzed by the electrolytic enrichment method. The samples selected for enrichment are from locations that are in position to show possible migration. Two 500-mL glass bottles and a 1-gal plastic container are filled at each sampling location. At the sample collection sites, the pH, conductivity, water temperature, and sampling depth are measured and recorded when the sample is collected. For wells with operating pumps, the samples were collected at the nearest convenient outlet. If the well has no pump, a truck-mounted sampling unit is used. With this unit, it is possible to collect 3-L samples from wells as deep as 1,800 m (5,900 ft).

When these locations were sampled for the first time, the samples were analyzed for ^{89,90}Sr, ^{238}Pu, $^{239+240}$Pu, and uranium isotopes in addition to the analyses mentioned above. The 500-mL samples were analyzed for tritium and the 1-gal sample from each site was analyzed by gamma spectrometry.

GROUNDWATER NEAR THE NEVADA TEST SITE

Water sampling around the NTS is conducted by R&IE-LV under an interagency agreement with DOE to ensure the radiological safety of public drinking water supplies, and representative water sources of rural residents and, where suitable, to monitor any migration of radionuclides from the NTS. This water monitoring is conducted within the LTHMP. R&IE-LV personnel routinely collect and analyze water samples from locations in the offsite areas surrounding the NTS. Due to the scarcity of surface waters in the region, most of the samples are groundwater, collected from existing wells. Samples from specific locations are collected monthly, biannually, annually, or biennially in accordance with a preset schedule. Many drinking water supplies used by the offsite population are represented in the LTHMP samples. A total of 23 offsite wells and springs were sampled by the R&IE-LV in support of the LTHMP during 1999. Figure 5.4 is a map of the locations sampled.

ROUTINE RADIOLOGICAL ENVIRONMENTAL MONITORING PLAN

Environmental monitoring has been conducted on and near the NTS by the DOE, through various agencies, for over forty years. Environmental measurements were made at first to determine the extent of contamination for the protection of operations and workers. Later, monitoring was expanded as needed to comply with state and federal regulations and permit requirements, and to address stakeholder issues regarding radiation contamination as a result of DOE activities. The DOE recently conducted a review of environmental monitoring at the NTS, taking into consideration all the media being monitored (air, vadose zone, water, and biota) by several different organizations, and as a result redesigned the entire program. The resulting RREMP is a single integrated and comprehensive monitoring program.

BN was tasked by the DOE/NV to establish and manage the NTS RREMP. Among the existing environmental monitoring programs incorporated into the RREMP are the LTHMP, and environmental monitoring operations by single programs or agencies, including the USGS, EPA, Joint Testing Organization, the DOE/NV Underground Testing Area (UGTA) project, and others. The RREMP remains a multi-organizational program; however, the RREMP provides for centralized management and reporting. Goals of the RREMP initiative include optimizing efficiency and reducing duplication, thereby minimizing costs while continuing to meet all regulatory, health and safety, and environmental obligations.

SURFACE WATER SAMPLING SITES

The surface water sample locations in the RREMP on the NTS include the E Tunnel containment ponds and nine sewage lagoons (Figure 5.2). Offsite locations include 12 natural springs. The criteria for selection was based on the monitoring objectives described in Section 1.3.1 of the RREMP (DOE 1998a). Water sources were selected for monitoring if they had the potential for exposing the public, onsite biota, or the environment to significant levels of radionuclides, or if they required monitoring under an existing State discharge permit.

All surface water samples are analyzed for tritium and gamma emitters. At selected locations and, at all new locations where a hydrochemical baseline does not exist, the analysis are expanded to include gross beta and gross alpha emissions, tritium (by the enrichment method), ^{238}Pu, $^{239+240}$Pu, and ^{90}Sr. In addition, flow rate at the springs, at the time of the sampling, will be measured, if feasible.

Surface water from onsite containment ponds and sewage lagoons will be sampled and analyzed quarterly for all contaminants listed above except ^{90}Sr, which will be checked only once a year. Offsite spring water will be sampled and analyzed for tritium semiannually, triennially, or annually depending upon proximity to the NTS and relation to groundwater flow paths. The initial samples at new locations will be analyzed for a wider suite of radioactive contaminants, including tritium (by the enrichment method), as well as standard water properties such as hydrogen ion concentration (pH), and conductivity, and hydrochemistry (alkalinity, bicarbonate, and principal anions/cations) to establish a

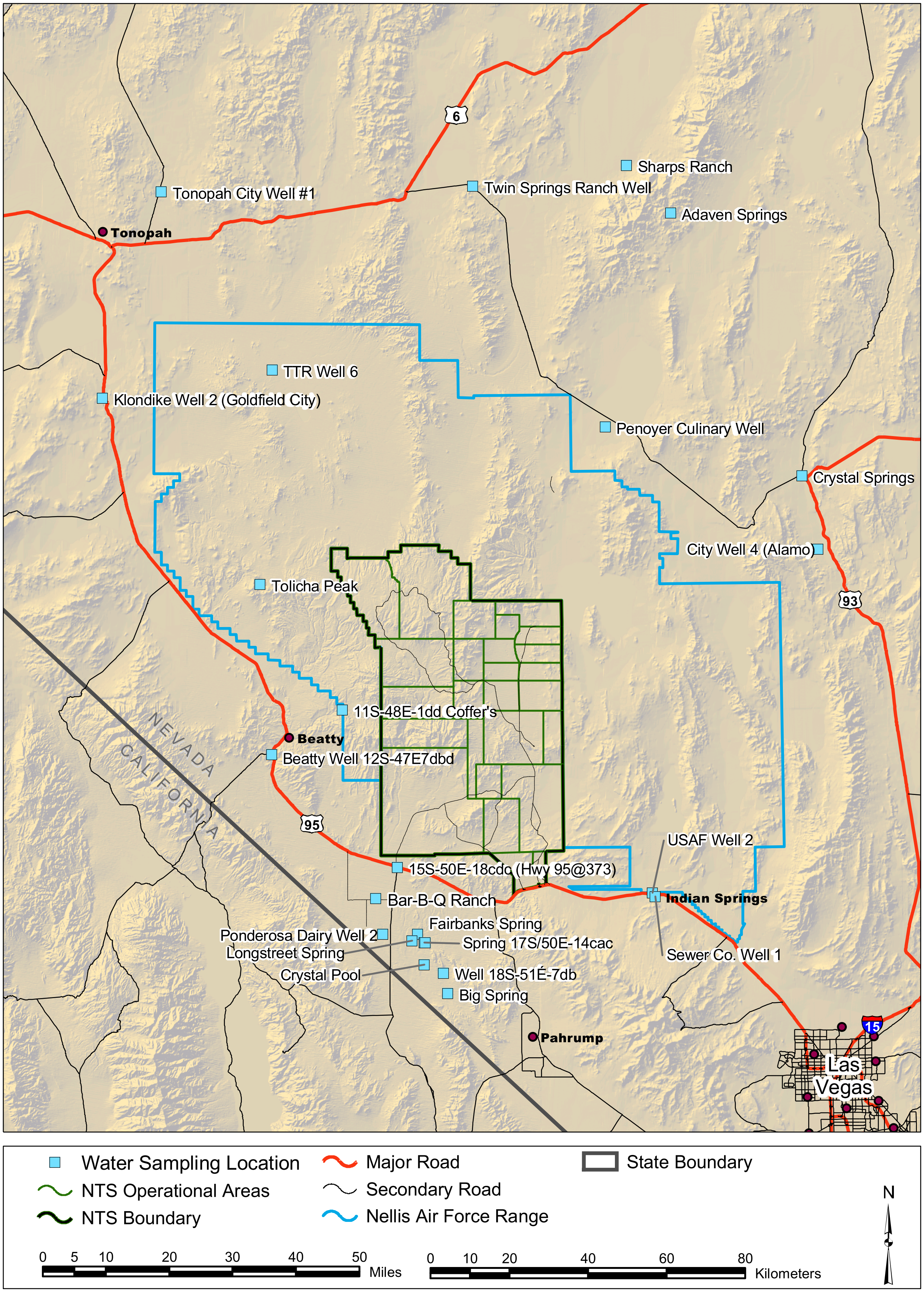


Figure 5.4 Wells and Springs Outside the NTS Included in the LTHMP - 1999

baseline. This sampling plan is summarized in Table 5.3. Sampling will not occur as scheduled if there is insufficient water at a site (e.g., the springs) to obtain a sample.

GROUNDWATER SAMPLING

Unless regulatory changes in permit conditions occur, the parameters and the action levels for the monitoring of the water supply wells and the permitted facilities on the NTS will remain the same. The parameter of interest for the routine radiological monitoring of groundwater is tritium. The action level for tritium is 10 percent of the drinking water standard. The standard method for tritium analysis, which can detect tritium at concentrations as low as 300 to 700 pCi/L, will be used at most wells. However, for wells in the southwestern offsite areas (Oasis Valley), and selected wells within corrective action units (CAUs), the enriched-tritium analysis method is used because tritium levels as low as 10 pCi/L can be detected with this method. Analyzing for tritium at all other offsite wells by the standard method is a cost-effective means of satisfying the program objectives. All wells will be sampled for the additional parameters as shown in Table 5.3.

Other water properties (e.g., pH, specific conductivity, principal anions and cations, etc.) will be measured at selected wells at the same time water samples for radiological analysis are collected. For example, at new monitoring wells which do not have previously established baseline data, water chemistry data will be collected during the first year of sampling. Also, at selected wells, it may be necessary to measure other water quality characteristics to confirm certain assumptions of radionuclide migration models for groundwater (e.g., confirm the existence of colloidal transport). These other properties are shown in Table 5.3 (see Type IV Analysis).

Sampling frequency for the wells in the proposed network will differ: water supply wells and wells near source areas will be sampled more frequently, and wells without established background data will be sampled more frequently for one year. Sampling frequencies of the wells are summarized in Table 5.3. The onsite groundwater monitoring wells included in the RREMP are shown in Figures 5.1 (onsite supply), and 5.3 (onsite monitoring wells).

DRINKING WATER CONSUMPTION ENDPOINTS

The drinking water network at the NTS consists of four separate systems, with seven consumption endpoints. Ten potable supply wells feed the four drinking water systems (Table 5.4). As a check on any effect the water distribution system might have on water quality, the seven water system endpoints (tap water) are sampled on a monthly (pre-fiscal year [FY] 1997), quarterly or annually (FY 1997) basis. No test-related radionuclides have been detected to date.

To support RREMP objectives and to demonstrate compliance with relevant regulations (e.g., Safe Drinking Water Act [SDWA], DOE Order 5400.5, and Nevada Revised Statutes 445A.361), the seven drinking water systems endpoints will continue to be sampled according to the schedule presented in Table 5.4. Distribution systems located within, or traversing, the historical testing areas will be sampled more frequently (quarterly), while the other systems will be sampled on an annual basis. The tap water samples will be analyzed annually for gamma emitters, gross alpha, gross beta, tritium (enriched method), ^{238}Pu, $^{239\text{-}240}$Pu, and ^{90}Sr.

ANALYTICAL PROCEDURES

Water samples collected for the RREMP are analyzed by BN's Analytical Services Laboratory. Analytical procedures used for water samples are briefly described here and also presented in Table 5.1. A 500-mL aliquot was taken from the water sample, placed in a plastic bottle, and counted for gamma activity with a germanium detector. A 2.5-mL aliquot was used for ^{3}H analysis by liquid scintillation counting. An 800-mL aliquot was evaporated to 15 mL, transferred to a stainless steel counting planchet, and evaporated to dryness after the addition of a wetting agent. Alpha and/or beta analyses were accomplished by counting the planchet samples for 100 minutes in a gas-flow proportional counter.

Tritium enrichment analyses were done on samples from the water supply wells by concentrating the volume and tritium content of a 250-mL sample aliquot to 10 mL by electrolysis of a basic solution and analyzing a 5-mL portion of the concentrate by liquid scintillation counting.

The ^{226,228}Ra concentrations were determined from low-background gamma spectrometric analyses of radium sulfate precipitates. The samples were prepared by adding a barium carrier and ^{225}Ra tracer to 800 mL of a sample, precipitating the barium and radium as a sulfate, separating the precipitate, and analyzing it by counting for 500 minutes in a low-level gamma spectroscopy facility.

The radiochemical procedure for plutonium was similar to that described in Chapter 4. Alpha spectroscopy was used to measure any ^{238}Pu, $^{239+240}$Pu, and the ^{242}Pu tracer present in the samples.

5.3 GROUNDWATER PROTECTION PROGRAM

HYDROGEOLOGY OF THE NTS

The NTS has three general water-bearing units: the lower carbonate aquifer, volcanic aquifers, and valley-fill aquifers. The water table occurs variably in the latter two units, while groundwater in the lower carbonate aquifer occurs under confined conditions. The depth to the saturated zone is highly variable, but is generally at least 210 m (approximately 690 ft) below the land surface (e.g. in Frenchman Flat) and is often more than 457 m (approximately 1,500 ft) (e.g. in Yucca Flat). The hydrogeologic units at the NTS occur in three groundwater subbasins in the Death Valley Groundwater Basin (see Chapter 2, Figure 2.7, for a diagram of these systems). The actual subbasin boundaries are poorly defined, but what is known about the basin hydrology is summarized below.

Groundwater beneath the eastern part of the NTS is in the Ash Meadows Subbasin and discharges along a spring line in Ash Meadows, south of the NTS (Waddell et al., 1984). Most of the western NTS is in the Alkali Flat-Furnace Creek Subbasin, with discharges occurring by evapotranspiration at Alkali Flat and by spring flow near Furnace Creek Ranch (Laczniak et al., 1996).

Groundwater beneath the far northwestern corner of the NTS may be in the Oasis Valley Subbasin, which discharges by evapotranspiration in Oasis Valley. Some underflow from the subbasin discharge areas probably travels to springs in Death Valley. Regional groundwater flow is from the upland recharge areas in the north and east toward discharge areas in Ash Meadows and Death Valley, southwest of the NTS. Because of large topographic changes across the area and the importance of fractures to groundwater flow, local flow directions may be radically different from the regional trend (Laczniak et al., 1996).

NTS AREAS OF POSSIBLE GROUNDWATER CONTAMINATION

In 1996, DOE/NV confirmed the location of 828 underground tests at the NTS that are included in areas of possible groundwater contamination as indicated on Figure 5.5. Approximately one third (259) of these tests were at or below the water table (DOE 1996b). The principal by-products from these tests were heavy metals and a wide variety of radionuclides with differing half-lives and decay products. Detonations within, or near, the regional water table have contaminated the local groundwater with

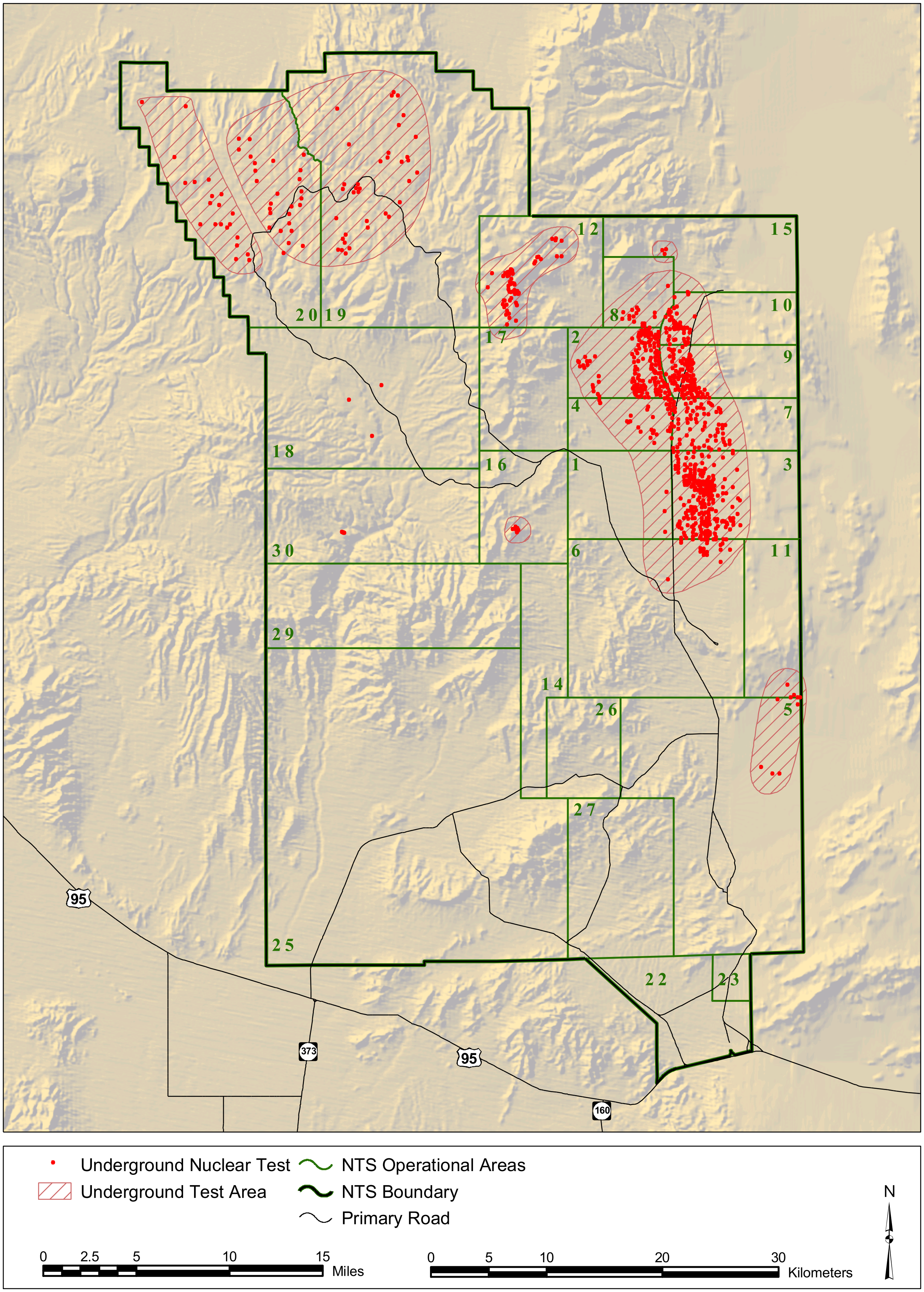


Figure 5.5 Areas of Potential Groundwater Contamination on the NTS

over 60 radionuclides, totaling 300 million curies, being in or near the water table with tritium being the most abundant (DOE 1996c).

Surface activities associated with underground testing and other NTS activities such as disposal of low-level radioactive waste (LLW) and mixed wastes, spill testing of hazardous liquefied gaseous fuels, and transport of radioactive materials, also pose potential soil and groundwater contamination risks. The types of possible contaminants found on the surface of the NTS include radionuclides, organic compounds, metals, and residues from plastics, epoxy, and drilling muds. A wide variety of surface facilities, such as former injection wells, leach fields, sumps, waste storage facilities, tunnel containment ponds and muck piles, and storage tanks, may have contaminated the soil and shallow unsaturated zones of the NTS. The known sites are categorized by type and listed in Appendices II, III, and IV of the Federal Facility Agreement and Consent Order (FFACO) (FFACO 1996), agreed to by the DOE, U.S. Department of Defense (DOD), and Nevada Division of Environmental Protection (NDEP). The great depths to groundwater and the arid climate mitigate the potential for mobilization of surface and shallow subsurface contamination. However, contaminants entering the carbonate bedrock from Rainier Mesa tunnel ponds, contaminated wastes injected into deep wells, underground tests near the water table, and wastes disposed of into subsidence craters have the potential to reach groundwater.

ACTIVITIES PROTECTIVE OF GROUNDWATER

DOE/NV has instituted a policy regarding protection of the environment. This policy states: “A principal objective of the DOE/NV policy is to assure the minimization of potential impacts on the environment, including groundwater, from underground testing.” An ongoing program to monitor and assess the effectiveness of groundwater protection efforts will be enhanced so that resources are allocated based on current understanding of the effectiveness of groundwater protection programs. Groundwater protection activities contained within DOE/NV programs are described below.

STORM WATER RUN-OFF

Storm water, at the NTS, primarily follows the natural terrain and after a large storm will temporarily collect on low spots, including dry lake beds (playas). With the great depth to groundwater at the NTS, this occasional pooling of storm-water runoff presents no hazard to groundwater.

Storm water surveys were conducted on the NTS in March 1999. The U.S. Army Corps of Engineers provided data and maps gathered in October 1998 that indicated areas which could potentially contribute storm water to waters of the United States.

DOE/NV and contractor personnel teamed to conduct a thorough regulatory and physical assessment of storm water conditions to determine the need for National Pollution Discharge Elimination System permitting related to “discharges associated with industrial activity.” Of primary concern were activities located in the Frenchman and Yucca Lake drainages.

In a letter to the NDEP, Bureau of Federal Facilities (May 1999), the DOE/NV noted that evidence gathered substantiates and supports the position that there are no industrial activities at the NTS that impact waters of the United States.

WASTE MINIMIZATION AND POLLUTION PREVENTION AWARENESS PROGRAM

The Waste Minimization and Pollution Prevention Awareness Program is designed to reduce waste generation and possible pollutant releases to the environment, thus increasing the protection of employees and the public. All DOE/NV contractors and NTS users who exceed the EPA criteria for small-quantity generators have established implementation plans in accordance with DOE/NV requirements. Contractor programs ensure that waste minimization activities are in accordance with federal, state, and local environmental laws and regulations and DOE Orders. A discussion of 1999 activities is given in Chapter 6.

There are three closed-loop recirculating steam cleaning units that are used to clean equipment prior to servicing. These units not only minimize the water that is needed to operate, but also prevent the wastewater from running onto the ground and potentially contaminating the soil. Potential contaminants (primarily hydrocarbon materials) are instead captured in a filter and properly disposed of or recycled.

WASTE TREATMENT, STORAGE, AND DISPOSAL

DOE/NV currently operates disposal facilities in Areas 3 and 5 at the NTS for LLW generated by DOE and the DOD facilities. All hazardous wastes generated at the NTS are stored at a Hazardous Waste Accumulation Site in Area 5 until shipped offsite to EPA-approved commercial disposal facilities.

Since both the RWMS-3 and RWMS-5 disposal sites contain mixed as well as LLW waste, they are subject to Hazardous Waste regulations dictated by the Resource Conservation and Recovery Act (RCRA). In accordance with Title 40 Code of Federal Regulations (CFR) 265 - Subpart F (CFR 1984), operators of interim status treatment, storage, and disposal facilities for hazardous waste are required to collect quarterly samples for one year from one upgradient and three downgradient wells for characterization of groundwater quality. However, the lack of a hydraulic gradient in the uppermost aquifer makes it difficult to define upgradient and downgradient directions around RWMS-5 (BN 2000a). There are three groundwater monitoring wells surrounding the RWMS-5. In a letter from NDEP to DOE/NV, dated February 24, 1994, NDEP stated that there was no need to install additional wells pending future data on the groundwater gradient, thereby effectively substituting the three pilot wells for the standard four RCRA wells. At the RWMS-3, there are no facility-specific groundwater monitoring wells, because NDEP has approved the request for a groundwater monitoring waiver. At RWMS-5, sampling protocols for characterization and detection data collection were based on the RCRA Groundwater Monitoring Technical Enforcement Guidance Document (EPA 1986). Groundwater elevation was measured prior to each sampling event. The first collections of these characterization data were performed in 1993. Subsequent semi-annual sampling was continued through 1999 (BN 2000a), and results were statistically compared with the initial characterization data. No chemical or radiological constituents attributable to the DOE's weapons testing or waste disposal activities have been detected. The uppermost aquifer meets current water quality standards for drinking water sources. The analyses performed are shown in Table 5.5. Groundwater monitoring results for 1999 can be found in "1999 Annual Data Report: Groundwater Monitoring Program Area 5 Radioactive Waste Management Site" (BN 2000a).

At the NTS there are three nonhazardous waste landfills that have state of Nevada Operating Permits. The permitting process considers groundwater protection at these locations. At the Area 23 Class II Municipal and Industrial Solid Waste Disposal Site, there is no groundwater monitoring well. However, Well SM-23-1 described below is considered (informally) by the state as a supplement to vadose zone monitoring (VZM) at the landfill.

VADOSE ZONE MONITORING

A VZM strategy is being implemented at the RWMSs in conjunction with groundwater monitoring at RWMS-5, in support of the RWMS-5 and RWMS-3 Performance Assessments (PAs), and as proof of concept. VZM offers many advantages over groundwater monitoring including:

- providing critical assessment of facility performance.

- detecting potential problems long before the groundwater resource would be impacted.

- allowing corrective actions to be made early.
- differentiating the source of contamination (UGTA versus RWMS).

- eliminating the need to retrofit monitoring on existing waste cells using nearby sites.

- considerably less expensive than groundwater monitoring.

The primary objective of RWMS VZM is to support the assumptions made in the PAs and to measure water movement through the vadose zone. In addition, DOE Orders 5820.2A (DOE 1988) and 435.1 (435.1 will replace 5820.2A) require that monitoring provide data to evaluate the performance of a waste management operation.

The RWMS VZM strategy is to directly measure the water balance for an entire facility. This is accomplished by use of, meteorological data to measure precipitation and to calculate potential evapotranspiration (ET); weighing lysimeters to measure actual ET; neutron logging through access tubes; and automated soil water sensors to measure actual soil water content and water potential changes with time and over a large spatial coverage. This strategy provides an accurate estimate of downward drainage through the facilities and therefore, potential recharge. Based on the initial results of this strategy, as well as other work (Tyler et al., 1996), there is essentially zero recharge to the groundwater under current conditions at the RWMS-3 and RWMS-5, and all precipitation is effectively returned to the atmosphere by plant transpiration and soil evaporation (BN 2000b).

Soil water content is monitored at Pits 1 through 5 at RWMS-5 and is monitored under the U-3ah/at, U-3ax/bl, and U-3bh disposal units at RWMS-3. At the RWMS-5, monitoring is conducted using neutron moisture meters in access tubes penetrating the operational cover (approximately 8 ft), the waste zone (20 - 30 ft), and the vadose zone below the pit floor. No wetting fronts were observed to pass through the operational covers at the RWMS-5 in 1999. At the RWMS-3, soil water content monitoring is conducted in cased boreholes angled under the U-3ah/at and U-3ax/bl disposal units, and in cased boreholes drilled directly into the floor of the U-3bh disposal unit. Soil water content below the RWMS-3 remained unchanged in 1999.

Installation of automated VZM systems was initiated in 1998 with water content sensors (Total Domain Reflectometry Probes) buried beneath the floors of Pit 3 and 5 at the RWMS-5. Sensors for measurement of water content were installed in the operational cover of Pit 3 in 1999 to provide data on waste cell cover performance.

WELLHEAD RECONSTRUCTION AND WELL REHABILITATION

There was no wellhead rehabilitation work in 1999. However, all of the wells associated with the state permitted drinking water distribution systems at the NTS have been inspected by the state and meet current wellhead protection regulations.

SEWAGE LAGOON COMPLIANCE

State Water Pollution Control Permit GNEV93001 requires that one of four methods of groundwater protection be established at active sewage lagoons on the NTS by January 31, 1999. The four acceptable groundwater protection methods identified in the permit include groundwater monitoring, VZM, engineered liner installation, and hydrogeological site characterization.

In February and June of 1999, the Area 23 monitoring well sampling results were all below the limits listed in Appendix III of the general permit (GNEV93001).

5.4 ENVIRONMENTAL RESTORATION PROGRAM (ERP)

The Nevada ERP was begun in the late 1980s to address contamination resulting primarily from nuclear weapons testing and related support operations. The goals of the project are to safeguard the public's health and safety and to protect the environment. This involves the assessment and cleanup of contaminated sites and facilities to meet standards required by federal and state environmental laws. Approximately 828 sites used for historic underground nuclear tests will be investigated, along with areas where more than 100 aboveground tests were conducted. Additionally, 1,500 other sites that were used for support operations will potentially require environmental remediation.

The DOE/NV is working closely with representatives of the state of Nevada to ensure compliance with applicable environmental regulations. The 1996 FFACO provides a mechanism for implementing corrective actions based on public health and environmental considerations in a cost-effective and cooperative manner. It also establishes a framework for identifying, prioritizing, investigating, remediating, and monitoring contaminated DOE sites in Nevada. The FFACO's corrective action requirements supersede some portions of the NTS RCRA Permit issued in May 1995. Investigations and remediations follow a strategy for investigation and remediation outlined in Appendix VI, Corrective Action Strategy, of the FFACO. The strategy is based on four steps: (1) identifying corrective action sites, (2) grouping the sites into corrective action units, (3) prioritizing the units for funding and work, and (4) implementing investigations or actions as applicable. The sites are broadly organized into underground test area sites, industrial sites, soil sites, and off sites. Information related to investigation and cleanup activities as it relates to groundwater protection follows.

UNDERGROUND TESTING AREA (UGTA) SITES

The goals of the UGTA project include evaluating the nature and extent of contamination in groundwater due to underground nuclear testing and establishing a long-term groundwater monitoring network. As part of the UGTA project, scientists are developing computer models to predict groundwater flow and contaminant migration within and near the NTS. To develop and test these models it is necessary to collect geologic, geophysical, and hydrologic data from new and existing wells to define groundwater migration pathways, migration rates, and quality.

In 1999, the UGTA Project initiated a hydrogeologic investigation well drilling program in the Western Pahute Mesa - Oasis Valley (WPM-OV) area of Nye County, Nevada (International Technology [IT] 1998). The goal of the WPM-OV program is to collect subsurface geologic and hydrologic data in a large, poorly characterized area down-gradient from Pahute Mesa, where underground nuclear tests were conducted, and up-gradient from groundwater discharge and withdrawal sites in Oasis Valley northeast of Beatty, Nevada (Figure 5.6). Data from these wells will allow for more accurate modeling of groundwater flow and radionuclide migration in the region. Some of the wells may also function as long-term monitoring wells.

Seven new wells were drilled under this program during 1999 (one onsite and six offsite, located just west of the NTS). Preliminary (predevelopement) groundwater characterization samples were collected from each of these wells. No man-made radionuclides were detected in these wells.

POST-SHOT WELLS ("HOT WELLS")

Accomplishments of the UGTA project in 1999 also include the sampling of three post-shot/cavity wells: U-4u PS#2A, U-19v PSlds, and U-20n PS#1ddh. These

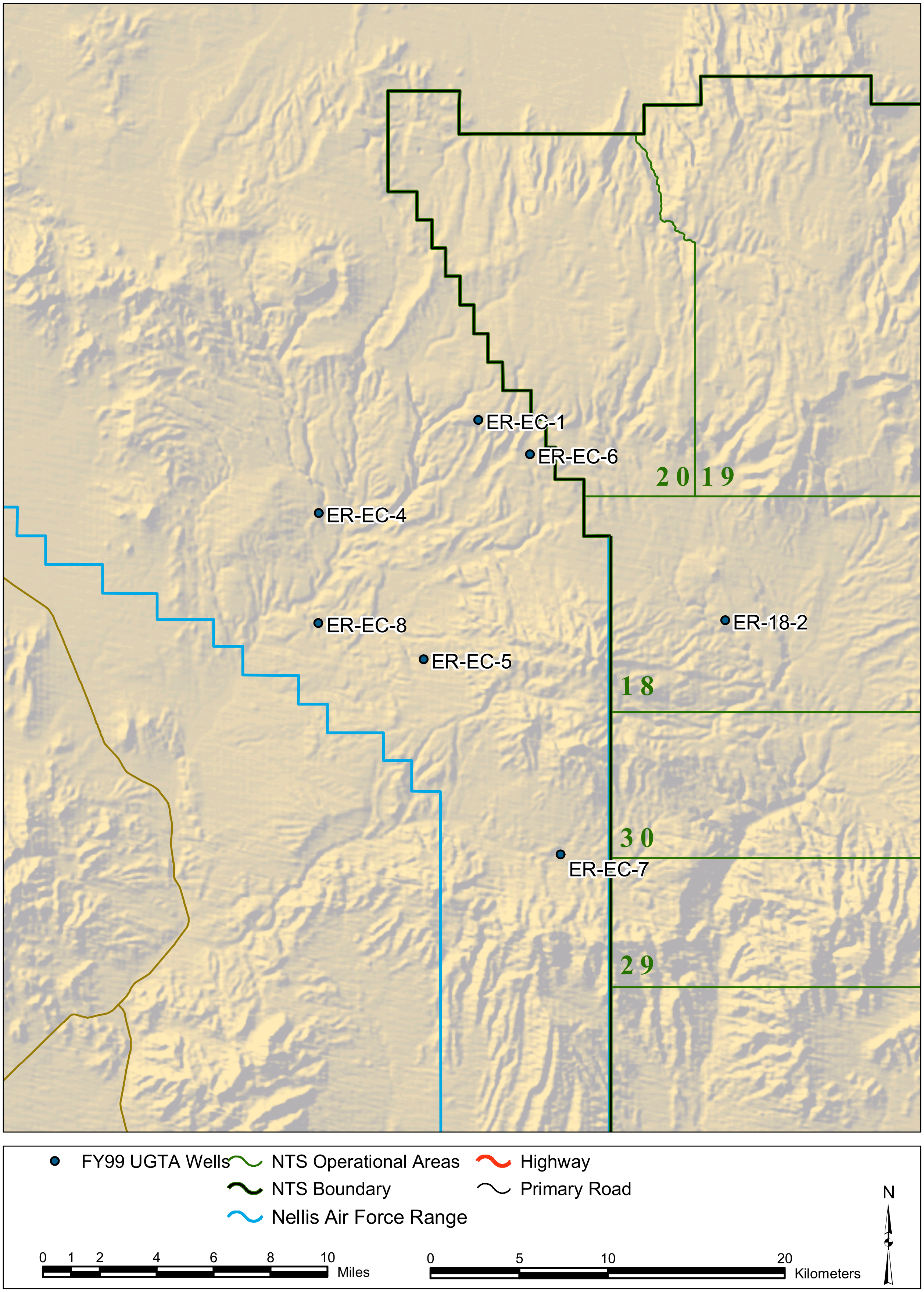


Figure 5.6 Locations of UGTA Wells - 1999

wells access cavities from the underground nuclear tests DALHART, ALMENDRO, and CHESHIRE, respectively. In general, preliminary results show expected levels of contamination for post-shot wells. Final laboratory analytical results for U-19v PSlds and U-4u PS#2A are pending (at time of publication), so only U-20n PS#1ddh is discussed below.

A multi-agency team consisting of personnel from the USGS, Los Alamos National Laboratory (LANL), and Lawrence Livermore National Laboratory (LLNL) collected fluid samples at U-20n PS#1ddh using a downhole sampling pump. The well accesses the test cavity via perforated 5.5 inch casing. During sample collection, field parameters, including temperature, pH, and conductivity were measured. Samples were then analyzed for ^{3}H, ^{14}C, gross alpha and gross beta (see Table 5.7).

U-20n PS#1ddh was drilled to support studies of radionuclide migration from the cavity/chimney region of the CHESHIRE underground test that was conducted on Pahute Mesa in February of 1976. Radionuclide migration studies at this site have been intermittent since 1976. Samples collected from the lower zone of U-20n PS#1ddh present a unique opportunity to analyze cavity fluids.

The results of this sampling effort at U-20n PS#1ddh will support the DOE's continuing efforts to create a long-term monitoring program for wells in or near underground nuclear test cavities. The program objectives are to characterize the hydrologic source term and evaluate the decay and potential migration of radionuclides through monitoring at or near the source.

MISCELLANEOUS STUDIES

Radionuclides in water samples were variously analyzed by IT, LLNL, Desert Research Institute (DRI), and LANL. Additional information and analytical results for 1999 studies will be reported by the respective organizations during 2000.

LLNL continues to investigate the occurrence, distribution, and potential mobility of radionuclides in the sub-surface through investigation of archival post-shot debris. Static leaching experiments of glass and crystalline samples were continued to elucidate controls on the solubility of radionuclides.

These and other related studies conducted by LLNL in 1999 in support of DOE's Hydrologic Resources Management Program and UGTA are reported in Smith et al., 2000.

INDUSTRIAL SITES AND DECONTAMINATION AND DECOMMISSIONING

ABANDONED UNDERGROUND STORAGE TANKS

The NTS underground storage tank (UST) program continues to meet regulatory compliance schedules. Details of this program are discussed in Chapter 3.

5.5 WATER SURVEILLANCE PROGRAM RESULTS

The analytical results obtained for water samples collected onsite and from the adjacent offsite area are described in this Section. Only a few samples from wells proximal to underground nuclear tests contained detectable concentrations of radionuclides. No detectable man-made radionuclides were detected offsite. Table 5.6 lists the routine sampling locations where well water samples contained activity levels greater than 0.2 percent of the National Primary Drinking Water Standards.

ONSITE WATER MONITORING RESULTS

RADIOACTIVITY IN SURFACE WATER

Surface water sampling at the NTS was conducted at three containment ponds (Well ER-18-2, post shot well U-20n PS#1ddh, and the E Tunnel ponds), one tunnel effluent (E Tunnel), and nine sewage lagoons. The locations of these sources are shown in Figure 5.2. When water was available and the weather permitted, a grab sample was taken and analyzed in accordance with Tables 5.2 (general summary) and 5.3 (RREMP).

The annual average for each radionuclide analyzed in surface waters is presented in Table 5.7, along with the results from analysis of tunnel effluents. The results from gamma spectrometry were non-detectable for all sample locations, except for samples from the E Tunnel effluent and related containment pond.

With the exception of the E Tunnel and U-20n PS#1ddh containment ponds, no annual average concentration in surface waters was found to be statistically different from any others at the 5 percent significance level.

RESERVOIRS AND SPRINGS

These surface waters (water well reservoirs and natural springs) were eliminated from the environmental monitoring program in accordance with the RREMP that was developed in 1998.

CONTAINMENT PONDS

Due to the sealing of the tunnels at the close of 1993, liquid effluents ceased at all tunnels except E Tunnel. The E Tunnel containment ponds were fenced and posted with radiological warning signs. During each sampling, a grab sample was taken from the E Tunnel containment pond and at the effluent discharge point. The samples were analyzed for ^{3}H, ^{90}Sr, ^{238}Pu, $^{239+240}Pu$, gross alpha, gross beta, and gamma activity in accordance with the schedule in Tables 5.2 and 5.3 (RREMP). The annual averages of these analyses from the two sampling locations are listed in Table 5.7.

The effluent from characterization Well ER-18-2 and purge water from source-term Well U-20n PS#1ddh in Areas 18 and 20 respectively, was discharged into lined containment ponds. No radioactivity related to man-made radionuclides was detected at Well ER-18-2 (BN 2000c; IT 1999). The total liquid discharged at U-20n PS#1ddh was measured (approximately 37,850 liters [10,000 gallons]). By multiplying that volume by the average concentration of ^{3}H in collected samples (see Table 5.7), the total amount of ^{3}H discharged may be calculated.

SEWAGE LAGOONS

Samples were collected quarterly during 1999 from the nine sewage lagoons on the network. Each of the lagoons is part of a closed system used for evaporative treatment of sanitary waste. The lagoons are located in Areas 5, 6, 12, 22, 23, and 25. The annual gross beta concentration averages for all lagoons ranged from 20.0 to 43.5 x 10^{-9} µCi/mL (0.74 to 1.6 Bq/L). No radioactivity was detected above the Minimum Detectable Concentrations (MDCs) for ^{3}H, ^{90}Sr, ^{238}Pu, or $^{239+240}Pu$ (Table 5.7). No test-related radioactivity was detected by gamma spectrometric analyses, except for ^{137}Cs, which was found at a concentration of 1.2 x 10^{-9} µCi/mL in one sample collected at the DAF Sewage Lagoon on April 22, 2000. A second sample collected on April 29, 2000, and analyzed by gamma spectrometry, was found to contain no test-related radioactivity.

RADIOACTIVITY IN SUPPLY WELLS AND DRINKING WATER

The principal water distribution system on the NTS is potentially the critical pathway for ingestion of waterborne radionuclides. Consequently, the water distribution system is sampled and evaluated frequently. The NTS water system consists of 13 supply wells, 10 of which supply potable water to onsite distribution systems. The drinking water is pumped from the wells to the points of consumption. The supply wells were sampled on a quarterly basis. Drinking water is sampled at taps on the end-points of the distribution systems to provide a constant check of the radioactivity and to allow end-use activity comparisons to the radioactivity of the water in the supply wells. In this section, analytical results are presented from samples taken at the 12 supply wells (Well C was inactive during 1999).

Each well was sampled and analyzed as noted in the schedule in Tables 5.2 and 5.3. As a cross check on the comparability of analyses by BN and EPA's R&IE-LV on water well samples, several wells were sampled by both organizations. The results of these analyses, listed in Table 5.8, showed reasonably good agreement.

The locations of the supply wells are shown in Figure 5.1. Water from these wells (10 potable and 2 nonpotable) was used for a variety of purposes during 1999. Samples were collected from those wells which could potentially provide water for human consumption. These data were used to help document the radiological characteristics of the NTS groundwater system. The sample results are maintained in a database so that long-term trends and changes can be studied.

Table 5.9 lists the drinking water sources with corresponding system endpoints, and Table 5.10 lists the potable and nonpotable supply wells and their respective radioactivity averages. No test-related radionuclides were detected by gamma spectrometry. Included in Table 5.10 are the median MDCs for each of the measurements for comparison to the concentration averages for each location. For various operational reasons, samples could not be collected from all locations every sampling period.

As a check on any effect the water distribution system might have on water quality, samples were taken from seven water distribution system end-points (tap water samples). To ensure that all of the water available for consumption was being considered, each drinking water system was identified. The drinking water network at the NTS consists of four drinking water systems. The components of the four systems are shown in Table 5.9. These systems, fed by ten potable supply wells (in 1999), are the source of the water for the seven end-points. Table 5.11 lists the annual concentration averages for all of the analyses performed on tap water samples. No test-related radionuclides were detected.

GROSS BETA

As shown in Table 5.10, the gross beta concentration averages for all of the supply wells were above the median MDC of the measurement. The highest average gross beta activity occurred at Well C-1 and was 1.3×10^{-8} µCi/mL (0.48 Bq/L), which was 4.4 percent of the DCG for ^{40}K and 33 percent of the DCG for ^{90}Sr based upon 4 mrem effective dose equivalent (EDE) per year. In earlier reports (Scoggins 1983; 1984), it was noted that the majority of gross beta activity was attributable to naturally occurring ^{40}K. All concentration averages were comparable to those reported in 1998.

As in previous years, the gross beta concentration averages for all tap water samples were above the median MDC of the measurements. The highest annual average of 10.3×10^{-9} µCi/mL (0.38 Bq/L) occurred in the Area 23 Cafeteria, similar to the supply well water. The annual EDE is also equivalent to that from the supply well water.

TRITIUM

As shown in Table 5.10, the average tritium concentrations at all supply wells was below the average MDC of the measurement (note that the MDC was 14.7×10^{-9} µCi/mL, based on tritium enrichment analysis).

The annual average tritium concentrations in tap water samples, as shown in Table 5.10, were all less than the median MDC of 14.7×10^{-9} µCi/mL. The tritium concentrations for all end-point water samples, which were also determined by a tritium enrichment method, are expected to be lower than the MDC, since the levels of tritium in the potable supply wells were below the median tritium enrichment MDC of 14.7×10^{-9} µCi/mL (0.54 Bq/L). These MDC values are 0.019 percent of the drinking water DCG adjusted to a 4 mrem (0.04 mSv) EDE.

PLUTONIUM

All supply well water samples analyzed for ^{238}Pu and $^{239+240}$Pu had concentrations below the MDCs of about 2.7×10^{-12} µCi/mL, which are about 2.0 percent of their respective DCGs adjusted to a 4 mrem EDE per year. Table 5.10 lists the concentration averages of these nuclides for each location.

The annual averages of $^{239+240}$Pu and ^{238}Pu for each tap water sample were below the median MDC of the measurements, which were both less than 2 percent of the 4 mrem DCG. These isotopes are not normally detected in drinking water.

GROSS ALPHA

In accordance with the National Primary Drinking Water Regulations (CFR 1976), gross alpha measurements were made on quarterly samples from the drinking water systems, namely the potable supply wells.

As shown in Table 5.10, the average gross alpha concentration for all of the supply wells, except Wells 8, J-12, and J-13 was above the median MDC of 1.8×10^{-9} µCi/mL. The highest concentration occurred in samples from C-1 in Area 6 and was 10.5×10^{-9} µCi/mL (0.39 Bq/L). This is acceptable according to the EPA drinking water standard (CFR 1976) as long as the combined concentration of ^{226}Ra and ^{228}Ra is less than 5×10^{-9} µCi/mL (0.19 Bq/L). The combined radium concentration, for these wells, was less than the combined MDC of 4.64×10^{-9} µCi/mL (0.17 Bq/L), as shown in Table 5.12.

As added assurance that no radioactivity gets into the systems between the supply wells and end-point users, measurements of gross alpha are also made quarterly on tap water samples. As shown in Table 5.11, the annual concentration averages for gross alpha radioactivity in tap water samples, collected at four locations, exceeded the screening level of 5 pCi/L (0.19 Bq/L), at which ^{226}Ra analysis is required.

RADIUM

Samples from the supply wells were collected and analyzed for both ^{226}Ra and ^{228}Ra. As shown by the radium results in Table 5.12, the sum of the average concentrations for ^{226}Ra and ^{228}Ra were all less than 5 pCi/L, which showed the onsite systems were in compliance with drinking water regulations.

STRONTIUM

Beginning in 1997, ^{90}Sr sampling frequency was reduced from quarterly to annually for supply water samples. Strontium-90 analyses were conducted on an annual bases for the seven selected tap-water endpoints. As indicated by Table 5.11, the ^{90}Sr results for samples collected from all the selected tap water samples had concentrations that were less than the median MDC of the measurements.

MONITORING ON AND AROUND THE NEVADA TEST SITE

NEVADA TEST SITE MONITORING

The present R&IE-LV sampling locations on the NTS, or immediately outside its borders on federally owned land are shown in Figure 5.3. All sampling locations are selected by DOE and many locations are now included in the RREMP. Since 1995, R&IE-LV has sampled only wells without pumps and, for quality assurance purposes, collected samples from some of the potable water supply wells sampled by BN. In 1999, 21 wells were included in the LTHMP and 27 wells were included in the RREMP (exclusive of the water supply wells).

All samples were analyzed by gamma spectrometry and for tritium. No gamma-emitting radionuclides were detected in any of the NTS samples collected in 1999.

Summary results of tritium analyses are given in Tables 5.13 (RREMP) and 5.14 (LTHMP). The highest average tritium activity was 2.12 x 10^5 pCi/L (7.8 kBq/L) at source-term Well RNM #2S (Table 5.13). This activity is above the DCG for tritium as established in DOE Order 5400.5 for comparison with the dose limit (4 mrem) in the National Primary Drinking Water Regulations. Seven of the wells yielded tritium results greater than the MDC. The trend in tritium concentration in samples from Test Well B is shown in Figure 5.7 and is typical of a well with decreasing tritium concentrations. The source of the tritium is unknown.

Well UE-7nS was drilled 137 m from the BOURBON underground nuclear test (U-7n) conducted in 1967. This well was routinely sampled between 1978 and 1987 and again since 1992. In 1999, approximately 241 pCi/L were detected in water samples from Well UE-7nS. This too represents a decreasing trend in recent years in tritium concentrations. However, this monitoring point marks the second known site on the NTS where the regionally important carbonate aquifer has been affected by radionuclides (Smith et al., 1999).

OFFSITE MONITORING IN THE VICINITY OF THE NEVADA TEST SITE

Water sampling around the NTS is conducted by the EPA's R&IE-LV, under an interagency agreement with DOE, to ensure the radiological safety of public drinking water supplies and representative water sources of rural residents and, where suitable, to monitor any migration of radionuclides from the NTS. The LTHMP sampling locations are shown on Figure 5.4 and the analytical results are in Table 5.16. No man-made gamma-emitting radionuclides were detected in any sample.

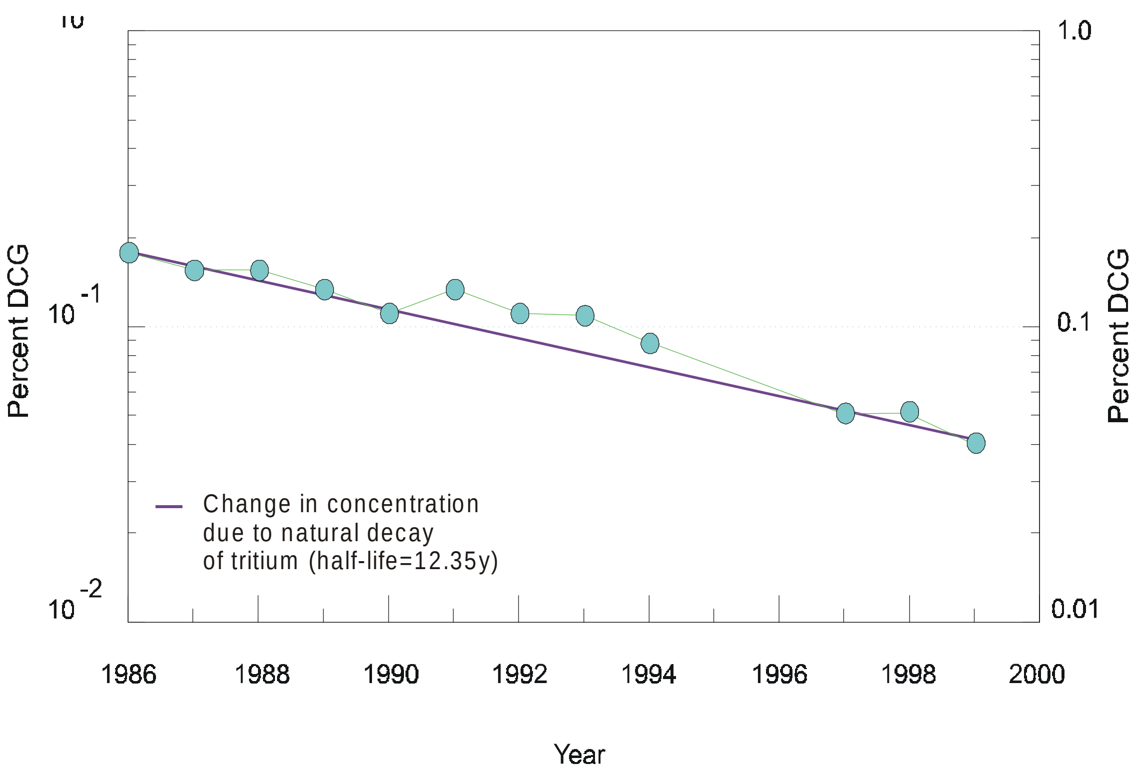


Figure 5.7 Trend in Tritium Concentration, Test Well B on the NTS

In 1999, a suite of offsite wells was also sampled by the RREMP. The RREMP sampling locations are shown on Figure 5.8 and the analytical results are presented in Table 5.15. No man-made gamma-emitting radionuclides were detected in any sample.

GROUNDWATER MONITORING

GROUNDWATER QUANTITY

Water levels are monitored annually by the USGS on and around the NTS at approximately 155 measurement locations, including 63 onsite and 92 offsite locations. Results are used in regional and local groundwater models, but are not routinely analyzed for water level trends. However, no significant water level impacts associated with groundwater usage were detected in 1999.

Water usage on the NTS is monitored by both the USGS and BN. Water use at the NTS continues to decline due to the moratorium on nuclear testing instituted in 1992 and was about 8.32 x 10^5 m^3 (219.8 x 10^6 gal) in 1999. Data for the 1999 water year for water levels and usage will be reported in the USGS "Water Resources Data Report -1999," (Jones, *et al.,* 1999) and is also available on the USGS website: www.nevada.usgs.gov.

GROUNDWATER QUALITY

Regional-scale groundwater investigations concentrated on determining recharge locations and flow paths for the groundwater flow systems in southern Nevada. This included several studies and field sampling activities.

Groundwater quality was determined by monitoring wells and springs, both onsite and offsite, for radioactive constituents as discussed above. The remainder of this chapter summarizes analyses of water for chemical constituents, radioisotopes, and stable isotopes in order to comply with environmental permits, better characterize NTS groundwater quality, and support regional groundwater flow and transport models.

5.6 NONRADIOLOGICAL MONITORING

The 1999 nonradiological monitoring program for the NTS included onsite sampling of various environmental media and substances for compliance with federal and state regulations or permits and for ecological studies.

MONITORING WATER SOURCES

Nonradiological monitoring of non-NTS DOE/NV facilities was conducted at three offsite facilities. This monitoring was limited to wastewater discharges to publicly owned treatment works. Routine nonradiological environmental monitoring on the NTS in 1999 was limited to:

- Sampling of drinking water distribution systems and water haulage trucks for SDWA and state of Nevada compliance.
- Sewage lagoon influent and E Tunnel discharge sampling for compliance with state of Nevada operating permit requirements.

CLEAN WATER ACT RESULTS

NTS OPERATIONS

The NTS General Permit requires quarterly reporting for biochemical oxygen demand (BOD) and specific conductance, organic loading rates, and reporting of second quarter influent toxics sampling. The results of this sampling are shown in Tables 5.17, 5.18, and 5.19, respectively. All values in these tables are in compliance with the permit requirements.

The permit also requires monitoring of the infiltration basins, which attain a depth of 30 cm or more in January and June for parameters listed in Appendix II of the

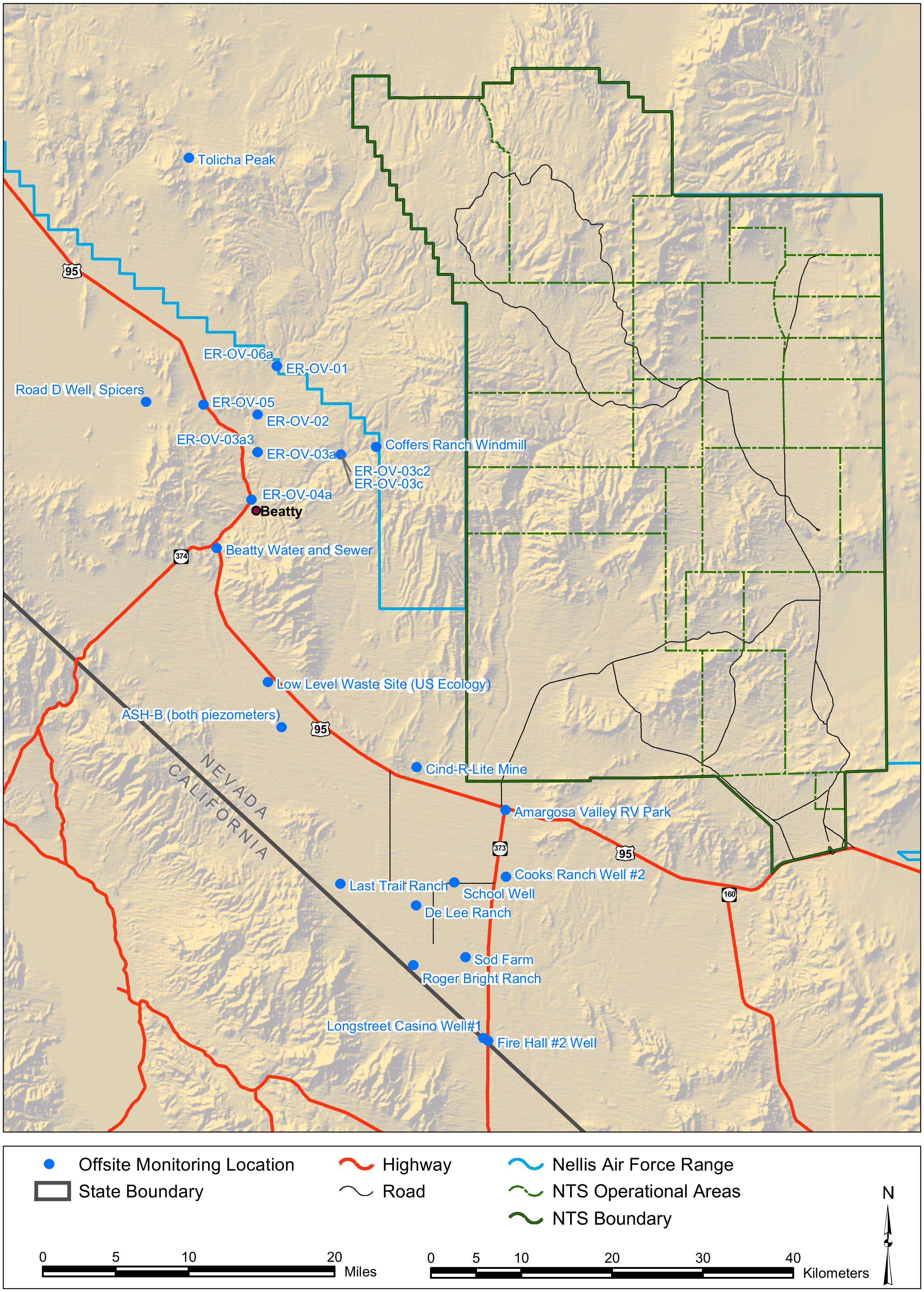


Figure 5.8 NTS Offsite Groundwater Radiological Monitoring Site in the RREMP - 1999

permit. Sampling is required as soon as any other system exceeds the 30 cm. Three secondary ponds at the Area 23 facility usually contain the required depth, but are excluded as needing the sampling in Part III.C.4 of the permit. During 1999, the Area 25 Central Support (Base Camp) was the only system which exceeded the 30 cm limit. Sampling results are given in Table 5.20. All values in this table are in compliance with the permit requirements.

NON-NTS OPERATIONS (NLVF and RSL)

The NLVF is required by permit to sample and analyze wastewater effluent and submit self-monitoring reports. The NLVF self-monitoring report consists of monitoring results for two outfalls and the burn pit batch discharge. All sampling results for 1999 were within permit limits. The RSL facility now discharges into the Nellis Air Force Base system and no longer requires a separate permit. Nellis Air Force Base does, however, require self-monitoring to be conducted in April and November. Reports of analytical results were submitted in 1999.

SAFE DRINKING WATER ACT RESULTS

Water sampling was conducted for analysis of bacteria, volatile organic compounds (VOCs), inorganic constituents, and water quality as required by the SDWA and state of Nevada regulations. Samples were collected from supply wells and from various locations throughout all drinking water distribution systems on the NTS. All samples were collected according to accepted practices, and the analyses were performed by state approved laboratories. Analyses were performed in accordance with Nevada Administrative Code (NAC) 445A (NAC 1996) and Title 40 CFR 141.

BACTERIOLOGICAL SAMPLING

Samples were submitted to the state-approved NEL Laboratories in Las Vegas, Nevada, for coliform analyses. All water distribution systems were tested quarterly at a minimum, with the number of people being served determining the number of samples collected and the frequency. If coliform bacteria are present, confirmation samples are collected, and the source of contamination is determined by the water system operator. Portions of the system may need to be shut down and disinfected. In order to reopen the system, the confirmation samples must meet state requirements. There were no incidents of positive coliform results during 1999.

Residual chlorine levels were determined at the collection point by using colorimetric methods approved by the state.

The results were recorded in BN’s drinking water sample logbook, and the chlorine residual level was recorded on an analysis form.

Samples from trucks, which hauled potable water from NTS wells to work areas, were also analyzed for coliform bacteria. There were no positive coliform sample results in 1999.

CHEMICAL ANALYSIS

Chemical analyses in 1999 were performed for metals and inorganics.

ORGANIC COMPOUND ANALYSIS

In accordance with the monitoring waivers issued in 1996, the DOE/NV did not collect VOC samples in 1999. The DOE/NV did request renewals for all current waivers.

METAL ANALYSIS

In compliance with a state agreement, samples were collected in the third quarter and analyzed for lead and copper. These samples were taken from faucets from all four potable water distribution systems. All results were below the method detection limits of 0.5 mg/L for copper. Lead results in Area 1 and Area 2-12 systems exceeded the

0.015 mg/L action level for lead. The source of lead in Area 1 is suspected to be an underground copper pipe. Rather than excavate the line in this sparsely used system, the DOE/NV chose to eliminate potable water taps to prevent potable uses of this water. No further lead sampling will take place unless buildings are reoccupied. Only one building in Area 12, the Miners' Change House (Building 12-43), is used regularly, and all lead and copper samples for this water system were collected in this building. Water in this building exceeded the lead action level. Lead solder is the suspected culprit. DOE/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.

INORGANIC COMPOUND ANALYSIS AND WATER QUALITY

To comply with a 1991 variance to the Area 25 water system permit, fluoride samples need to be taken annually 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 second quarter of 1999 confirmed that the fluoride concentration was acceptable.

During the first quarter of 1999, samples were collected and analyzed for nitrates, nitrites, and secondary standards. The results of these analyses are shown in Table 5.21. All results were within acceptable limits.

5.7 WATER QUALITY PERMITS

Water quality permits were required by the state for onsite drinking water systems. Other types of water permits were required for onsite and offsite sewage-related activities.

ONSITE WATER PERMITS

DRINKING WATER SYSTEM PERMITS

Four NTS drinking water system permits issued by the state of Nevada, as shown in Table 5.22 were renewed with new expiration dates. During 1994, the state of Nevada determined that the trucks used for hauling potable water should also have permits, so three additional permits were obtained. These permits were also renewed. No drinking water systems were maintained by non-NTS facilities.

SEWAGE DISCHARGE PERMITS

Sewage discharge permits from the state of Nevada, Division of Environmental Protection are listed in Table 5.23 and require submission of quarterly discharge monitoring reports.

NTS SEWAGE HAULING PERMITS

Permits issued by the state of Nevada, Division of Health for four sewage hauling trucks for the NTS were renewed in November 1999 and are listed in Table 5.24.

NON-NTS SEWAGE PERMITS

One sewage permit was required at the NLVF and two at the Special Technologies Laboratory (STL) as shown in Table 5.23. Each was issued by the county or local municipality in which the facility was located as follows:

- NLVF - The NLVF self-monitoring report was submitted in October 1999. Two outfalls and the burn pit batch discharge are monitored.

- STL - The STL holds wastewater permits for the Botello Road and Ekwill Street locations. There is no required self-monitoring.

Table 5.1 Summary of Analytical Procedures for Water Samples - 1999

Type of Analysis	Analytical Equipment	Count Time-min	Analytical Procedure	Sample Size-mL	Approximate MDC
		RREMP	(BN) Procedures		
Gross α	Gas-flow Proportional Counter	100	Boil down. Place on planchet and heat to dryness	800	2 pCi/L
Gross β	Gas-flow Proportional Counter	100	Boil down. Place on planchet and heat to dryness	800	2 pCi/L
Gamma	HpGe detector calibrated at 1 keV/channel	100	Online computer analysis	500	10 pCi/L for ^{137}Cs
Tritium Convent.	Liquid scintil-lation counter	70	Distillation of 100 mL	2.5	300-700 pCi/L
Tritium Enrichment	Liquid scintil-lation counter	300	Electrolysis of 250 mL basic solution	5	20 pCi/L
Plutonium	Alpha Spectrometer	1000	Tracer, ion exchange, collect precipitate on filter	900	0.02 pCi/L
Radium	Gamma Spectrometer	1000	Tracer, precipitate as sulfate, collect on filter	900	1 pCi/L for ^{228}Ra 3 pCi/L for ^{226}Ra
Strontium	Gas-flow Proportional Counter	100	precipitate as carbonate, count yttrium in-growth	900	0.3 pCi/L
		LTHMP	(R&IE-LV) Procedures		
Gamma	HpGe detector calibrate at 0.5 keV/channel	100	Online computer analysis	3500	Varies with nuclide/detector ^{137}Cs: 7 pCi/L
Tritium Convent.	Liquid scintil-lation counter	300	Distillation of sample	5-10	300-700 pCi/L
Tritium Enrichment	Liquid scintil-lation counter	300	250 mL concentrate by electrolysis, distill	5	5 pCi/L

Table 5.2 Summary of the Onsite Water Surveillance Program - 1999

Sample Type	Description	Collection Frequency	Number of Sampling Locations[a]	Type of Analysis
Tap	Grab sample	Quarterly	7	Gamma spectroscopy, Water gross α & ß, ^{3}H, $^{238,239+240}Pu$, ^{90}Sr annually).
Potable Supply Wells	Grab sample	Quarterly	10	Gamma spectroscopy, gross α & ß, $^{226 \& 228}Ra$, $^{238,239+240}Pu$, ^{3}H enrich, ^{90}Sr.
Nonpotable Supply Wells	Grab sample	Quarterly	2	Gamma spectroscopy, gross α & ß, ^{3}H, (^{90}Sr annually) $^{238,239+240}Pu$.
Containment Ponds	Grab sample	Quarterly	3	Gamma spectroscopy, gross ß, ^{3}H, $^{238,239+240}Pu$ (^{90}Sr annually).
Sewage Lagoons	Grab sample	Quarterly	10	Gamma spectroscopy, gross α, ^{3}H, $^{238,239+240}Pu$ (^{90}Sr annually).
Monitoring Wells	Grab sample	Variable	27	^{3}H[b]

(a) All locations were not sampled for various reasons.
(b) Refer to Table 5.3 for schedules of other analyses.

Table 5.3 Sampling and Analysis Schedule for RREMP Groundwater and Surface Water 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, 1996).

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 5.4 RREMP Sampling and Analysis Schedule for NTS Drinking Water System Consumption Endpoints

Endpoint	System	Supply Wells	Sampling Frequency	Analysis[a]
Area 6, Cafeteria (at CP)	No. 1	Wells C-1, 4, 4A, 5B and Army No. 1	Quarterly	Ie, II, III
Area 6, Building 6-900	“	“	Quarterly	Ie, II, III
Area 2, Restroom[b]	No. 2	Well 8	Quarterly	Ie, II, III
Area 12, Building 12-23[c]	“	“	Annually	Ie, II, III
Area 1, Building 101	No. 3	Well UE-16d	Annually	Ie, II, III
Area 23, Mercury Cafeteria	No. 4	Wells 5b and Army No. 1	Quarterly	Ie, II, III
Area 25, Building 4221	No. 4	Wells J-12 and J-13	Annually	Ie, II, III

(a) Analysis:
Type Ie: Includes tritium (enriched method).
Type II: Includes gross alpha and gross beta.
Type III: Includes gamma spectroscopy, ^{238}Pu, $^{239+240}$Pu, and ^{90}Sr (annually).

(b) Dormant sampling point while building is unused.

(c) Building unused; sampling location changed to Ice House.

Table 5.5 Groundwater Monitoring Parameters at the RWMS-5

Parameters Establishing Water Quality

Ca, Cl, F, Fe, K, SiO_2, Na, Mg, Mn, HCO_3, H_2CO_3, $SO_4^{=}$, and $CO_3^{=}$,

Indicators of Contamination

pH
Specfic Conductance
Total Organic Halogen
Total Organic Carbon
Tritium

Additional RREMP Data

Gross Alpha	Gross Beta
Gamma Spectroscopy	Plutonium 238 and 239+240
Strontium 90	Radium 226 and 228

Table 5.6 Groundwater Sampling Locations with Detectable Man-Made Radioactivity - 1999[(a)]

Location	Radionuclide	Concentration $\times 10^{-9}$ µCi/mL[(b)]
NTS Onsite Network		
Well A	^{3}H	668
Well PM-1	^{3}H	181
Well UE-5n	^{3}H	120,000
RNM#2S (Source-term well)	^{3}H	212,000
Well UE-6d	^{3}H	540
Well UE-7nS	^{3}H	240
Well ER-12-1	^{3}H	27.9
Well U-19bh	^{3}H	62.1
Well USGS HTH#1	$^{239+240}Pu$	0.046

(a) Only ^{3}H concentrations greater than 0.2 percent of the 4 mrem DCG are shown (i.e., greater than 1.6×10^{-7} µCi/mL [160 pCi/L {6 Bq/L}]). Detectable levels of other man-made radioisotopes are also shown.

(b) Underlined results are for enrichment analysis (MDC of 10×10^{-9} µCi/mL); otherwise indicates conventional tritium analysis (MDC of 750×10^{-9} µCi/mL).

Table 5.7 Radioactivity in NTS Surface Waters - 1999

		Annual Average Concentrations (10^{-9} µCi/mL)					
Source of Non-Potable Water	No. of Sites	Gross Alpha	Gross Beta	Tritium	^{238}Pu	$^{239+240}$Pu	^{90}Sr
Containment Ponds							
E Tunnel[a]	2[b]	21.7	67.4	9.4×10^5	0.33	2.8	1.1
Mean MDC		1.9	1.3	736	0.02	0.02	1.1
U-20n PS#1ddh[c]	1	-53	1.47×10^3	5.2×10^7			
Mean MDC		6.9	7.7	490			
Sewage Lagoons	9	5.9	27.2	-26.2	-0.001	0.0012	0.11
Mean MDC		3.4	1.4	747	0.02	0.023	0.12

(a) ^{137}Cs detected by gamma spectroscopy; annual average concentration was 182×10^{-9} µCi/mL.
(b) A pond and an effluent.
(c) Analyses by C&MS Environmental Services, LLNL.

Table 5.8 NTS Well Cross-Check Results - 1999

	Tritium Concentration (10^{-9} µCi/mL)[a]	
Location	RREMP (BN)	EPA
Area 4, Test Well D	-2.62	64.6
Area 5, UE-5n	120,000	105,000
Area 5, Well 5C	0.92	-2.9
Area 6, UE-6e	14.40	160
Area 6, Well 4	-.51	1.75
Area 6, Well C-1	4.96	13
Area 17, Well HTH-1	0.66	160
Area 18, Well UE-18r	0.94	-2.05
Area 20, Well PM-1	181	164
Area 25, Well J-13	0.16	1.39

(a) Underlined results are for enrichment analysis (MDC of about 14.7×10^{-9} µCi/mL); otherwise indicates conventional tritium analysis (MDC of about 750×10^{-9} µCi/mL).

Table 5.9 NTS Drinking Water Sources and Corresponding System End-Points - 1999

System	Supply Wells	End-Point
No. 1	Wells C1, 4, 4A	Area 6, Cafeteria
	Wells 5B, 5C	Area 6, Building 6-900
	Army No. 1	Area 23, Cafeteria
No. 2	Well 8	Area 2, Restroom[a]
		Area 12, Building 12-23
No. 3	Well UE-16d	Area 1, Building 101
No. 4	Wells J-12, J-13	Area 25, Building 4221

(a) Dormant sampling point while building is unused.

Table 5.10 NTS Supply Well Radioactivity Averages - 1999

	Annual Average Concentrations - 10^{-9} µCi/mL					
Description	Gross Beta	^{3}H	$^{239+240}Pu$	^{238}Pu	Gross Alpha	^{90}Sr[b]
			Potable Water Supply Wells			
Area 5, Well 5C	5.4	0.92	-0.0034	0.0018	7.8	(c)
Area 5, Well 5B	10.7	2.49	-0.0026	-0.0011	5.4	(c)
Area 6, Well 4	5.4	-0.51	-0.0044	-0.0024	7.5	(c)
Area 6, Well 4A	6.1	-0.28	--	--	8.8	(c)
Area 6, Well C1	13.2	4.96	0.0012	-0.0023	10.5	(c)
Area 6, Well C[a]	-	-	-	-	-	-
Area 16, Well UE-16d	6.7	-0.44	-0.0042	-0.0022	7.4	(c)
Area 18, Well 8	2.6	3.02	-0.0039	0.0021	0.7	(c)
Area 22, Army Well No.1	6.5	0.06	-0.0036	-0.0019	6.0	(c)
Area 25, Well J-12	4.0	3.24	0.0012	-0.0023	1.3	(c)
Area 25, Well J-13	3.8	0.16	-0.0011	-0.0021	1.6	(c)
			Non-Potable Water Supply Wells			
Area 5, Well UE-5c	7.73	2.2	-0.0009	0.0007	8.13	(c)
Area 20, Well U-20	2.91	0.67	--	--	3.73	(c)
Median MDC	1.24	14.7	-0.0035	0.002	1.8	--

(a) Pump not operable.
(b) Only one sample collected during the year.
(c) No ^{90}Sr analysis in 1999.

Table 5.11 Radioactivity Averages for NTS Tap Water Samples - 1999

	Annual Average Concentrations -10^{-9} µCi/mL					
Description	Gross Beta	^{3}H[a]	$^{239+240}Pu$	^{238}Pu	Gross Alpha	^{90}Sr[b]
Area 1, Bldg. 101[c]	5.9	-0.6	-0.0014	-0.0028	3.7	-0.02
Area 2, Restroom[d]	-	- (not sampled in 1999)-			-	-
Area 6, Cafeteria	6.5	-1.4	-0.0037	-0.0030	10	-
Area 6, Bldg. 6-900	6.3	-1.4	0.0038	-0.0031	9.4	-0.12
Area 12, Ice House	3.0	-1.6	0.0053	-0.0003	0.30	0.07
Area 23, Cafeteria	10.3	1.4	0.0030	-0.0009	11	-0.76
Area 25, Bldg. 4221	3.8	-3.1	-0.0049	-0.0045	1.3	0.04
Median MDC	1.2	14.7	-0.0035	-0.002	1.8	0.28

(a) Enriched tritium method.
(b) ^{90}Sr values are for one sample.
(c) Water was shut off at all buildings in Area 1 Complex.
(d) Building was not accessible; only one sample collected at outside water tap.

Table 5.12 Radium Analysis Results for NTS Potable Water Supply Wells - 1999

		Concentrations (10^{-9} µCi/mL)			
Location	Number of Samples	^{226}Ra Arithmetic Mean	Standard Deviation	^{228}Ra Arithmetic Mean	Standard Deviation
Area 5, Well 5B	5	0.46	1.77	0.44	0.43
Area 5, Well 5C	4	0.86	0.55	0.21	0.20
Area 6, Well 4	2	0.15	1.72	0.64	0.07
Area 6, Well 4A	4	1.61	1.38	0.41	0.19
Area 6, Well C-1	4	3.22	0.93	0.67	0.28
Area 16, Well UE-16d	4	2.16	1.16	0.46	0.19
Area 18, Well 8	4	0.77	1.18	0.08	0.34
Area 23, Army Well No. 1	5	1.88	1.19	0.56	0.20
Area 25, Well J-12	4	1.17	1.00	0.30	0.19
Area 25, Well J-13	5	-0.29	0.82	0.001	0.32
Median MDC		3.69		0.95	

Table 5.13 Summary of Tritium Results for NTS Wells Sampled by RREMP - 1999, (Enriched Analytical Method, Except UE-5n and RNM #25)

		µCi/mL × 10^{-9}					
Sampling Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	Median MDC
Aquifer Monitoring Wells							
Area 1, UE-1q	2	-7.76	-7.76	6.84	-12.60	-2.92	16.15
Area 3, USGS Water Well A	1	668.00					13.70
Area 4, UE-4t #1	1	7.20					20.00
Area 4, UE-4t #2	1	5.09					16.80
Area 4, USGS Test Well D	2	-3.62	-3.62	4.17	-6.57	-0.67	16.80
Area 5, UE-5n	1	120,000					796
Area 6, UE-6e	1	14.40					33.70
Area 17, USGS Well HTH-1	5	0.66	-0.15	1.72	-0.97	3.25	16.00
Area 18, UE-18r	2	0.94	0.94	1.30	0.02	1.86	15.55
Area 19, U-19bh	1	62.10					12.50
Area 20, Well PM-1	1	181.00					13.90
Area 25, UE-25p#1	1	15.9					16.0
Area 25, UE25-WT#6	1	-3.39					17.0
All aquifer monitoring wells combined	17	54.13	1.55	164.61	-12.60	668.00	16.00
UGTA Wells							
Area 2, Water Well 2	1	-4.50					16.50
Area 3, ER-3-2	1	-4.06					16.80
Area 6, ER-6-1	1	2.87					16.40
Area 12, ER-12-1	1	27.90					16.00

Table 5.13 (Summary of Tritium Results for NTS Wells Sampled by RREMP - 1999, [Enriched Analytical Method, except UE-5n and RNM #25], cont.)

Sampling Location	Number of Samples	Mean (μCi/mL × 10^{-9})	Median	Standard Deviation	Minimum	Maximum	Median MDC
UGTA Wells, cont.							
Area 19, UE-19c Water Well	1	3.42					13.20
Area 20, ER-20-1	2	9.38					30.10
Area 20, ER-20-2#1	2	4.12					16.10
Permitted Facility Monitoring Wells							
Area 5, UE5PW-1	2	-1.36					14.15
Area 5, UE5PW-2	2	-3.37					14.35
Area 5, UE5PW-3	2	1.08					12.7
Area 23, SM-23-1	1	8.31					13.5
Source-Term Wells							
RNM #2S	3	212,333					2278

Table 5.14 Summary of Tritium Results for NTS Wells Sampled by R&IE-LV - 1999

Tritium Concentration (μCi/mL × 10^{-9})

Location	Number of Samples	Maximum	Minimum	Arithmetic Mean	1 Sigma	Mean as %DCG[a]	Mean MDC
Test Well B	1	---	---	33.1	1.8	0.04	4.9
Test Well D	1	---	---	64.6	64	[b]	207
Well HTH-F	1	---	---	-1.49	1.6	[b]	5.4
Well C-1	1	12.9	---	12.9	1.76	[b]	5.0
Well HTH-1	1	---	---	165	65	0.18	207
Well PM-1	1	---	---	164	5.7	0.18	5.0
Well U-3cn5	(Not Sampled)						
Well UE-1c	2	32	-16.1	7.95	62	[b]	204
Well UE-5n	2	124,000	87,600	105,800	382	117	204
Well UE-6d	2	608	470	539	67	0.60	204
Well UE-6e	2	195	124	159	63	[b]	204
Well UE-7nS	2	314	169	241	64	0.19	204
Well UE-16f	1	---	---	39.6	63	[b]	207
Well UE-18r	2	-1.27	-2.84	-2.05	1.51	[b]	5.0
Well UE-18t	1	---	---	144	2.85	0.16	5.6

(a) DCG - Derived Concentration Guide; established by DOE Order as 90,000 pCi/L for water.
(b) Not applicable because the result is less than the MDC or water is known to be nonpotable.
Note: Underline indicates enrichment analysis of ^3H, regular font indicates conventional analysis.

Table 5.14 (Summary of Tritium Results for NTS Wells Sampled by R&IE-LV - 1999, cont.)

Tritium Concentration (µCi/mL × 10^{-9})

Location	Number of Samples	Maximum	Minimum	Arithmetic Mean	1 Sigma	Mean as %DCG[(a)]	Mean MDC
Well J-13	1	---	---	1.39	1.5	5	5
Well 2	1	---	---	110	64	(b)	207
Well 4	1	---	---	-1.75	150	(b)	5
Well 5C	1	---	---	-2.9	1.4	(b)	5
Well 6A Army	2	86	-1.33	42	33	(b)	107

(a) DCG - Derived Concentration Guide; established by DOE Order as 90,000 pCi/L for water.
(b) Not applicable because the result is less than the MDC or water is known to be nonpotable.
Note: Underline indicates enrichment analysis of ^3H, regular font indicates conventional analysis.

Table 5.15 Summary of Tritium Results for Wells Near the NTS Sampled by BN (RREMP) -1999

Location	Tritium Concentration (10^{-9} µCi/mL)[(a)]	Location	Tritium Concentration (10^{-9} µCi/mL)[(a)]
Amargosa Valley RV Park	3.7	ER-OV-03C2	1.05
Ash-B Piezom #1	8.37	ER-OV-04A	-2.34
Ash-B Piezom #2	-2.97	ER-OV-05	4.89
Beatty Water and Sewer	2.32	ER-OV-06A	-5.12
Cind-R-Lite Mine	1.17	Fire Hall Well #2	1.41
Coffer's Ranch Windmill	4.49	Last Trail Ranch	2.9
Cook's Ranch Well	0.41	Longstreet Casino Well #1	3.76
De Lee Ranch	4.09	Road D Well	-3.95
ER-OV-01	7.64	Roger Bright Ranch	-0.51
ER-OV-02	-5.64	School Well	3.88
ER-OV-03A	-7.65	Sod Farm	4.71
ER-OV-03A3	2.98	Tolicha Peak	14.3
ER-OV-03C	9.26	U.S. Ecology	1.3

(a) Results are for enrichment analysis (MDC of 15.15 x 10^{-9} µCi/mL).
No summary statistics since only one sample was collected at each of these locations.

Table 5.16 LTHMP Summary of Tritium Results for Wells Near the NTS - 1999

Location	Number of Samples	Tritium Concentration (µCi/mL × 10^{-9}) Max	Min	Mean	1 Standard Deviation	% of DCG[a]	Mean MDC
Adaven							
Adaven Spring	4	-9.2	-2.45	-1.29	65	(b)	220
Alamo							
Well 4 City	2	308	-78	115	65	(b)	207
Amargosa Valley							
Bar-B-Q Ranch	4	-1.1	-6.1	3.75	1.6	(b)	5.3
Ponderosa Dairy Well 2	4	73	-299	-35	66	(b)	220
Ash Meadows							
Big Spring	2	-1.51	-4.87	-3.2	146	(b)	5.0
Crystal Pool	4	-1.43	-7.4	-4.4	1.6	(b)	5.2
Fairbanks Spring	2	0.16	-3.94	-1.90	1.6	(b)	5.4
Longstreet Spring	2	-2.04	-2.81	-2.42	1.6	(b)	5.3
17S-50E-14cac	2	40	-25	7.8	64	(b)	206
Beatty							
Low Level Waste Site	Well Down						
Tolicha Peak	4	132	-305	-122	65	(b)	220
11S-48E-1dd Coffer's	4	83.1	-3.68	23	7.7	(b)	5.2
12S-47E-7dbd City	2	105	0	63	63	(b)	206
Clark Station							
TTR Well 6	2	95	36	65	63	(b)	206
Goldfield							
Klondike #2 Well	2	18	-47	-14	1.3	(b)	208
Hiko							
Crystal Springs	2	140	-25	8	63	(b)	206
Indian Springs							
Sewer Co. Well 1	2	57	-41	27	63	(b)	206
Air Force Well 2	2	27	-41	12	63	(b)	206
Lathrop Wells							
15S-50E-18cdc City	2	88	-1.65	43	63	(b)	206
Nyala							
Sharp's Ranch	2	79	-8	36	63	(b)	206
Rachel							
Penoyer Culinary	4	65	-33	3.6	65	(b)	219
Tonopah							
City Well	2	95	36	65	63	(b)	206
Warm Springs							
Twin Springs Ranch	4	-5.4	-333	-145	65	(b)	220

(a) DCG - Derived Concentration Guide. Established by DOE Order as 90,000 pCi/L.
(b) Not applicable because the result is less than the MDC or water is known to be nonpotable.
Note: Underline indicates enrichment analysis ^3H, regular font indicates conventional analysis.

Table 5.17 NTS Sewage Influent Quality - 1999

	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter	
Facility	S.C.[b] (mS/cm)	BOD5[a] (mg/L)	S.C.[b] (mS/cm)	BOD5[a] (mg/L)	S.C.[b] (mS/cm)	BOD5[a] (mg/L)	S.C.[b] (mS/cm)	BOD5[a] (mg/L)
Gate 100	1.23	266	1.32	1188	2.27	180	1.60	402
Mercury	0.76	184	0.80	339	0.99	150	0.87	585
Yucca Lake	0.85	169	1.05	299	0.63	82	0.88	209
LANL	1.15	162	1.26	159	1.18	150	1.05	174
DAF	1.13	47	1.04	35	1.23	12	1.04	64
Reactor Control	0	0	0	0	0	0	0	180
Test Stand 1[c]	0	0	0	0	0	0	0	0
Area 25 CSF	1.05	142	0.83	89	0.87	61	0.95	331
Area 12 Camp	0.22	<2.0	0.24	2.0	0.24	<5.0	0.25	3.0
Area 5 RWMS	1.09	137	1.31	96	1.41	110	1.11	1071

(a) Biochemical Oxygen Demand - 5-day Incubation.
(b) Specific Conductance.
(c) Standby Status - Portable Toilet Waste Only.

Table 5.18 NTS Sewage Pond Organic Loading Rates - 1999

Facility	Limit (Kg/day)	(Jan-Mar) Mean Daily Load	(Apr-June) Mean Daily Load	(Jul-Sept) Mean Daily Load	(Oct-Dec) Mean Daily Load
			Metered Rates		
Mercury	172	31.85	54.78	24.50	86.50
LANL	5.0	0.63	0.64	0.60	0.70
Yucca Lake	8.6	3.20	4.06	2.20	2.90
Area 12 Camp	54	0.01	0.01	0.00	<0.10
Area 5 RWMS	0.995	0.58	0.56	0.60	0.60
			Calculated Rates		
DAF	7.6	0.24	0.38	0.60	0.60
Reactor Control	4.2	0	0	0	0
Eng Test Stand	2.3	0	0	0	0
Area 25 CSF	7.4	2.41	1.66	0.70	4.10
Gate 100	2.4	0.23	3.60 [a]	1.40	1.80

(a) Calculated BOD exceeded, no septic conditions noted.

Table 5.19 Influent Toxics for Facilities that Received Industrial Wastewater - 1999

Parameter	Compliance Limit (mg/L)	Mercury Measurement (mg/L)	Area 25 Base Camp Measurement (mg/L)	Area 6 DAF Measurement (mg/L)	Area 5 RWMS Measurement (mg/L)	Area 6 LANL Measurement (mg/L)	Area 6 Yucca Lake Measurement (mg/L)
Arsenic	5.0	(a)	(a)	(a)	(a)	(a)	(a)
Barium	100	(a)	(a)	(a)	(a)	(a)	(a)
Cadmium	1.0	(a)	(a)	(a)	(a)	(a)	(a)
Chromium	5.0	(a)	(a)	(a)	(a)	(a)	(a)
Lead	5.0	(a)	(a)	(a)	(a)	(a)	(a)
Mercury	0.2	(a)	(a)	0.0041	(a)	(a)	(a)
Selenium	1.0	(a)	(a)	(a)	(a)	(a)	(a)
Silver	5.0	(a)	(a)	(a)	(a)	(a)	(a)
Benzene	0.5	(a)	(a)	(a)	(a)	(a)	(a)
Carbon Tetrachloride	0.5	(a)	(a)	(a)	(a)	(a)	(a)
Chlorobenzene	100	(a)	(a)	(a)	(a)	(a)	(a)
Chloroform	6.0	(a)	(a)	(a)	(a)	(a)	(a)
1,4-dichlorobenzene	7.5	(a)	(a)	(a)	(a)	(a)	(a)
1,2-dichloroethane	0.5	(a)	(a)	(a)	(a)	(a)	(a)
1,1-dichloroethylene	0.7	(a)	(a)	(a)	(a)	(a)	(a)
Methylethyl Ketone	200	(a)	(a)	(a)	(a)	(a)	(a)

(a) Not Detected.

Table 5.19 (Influent Toxics for Facilities that Received Industrial Wastewater - 1999, cont.)

Parameter	Compliance Limit (mg/L)	Mercury Measurement (mg/L)	Area 25 Base Camp Measurement (mg/L)	Area 6 DAF Measurement (mg/L)	Area 5 RWMS Measurement (mg/L)	Area 6 LANL Measurement (mg/L)	Area 6 Yucca Lake Measurement (mg/L)
Pyridine	5.0	(a)	(a)	(a)	(a)	(a)	(a)
Tetrachloroethylene	0.7	(a)	(a)	(a)	(a)	(a)	(a)
Trichloroethylene	0.5	(a)	(a)	(a)	(a)	(a)	(a)
Vinyl Chloride	0.2	(a)	(a)	(a)	(a)	(a)	(a)
Cresol, total	200	(a)	(a)	(a)	(a)	(a)	(a)
2,4-dinitrotoluene	0.13	(a)	(a)	(a)	(a)	(a)	(a)
Hexachlorobenzene	0.13	(a)	(a)	(a)	(a)	(a)	(a)
Hexachlorobutadiene	0.5	(a)	(a)	(a)	(a)	(a)	(a)
Nitrobenzene	2.0	(a)	(a)	(a)	(a)	(a)	(a)
Pentachlorophenol	100	(a)	(a)	(a)	(a)	(a)	(a)
2,4,5-trichlorophenol	400	(a)	(a)	(a)	(a)	(a)	(a)
2,4,6-trichlorophenol	2.0	(a)	(a)	(a)	(a)	(a)	(a)
Chlordane	0.03	<0.03	<0.03	(a)	(a)	<0.03	(a)
Endrin	0.02	<0.02	< 0.02	(a)	(a)	<0.02	(a)
Heptachlor	0.008	<0.008	0.008	0.008	(a)	<0.008	<0.008
Lindane	0.4	<0.40	<0.40	(a)	<0.40	<0.40	(a)
Methoxychlor	10.0	<10.0	<10.0	<10.0	(a)	<10.0	<10.0
Toxaphene	0.5	<0.50	<0.50	(a)	<0.50	<0.50	(a)
2,4-D	10.0	(a)	(a)	(a)	(a)	(a)	(a)
2,4,5-TP (Silvex)	1.0	(a)	(a)	(a)	(a)	(a)	(a)

(a) Not Detected.

Table 5.20 Sampling Data for Infiltration Ponds Containing 30 cm or More - 1999

Parameter	Action Level (mg/L)	A-25 CSF January (mg/L)	A-25 CSF June (mg/L)
Arsenic	0.5	0.03	(a)
Cadmium	0.1	(a)	(a)
Chromium	0.5	(a)	0.01
Lead	0.5	0.002	0.06
Selenium	0.1	0.012	(a)
Silver	0.5	(a)	(a)
Nitrate Nitrogen	100	(a)	(a)
Sulfate	5000	66	170
Chloride	1000	53	150
Fluoride	40	6.6	15
Tritium	Monitor Only	--------	72 (pCi/L)

(a) Not Detected.
Note: Most sewage ponds on the NTS are exempt from this requirement.

Table 5.21 Nitrate Analyses of Well Water Samples, First Quarter - 1999

Water System/Well	Nitrates (MCL[c] 10 ppm[a])	Nitrates + Nitrites (MCL10 ppm)	Fluoride (MCL 4 ppm)	Arsenic (MCL .05 ppm)	Lead (action level .015 ppm)
NY-0360-12C					0.0073
Army Well	0.3	(b)		(b)	
Well 5B	3.3	(b)		(b)	
Well 5C	1.7	(b)		0.035	
Well 4	4.2	4.3		(b)	
Well 4A	4.1	4.2		(b)	
Well C-1	ND	(b)		(b)	
NY-4098-12NCN					0.0076
Well J-12	2.0	(b)	2.1	(b)	
Well J-13	2.1	(b)	2.3	(b)	
NY-4099-12C					0.0275
Well 8	1.2	1.2		(b)	
NY-5024-12NCN					0.03
Well UE16d	(b)	(b)		(b)	

(a) Parts per Million.
(b) Not Detected.
(c) Maximum Contaminant Level.

Table 5.22 NTS Drinking Water System Permits - 1999

Permit No.	Area(s)	Expiration Date	Reporting Required
NY-5024-12CNT	Area 1	09/30/2000	None
NY-4099-12C	Area 2 & 12	09/30/2000	None
NY-360-12C	Area 5,6,22, 23	09/30/2000	None
NY-4098-12CNT	Area 25	09/30/2000	None
NY-835-12H	Sitewide Truck	09/30/2000	None
NY-836-12H	Sitewide Truck	09/30/2000	None
NY-841-12H	Sitewide Truck	09/30/2000	None

Table 5.23 Sewage Discharge Permits - 1999

Permit No./Location	Areas	Expiration Date	Reporting Required
	NTS Permits		
GNEV93001[(a)]	NTS General Permit	12/07/2004	Quarterly
NY-17-05704	X Tunnel Collection System	09/30/00	Quarterly
	Off-NTS Permits		
North Las Vegas Facility			
VEH-112	Class II Wastewater Contribution Permit[(a)]	12/31/2001	Annually
Special Technologies Laboratory			
AII-204/Santa Barbara, California		12/31/2001	
III-331/Santa Barbara, California		12/31/2001	

(a) Owner/Operator effluent monitoring required by permit.

Table 5.24 Permits for NTS Septic Waste Hauling Trucks - 1999

Permit Number	Vehicle Identification Number	Expiration Date
NY-17-03313	Septic Tank Pumper E-105293	11/30/2000
NY-17-03315	Septic Tank Pumper E-105919	11/30/2000
NY-17-03317	Septic Tank Pumper E-105918	11/30/2000
NY-17-03318	Septic Tank Pumping Subcontractor	11/30/2000

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

6.0 OTHER REPORTABLE ACTIVITIES

Reported in this section are environmental surveillance activities other than those in air and water. Activities reported are those related to the Nevada Test Site (NTS) missions and special studies under the purview of the Environment, Safety and Health Division (ESHD) of the U.S. Department of Energy Nevada Operations Office (DOE/NV). Included herein are ecological monitoring, historic preservation, pollution prevention, Hazardous Materials Spill Center (HSC) operations, and waste management activities. Ecological monitoring encompasses habitat mapping, ecosystem monitoring, monitoring of special interest wildlife and plants, monitoring of natural and man-made water sources used by wildlife and related studies.

6.1 STOCKPILE STEWARDSHIP RELATED ACTIVITIES

Under the terms of an Interagency Agreement between the DOE and the U.S. Environmental Protection Agency (EPA), the EPA's Office of Radiation and Indoor Environments National Laboratory-Las Vegas (R&IE-LV) conducts the Offsite Radiation Safety Program (ORSP). The primary activity of the ORSP is routine monitoring of potential human exposure pathways. These pathways include groundwater (discussed in Chapter 5), and air and direct radiation exposure (discussed in Chapter 4). Maintaining readiness to support nuclear testing, public information, and community assistance constitute secondary activities.

Three subcritical experiments were conducted in 1999. For each of the experiments, R&IE-LV senior personnel served on the Test Controller's Scientific Advisory Panel and on the EPA's offsite radiological safety staff. No radioactive materials were released to the ambient environment as a result of these experiments.

6.2 NONRADIOLOGICAL MONITORING

The 1999 nonradiological monitoring program for the 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 habitat mapping in northern NTS areas, characterized springs, monitored man-made water sources, conducted wild horse surveys, and prepared a biological monitoring plan for the HSC. In 1999, nonradiological monitoring was performed for six tests involving 21 chemicals that were at the HSC.

ENVIRONMENTAL SURVEILLANCE

Routine nonradiological monitoring on the NTS in 1999 was limited to:

- Nevada operating permit requirements.
- Sampling of electrical equipment oil, soil, water, surfaces, and waste oil for the presence of polychlorinated biphenyls (PCBs) as part of Toxic Substance Control Act compliance.
- Sampling of soil, water, sediment, waste oil, and other media for Resource Conservation and Recovery Act (RCRA) constituents.

Two facilities at the NTS that are listed in the NTS Hazardous Waste Management Permit have undergone RCRA Closure and require post-closure monitoring.

- Post-closure monitoring of the Mercury Landfill Hazardous Waste Trenches RCRA Closure Unit was conducted in 1999. The covers continue to perform as designed, with no releases occurring.

- Post Closure monitoring of the U-3fi Injection Well RCRA Closure Unit was conducted on a quarterly basis. Downward movement of moisture was not detected during the calendar year (CY); therefore, the conditions of the permit have not been exceeded.

ECOLOGICAL MONITORING

The ecological monitoring tasks conducted under the EMAC program in 1999 included habitat mapping, monitoring of special interest plants and wildlife, monitoring wetlands and wildlife water sources, and review of test plans for experiments conducted at the HSC to determine if biological monitoring was needed.

HABITAT MAPPING

In CY 1996, efforts began to map the wildlife and plant habitat of the NTS. Selected biotic and abiotic habitat features were collected within field mapping units called Ecological Landform Units (ELUs). ELUs are landforms with visually similar vegetation, soils, slope, and hydrology. Boundaries of the ELUs were defined using aerial photographs, satellite imagery, and field confirmation. ELUs are considered to be the most feasible mapping units by which sensitive plant and animal habitats on the NTS can be described. A total of 1,510 ELUs have been sampled on the NTS. Within each sampled ELU, habitat and vegetation data such as the surficial geology, relative abundance of shrub and tree species, and the percent ground cover by perennial plants were recorded. A habitat map showing the location of major woodland and shrubland alliances on the NTS was developed based on cluster analysis of the vegetation data from the 1,510 ELUs (Figure 6.1). ELUs were grouped into clusters based on the abundance of shrub/tree species within them. The analysis identified clusters, called vegetation associations, that were named according to the two or three most abundant shrub species found in a cluster. Each cluster of ELUs was then grouped into an alliance, defined by The Nature Conservancy (Grossman *et al.*, 1998; Anderson *et al.*, 1998), as a group of vegetation associations that have the same two to four dominant species. For the purposes of presentation, the vegetation alliances on the NTS were divided into groups, characteristic of either the Mojave Desert, the Great Basin Desert, or the Transitional Zone between these two deserts.

Analysis of selected biotic and abiotic data collected from ELUs was performed to identify groups of ELUs which may warrant active protection from DOE activities. Four groups of ELUs were identified:

- Pristine - ELUs with few man-made disturbances.
- Unique - ELUs containing uncommon biological resources such as a natural wetland.
- Sensitive - ELUs containing vegetation associations which recover very slowly from direct disturbance.
- Diverse - ELUs with high plant species diversity.

These groups are considered important NTS habitats (Figure 6.2). One ecosystem management goal is to minimize cumulative impacts on all plants and animals of the NTS. The long-term protection of these important habitats is considered one method by which overall cumulative impacts on biological resources can be minimized. During the siting review for new projects, it is recommended that these habitats be avoided, whenever possible.

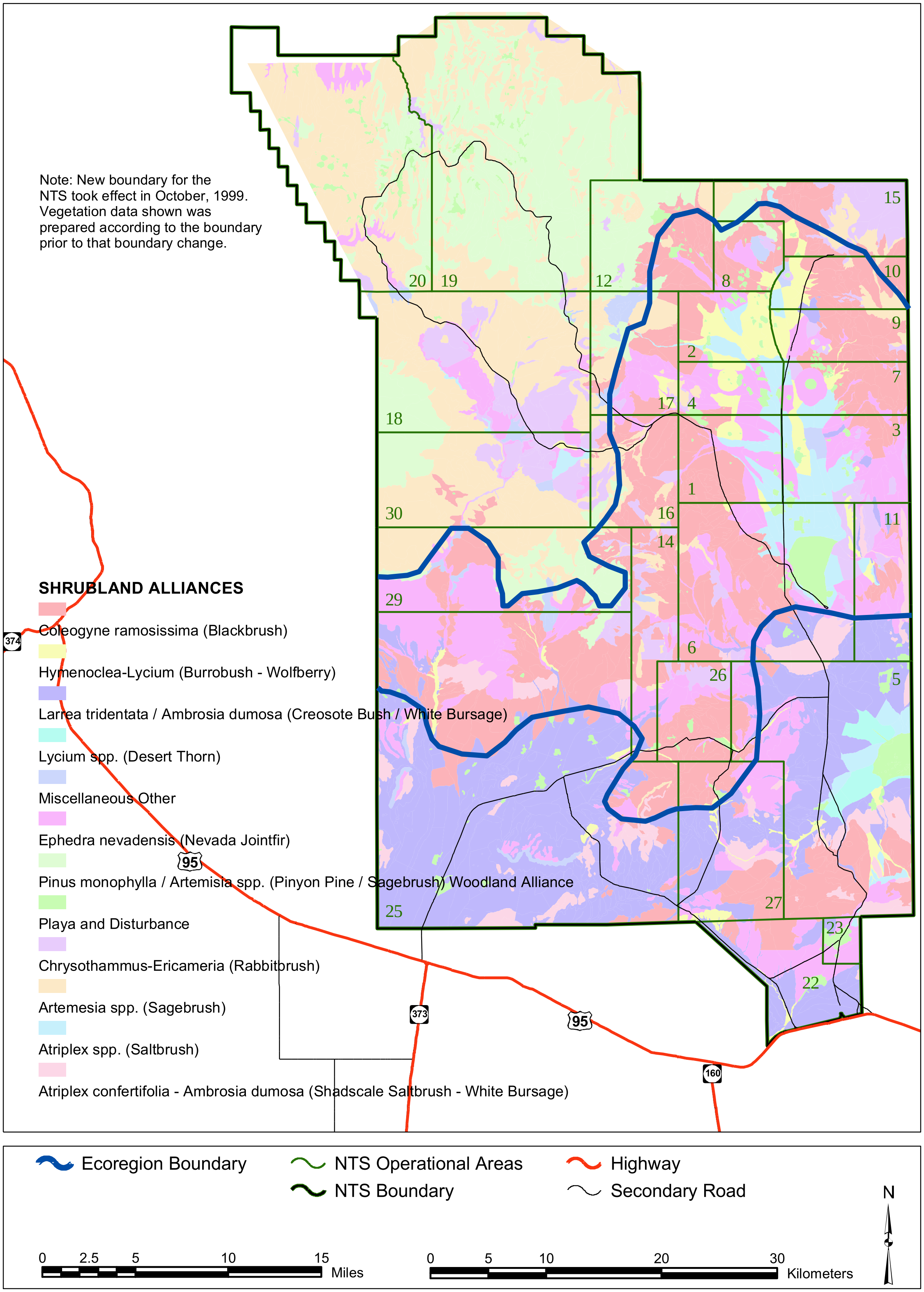


Figure 6.1 Habitat Map of Vegetation Alliances on the NTS

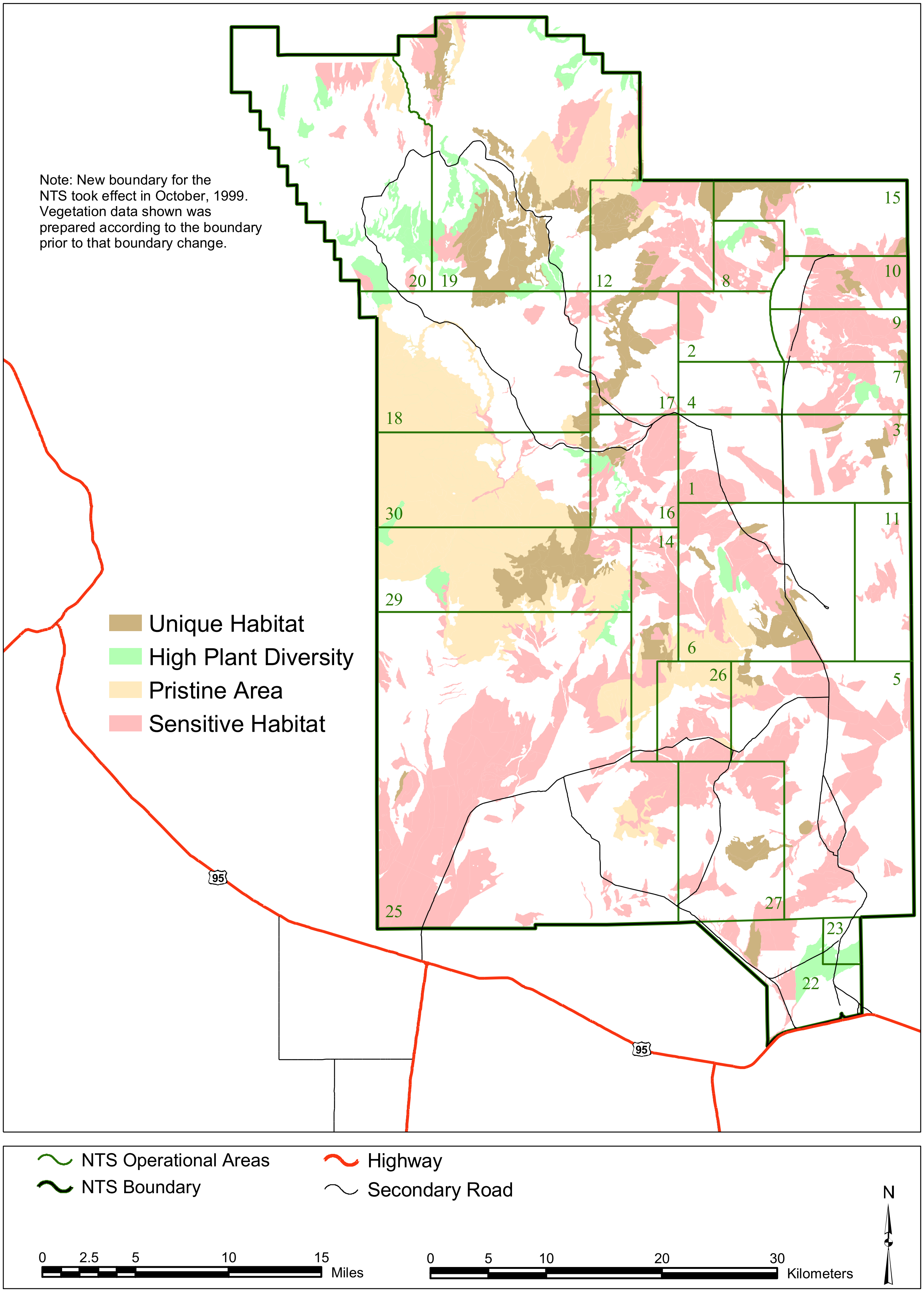


Figure 6.2 Important Habitats on the NTS

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 DOE/NV actions. 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

Clokey's eggvetch (*Astragalus oophorus* var. *clokeyanus*) is currently the only candidate plant known to occur on the NTS. Field surveys to collect baseline data for this plant were initiated in 1996 and completed in 1998 (Anderson 1998). The field surveys contributed significantly to the overall understanding of this species' distribution and need for protection. Its distribution extends from the Spring Mountains, just west of Las Vegas, Nevada, north to Cedar Pass in the Kawich Range, approximately 70 miles southeast of Tonopah, Nevada. Anderson (1998) concluded that, due to its localized distribution within Nevada, Clokey's eggvetch should be considered a species of concern, but it does not warrant the status of candidate species for listing under the ESA. This recommendation was approved by the USFWS.

Surveys for twelve plant species of concern were completed in 1995 (Blomquist *et al.*, 1995). No new field surveys for sensitive plants were conducted in 1999. Sufficient baseline data has been collected to initiate long-term monitoring of all sensitive plants.

WESTERN BURROWING OWL

The western burrowing owl (*Speotyto cunicularia*) is a species of concern which breeds on the NTS. It is found throughout the central and western United States and Canada in flat, open, well-drained grasslands, steppes, deserts, prairies, and agricultural lands (Haug *et al.*, 1993). These owls usually occupy the burrows made by other animals, and population declines over their range have been related to habitat destruction, pesticides, and predators. On the NTS, the burrowing owl occurs in all three ecoregions: the Great Basin Desert, Transition Zone, and the Mojave Desert (Figure 6.3). They occupy the burrows of predators (e.g., coyote, kit fox, badger) and desert tortoises, as well as man-made structures such as buried pipes.

The objective of burrowing owl monitoring is to collect baseline information on the distribution and relative abundance of these owls on the NTS. This information will allow DOE/NV to minimize impacts of its activities on the species and be prepared for consultation with the USFWS if the species were ever listed under ESA. Collection of baseline data continued in 1999.

Twenty-eight burrows were found this year during searches for new burrows, bringing the total number of known burrows to 64 (Figure 6.3). For monthly monitoring of known burrows, 19 burrows were monitored in the Mojave Desert ecoregion, 35 in the Transition Zone, and 7 in the Great Basin Desert. This is the second year of monitoring which has confirmed that some burrowing owls reside year round on the NTS, although most migrate seasonally.

Seven different breeding pairs of owls were detected. A total of 14 juvenile owls were observed at 4 burrows in the Transition Zone (3 to 5 young per burrow) and 10 juveniles were observed at three burrows in the Great

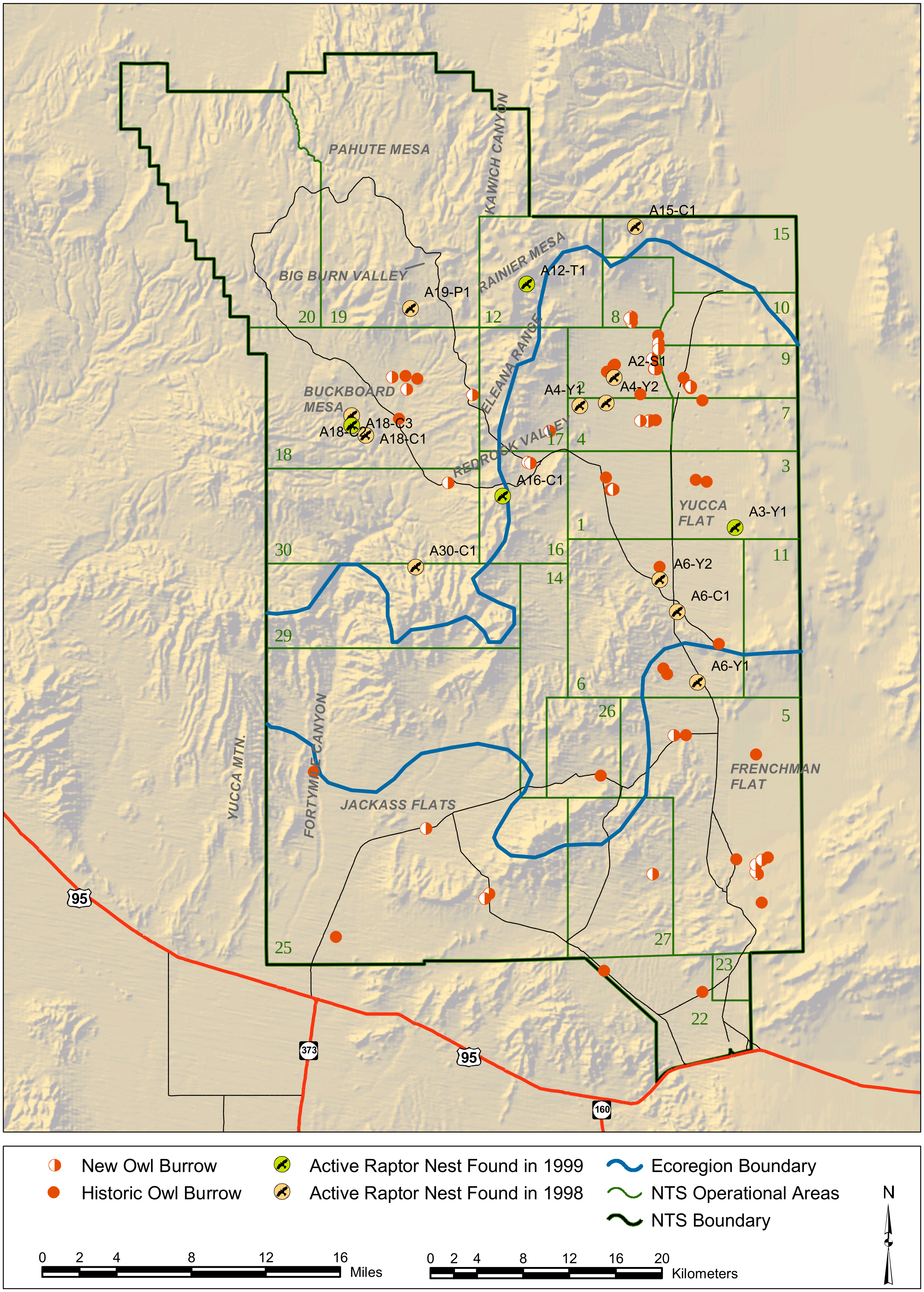


Figure 6.3 Location of Known Owl Burrows and Raptor Nests on the NTS - 1999

Basin Desert (one to six young per burrow). No breeding pairs or young owls were detected in the Mojave Desert ecoregion.

The 1999 monitoring data suggest that prey may have been more abundant and owl habitat better in the Transition Zone and Great Basin Desert portions of the NTS than in the Mojave Desert portion. Also, nearly two-thirds of the known burrows monitored this year were man-made, consisting of partially- or fully- buried pipes and open-ended culverts. This suggest that some human activities on the NTS have benefitted this species by providing suitable burrows.

BAT SPECIES OF CONCERN

Minimal work has been done in the past to document bat communities on the NTS. Jorgensen and Hayward (1965) opportunistically collected four bat species on the NTS, although O'Farrell and Emery (1976) concluded that there were several additional species having geographic ranges which overlap the NTS. During the 1990s, surveys brought the number of bat species on the NTS to 13 (EG&G/EM 1993; Saethre 1994; Steen *et al.*, 1997; BN 1998). In 1999, yet another species (the big free-tailed bat [*Nyctinomps macrotis]*) was detected on the NTS via vocalization surveys. Of the 14 bat species now documented on the NTS, 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.

Mist-net capture and recorded-vocalization surveys for bats were continued this year to estimate the distribution of these species and their roost sites. These data are used to evaluate and mitigate impacts of DOE/NV activities on these bats and will be used as baseline date for monitoring trends in the distribution and abundance of the bats.

In 1999, 46 bats representing 5 species of concern, were captured in mist-nets at water sources in the Great Basin Desert eco-region. No bat species of concern were captured in the other two eco-regions of the NTS (Mojave Desert, Transition Zone) this year.

Mist-net trapping data suggest that the best bat habitat on the NTS is found in the Great Basin Desert ecoregion. This is probably due to the fact that bats use mines, caves, crevices, trees, and/or cliffs as roost sites (Brown and Pierson, 1996), and these features are found in greater abundance in the Great Basin Desert ecoregion than in the other ecoregions of the NTS.

WILD HORSES

Wild horses (*Equus caballus*) occur on the NTS, and ongoing monitoring of this species was conducted in fiscal year (FY) 1999. 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, DOE/NV is committed to this same management goal on the NTS. In 1997, DOE/NV signed a Five-Party Cooperative Agreement with Nellis Air Force Range (NAFR), USFWS, U.S. Bureau of Land Management (BLM), 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. BN conducts an annual horse census on the NTS. The NTS horse population has not increased in size over time as on the NAFR, and it appears to be isolated from the NAFR population. In the past five years, a decline in horse numbers on the NTS has been observed.

In FY 1999, BN biologists performed three tasks related to horse monitoring:

- Annual horse abundance was estimated to monitor population stability.

- Horse signs were recorded along selected roads to better define the geographic range of horses on the NTS.

- 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.

Since 1995, the feral horse population has declined 43 percent, from 54 to 31 horses (these counts exclude foals) (Table 6.1). Of the 23 horses which have been classified as missing since 1995, 11 were males, 10 were females, and 2 were yearlings of unknown sex. No foals observed in 1995 through 1998 survived to yearlings. Natural processes (e.g., predation, emigration) may be likely causes of the observed population decline. Although some indirect evidence of predation on foals and adults has been observed (e.g., partially eaten carcasses), direct evidence is lacking.

The annual population census of horses has routinely been conducted in the summer when horses are nearer to water sources and thus easier to find. These census surveys provide an adequate estimate of the summer range of horses on the NTS but are not useful for estimating their annual range. In 1999, selected roads were driven within and along the boundaries of the suspected annual horse range and all fresh sign (estimated to be < 1 year old) located on and adjacent to the roads were recorded. Horse sign data collected during the road surveys and horse use at natural and man-made water sources indicate that the 1999 NTS horse range includes Kawich Canyon, Gold Meadows, northwest Yucca Flat, southwest foothills of the Eleana Range, and southeast Pahute Mesa (Figure 6.4).

The annual horse range appears not to have changed in areal extent or shape from the previous year.

Two newly found wetlands in Area 30, Wild Horse and Little Wild Horse seeps, are located within the annual horse range on the NTS and were used by horses in spring and summer. Only two other natural water sources (Captain Jack and Gold Meadows Springs in Area 12) and one man-made pond (Camp 17 Pond in Area 18) were used by horses this summer, as in past years.

RAPTORS

There are eight raptors (Table 6.2) which are known to breed on the NTS (Greger and Romney, 1994); 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 1999.

From April through July 1999, the following regions were surveyed: Yucca Flat, Oak Spring Butte, Buckboard Mesa, Rainier Mesa, lower Stockade Wash, Shoshone Mountain, and the Tippipah Spring area. These regions included three new areas which had not been previously searched: (1) a Joshua tree habitat in southeast Yucca Flat, (2) a cliff site west of Tippipah Spring, and (3) a cliff site in Stockade Wash. Ten of the twelve active nest sites found in 1998 were surveyed again in 1999.

When nests were found, efforts were made to determine the number of young in the nest without disturbing the birds. Nests containing young were periodically revisited to determine the status of nestlings.

Four new raptor nests were detected during ground searches (Figure 6.3). Five active nests were detected this year (two golden eagle cliff nests, one red-tailed hawk cliff nest, one red-tailed hawk Joshua tree nest,

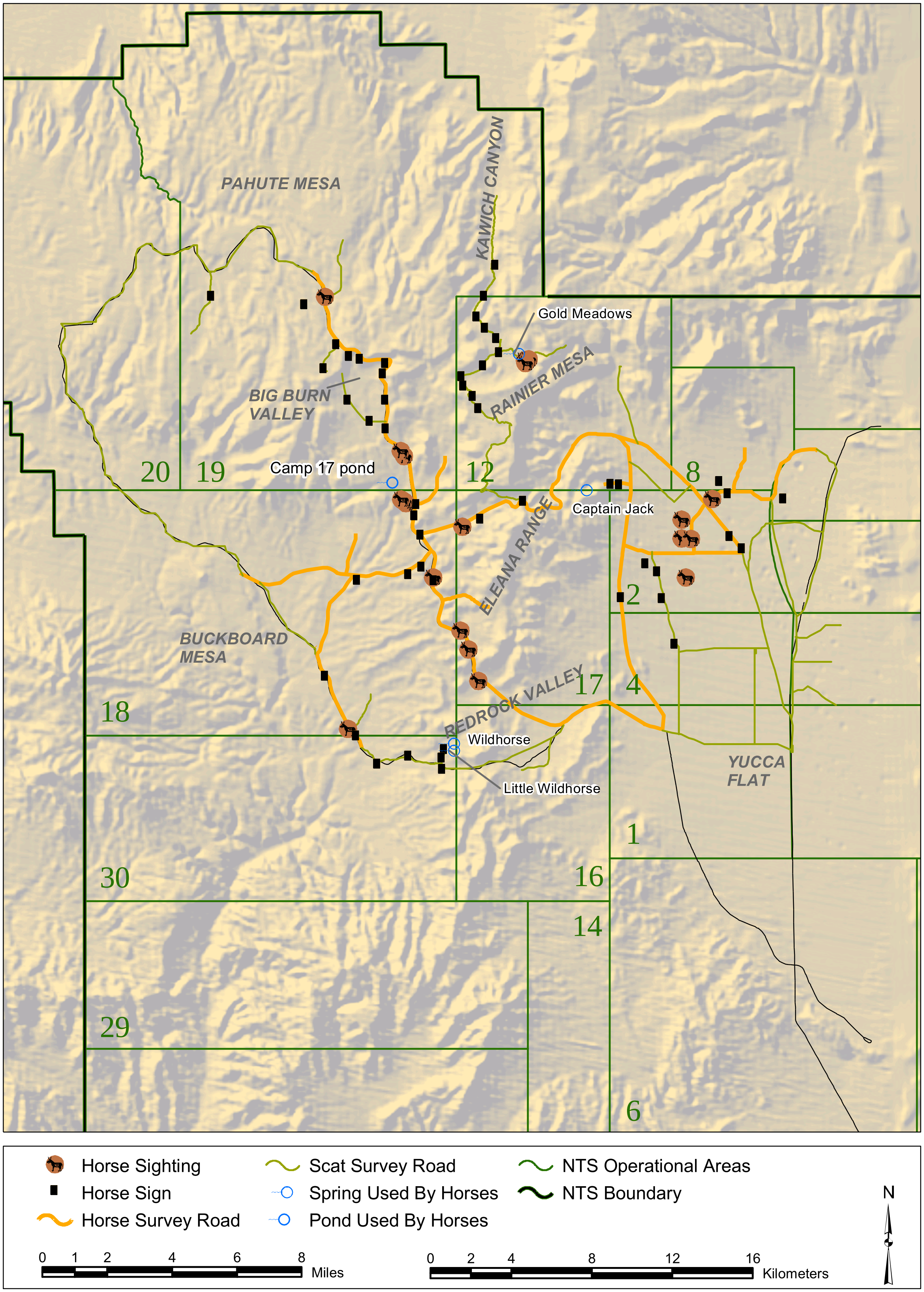


Figure 6.4 Feral Horse Sightings and Horse Sign Observed on the NTS - 1999

and one red-tailed hawk microwave tower nest). Twelve active raptor nests were observed last year. None of four Joshua tree nests and one of five cliff nests active in 1998 were reused this year.

Three of the five active nests found this year contained young birds. Among them were three eaglets and two red-tailed hawk nestlings.

The number of active nests is an index of the number of breeding pairs on the NTS. The low number of breeding pairs (i.e., active nests) observed this year may be due to a reduced prey base of mourning doves. Lower numbers of doves on the NTS (and other prey species like small mammals and insects) may be the result of a relatively dry fall in 1998 and a dry winter and spring in 1999.

These survey data continue to support the recommendation to avoid, whenever possible, the removal of Joshua trees within proposed project areas because they are known to provide an important structural component to the ecosystem. Also, elevated cliff-nesting sites for species such as golden eagles and red-tailed hawks should be left unaltered whenever possible because they may be used repeatedly year after year.

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 DOE/NV activities. Also, if a spring classified as a jurisdictional wetland were to be unavoidably impacted by a DOE/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.

In 1998, BN biologists described five new wetland sites on the NTS (four new seeps and one man-enhanced pond) (BN 1998). They are Wildhorse, Little Wildhorse, Rattlesnake seeps, Wahmonie Seep #4, and Pahute Mesa Pond (Figure 6.5). These five sites were visited in May 1999 to determine if they have the following three field indicators which meet the criteria of jurisdictional wetlands: hydrophytic vegetation, wetland hydrology, and hydric soils. These field indicators have been measured and reported for the other 25 natural water sources of the NTS (Hansen *et al*., 1997). During the May survey, Wildhorse Seep, Little Wildhorse Seep, and Wahmonie Seep #4 possessed all three field indicators. Rattlesnake Seep and Pahute Mesa Pond lacked dominance of hydrophytic vegetation. These five water sources will continue to be monitored for the next two years to determine variations in site vegetation and hydrology. Once the hydrology and vegetation have been fully characterized, a supplement to the previous wetlands report (Hansen et al., 1997) will be prepared.

Monitoring of selected NTS wetlands was continued this year to characterize seasonal trends in physical and biological parameters. A total of 18 wetlands was visited at least once to record the presence/absence of land disturbance, water flow rates, and surface area of standing water (Table 6.3).

The wildlife observed during visits to these water sources was also recorded. Four species of mammals and 16 species of birds were detected at 14 water sources. The most widely distributed species was the coyote, observed at 9 of the 14 sites. Horses, mule deer, and mountain lion were the other mammals observed. Chukar and Gambel's quail were each observed at four different sites and were the most abundant

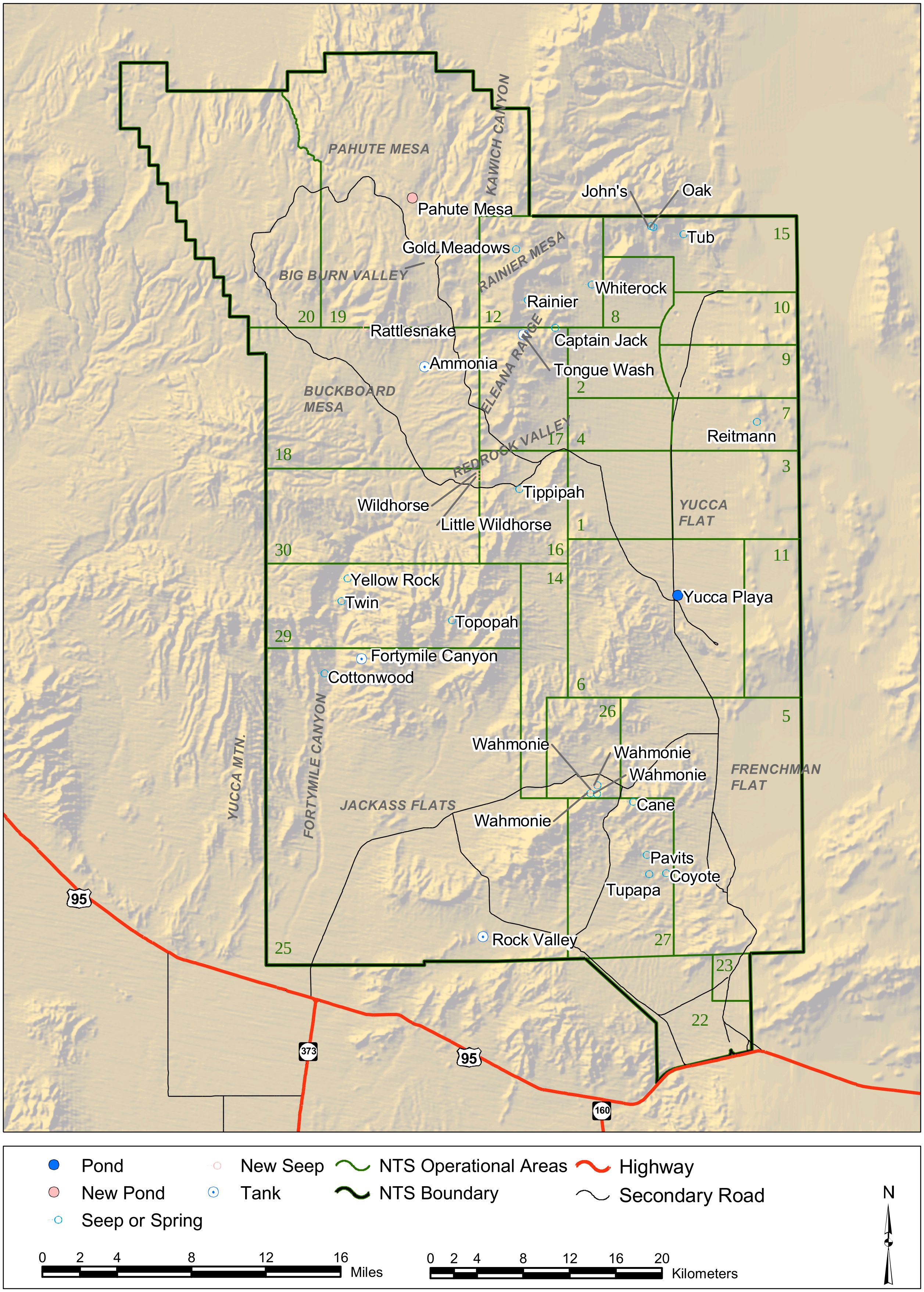


Figure 6.5 Natural Water Sources on the NTS

bird species observed. Mourning doves were not observed at any of the water sources, whereas in 1998, they were the most numerous and widely distributed birds observed during the summer.

MONITORING MAN-MADE WATER SOURCES

Man-made excavations constructed to contain water occur throughout the NTS. Like natural water sources, they too can affect the movement patterns of some species (e.g., wild horses). However, they can also cause accidental wildlife mortalities from entrapment and drowning if not properly constructed or maintained. Quarterly monitoring of man-made water sources was conducted in 1999. These sources, located throughout the NTS, included 35 plastic-lined sumps, 39 sewage treatment ponds, 13 unlined well ponds, and 4 radioactive containment ponds. Several ponds or sumps are located next to each other at the same project site. They are monitored to assess their use by wildlife and to develop and implement mitigation measures to make them safer for use by wildlife. Mitigation measures, required under the Mitigation Action Plan for the Final Environmental Impact Statement (DOE 1996c), include placing flag lines over contaminated water sources to repel birds, or fencing or covering them. Quarterly monitoring ensures that all flag lines, fencing, or covers are checked for their integrity and repaired when needed.

Man-made water sources were visited during four quarterly sampling periods; November, February, May and August 1999. Use of unlined sumps and ponds by migratory birds and mammals such as coyotes and deer was common. The fences installed around the plastic-lined sumps do not exclude coyotes or deer, as their tracks were observed commonly inside many of the fences. Birds were observed much less at the plastic-lined sumps compared to the unlined ponds.

Four coyotes have drowned in sump #3, a plastic-lined sump at ER-20-6 in Area 20. One deer was also found dead in sump #4, also located at ER-20-6, during February 1999. Sump #3 is particularly dangerous to animals because it is commonly nearly full and there are no ramps extending above the waterline which can be used by trapped animals. Recommendations to install a sediment ramp in one corner of this sump and lowering the water level 4-5 ft in depth were made in quarterly reports.

HAZARDOUS MATERIALS SPILL CENTER MONITORING

Biological monitoring at 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, DOE 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.

Biota monitoring was not conducted for any of the chemical tests at the HSC during 1999. No baseline monitoring was conducted at established control-treatment transects near the HSC due to insufficient funding.

HISTORIC PRESERVATION

Historic preservation studies and surveys are conducted by the Desert Research Institute (DRI), University and Community College System of Nevada. In 1999, six cultural resources surveys, one inventory project, and one historical evaluation were conducted at the NTS. The six cultural resources surveys were undertaken in support of proposed projects with 2,928 acres examined by historic preservation personnel. Seven archaeological sites were located and recorded during these surveys. Only one of the sites, Camp Desert Rock, was determined eligible to the National Register of Historic Places (NRHP) through consultation between the DOE/NV and the Nevada State Historic Preservation Office (NSHPO). The other six sites did not meet the criteria for NRHP eligibility. The one inventory project entailed the recording of atmospheric nuclear testing remains in and near Frenchman Lake in Area 5. This project identified 155 structures and associated features. The technical report detailing the results is in progress and is expected to result in the creation of a Frenchman Flat Historic District. A historical evaluation of the Nuclear Rocket Development Station Train Engine housed in the EMAD facility in Area 25 was undertaken in response to a proposal to move the train engine from its present location to the train museum in Boulder City. The historical evaluation demonstrated the significance of the train engine for its association with important events in our history. Through consultation between DOE/NV and the NSHPO, the engine was determined eligible to the NRHP and DOE/NV received concurrence from the NSHPO to relocate it.

The technical report that describes the results of an archaeological data recovery program for the proposed Kistler Rocket Launch Facility in the northern part of the NTS was finalized and accepted for inclusion in Nevada's Cultural Resources archives. This mitigative action was conducted because a proposed project could not be relocated and impacts to the site were considered unavoidable. Also completed this year was the draft technical report on the Fortymile Canyon petroglyphs. The archaeological research documented more than 2,900 images on approximately 700 boulders at a number of sites in the area. The final report will be issued in 2000.

In addition to the aforementioned documents, the Secretary of the Interior's Report to Congress on Federal Archaeological Activities Questionnaire for FY 1998 was completed for DOE/NV activities. The Cultural Resources Management Plan for the NTS was finalized and distributed to interested parties. Besides reviewing compliance requirements and DOE/NV procedures related to cultural resources, the plan also identifies the historic preservation projects that need to be conducted in the near future. Following DOE/NV's commitments relating to the Resource Management Plan (RMP), the historic preservation section for the 1999 annual update to the RMP was completed. Additionally, the databases outlined in the RMP were maintained and updated.

The program to monitor the historic properties on the NTS was initiated in 1999 with a database study to determine the number of sites to be monitored in 2000 and to compile all information regarding these sites. The purpose of this program is to determine if any of the sites are being adversely affected by natural and human activities.

To comply with federal regulations in Title 36 CFR 79 (CFR 1966), DRI continues to curate the more than 500,000 artifacts in the DOE/NV collection. DRI produced an annual report summarizing curation compliance activities.

One report was prepared on consultations conducted with Native American tribes and organization. The report summarized the recommendations of the Consolidated Group of Tribal Organizations in regard to the repatriation of selected artifacts from recently accessioned collections from the NTS.

Other efforts on the NTS in 1999 included preparing management objective and plans and promoting public relations and communications concerning the NTS historic preservation program.

6.3 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. DOE/NV's 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.

Another effective method for source reduction is the coordination of the material exchange program within DOE/NV and between DOE/NV and other governing agencies (e.g., Nevada Department of Environmental Protection). Unwanted chemicals, supplies, and equipment are posted on the intranet 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, DOE/NV's P2 program must include the implementation of an employee awareness program. Employee awareness of P2 issues throughout DOE/NV is accomplished by dissemination of articles through both electronic mail and DOE/NV newsletters, the development and 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.

POLLUTION PREVENTION ACTIVITIES

DOE/NV demonstrated efforts to deactivate reactive waste, specifically the treatment of waste explosives at the NTS Area 11 Explosive Ordnance Disposal Unit (EODU). Approximately 2.27 kilograms (kg) (5 pounds [lb]) of reactive hazardous waste (waste explosives) were treated at the EODU during CY 1999. In addition, approximately 116 kg (250 lb) of commercially manufactured explosive devices destined for disposal were evaluated and determined to be useful products, thereby eliminating the need for treatment and disposal.

One PPOA was performed during CY 1999 that involved an evaluation of the disposal of dry cell Nickel Cadmium (Ni-Cd) batteries. The current practice included managing dry cell Ni-Cd batteries as universal waste and shipping them offsite for disposal. The conclusion of the assessment was to continue managing the dry cell Ni-Cd batteries as universal waste and ship them offsite to a recycling facility. While researching information for the assessment, we discovered the Rechargeable Battery

Recycling Corporation (RBRC), a nonprofit public service organization, whose mission is to be the international leader in the environmentally safe collection, transportation, and recycling of rechargeable batteries. This organization is funded by various battery manufacturers and provides prepaid shipping containers at a minimal cost. By shipping Ni-Cd batteries to an approved recycling facility through the RBRC program, waste generators can realize a significant cost savings. This PPOA is in the process of being implemented.

Through the material exchange program, approximately 2.67 metric tons (mTon) of materials and equipment, at a cost savings of about $62,000, were exchanged. These materials included both hazardous and non-hazardous materials.

The following activities enhanced employee awareness of P2 practices:

- Bring Your Kids to Work Day: Workshop was conducted on recycling and pollution prevention practices for employees and their children.

- Earth Day: The week-long event included an exhibit of office products containing post consumed recycled materials in accordance with Affirmative Procurement; handouts of literature on helpful P2 hints; articles published in the Sitelines publicatoin; P2 messages through electronic mail; and distribution of promotional items made from recycled materials as daily reminders regarding the benefits of recycling.

- Holiday and all-occasion card collection: St. Jude’s Ranch recycles these cards into new “born again” cards.

- National P2 Week: The week-long event included an exhibit of P2 success stories; office products containing post consumed recycled materials in accordance with Affirmative Procurement; and viewing of the P2 home page.

- Integrated Safety Management Day: The event included an exhibit of P2 success stories; literature containing pollution prevention holiday tips; literature about composting; and distribution of promotional items made from recycled materials as daily reminders regarding the benefits of recycling.

- Publication of various P2 articles: Another means of employee communication includes dissemination of articles through both electronic mail and DOE/NV newsletters with the intent of increasing employee awareness of environmental issues and their role in improving environmental conditions in the workplace and community.

- P2 Website: An intranet P2 website has been on-line since April 1998. Information found on the website includes, but is not limited to: points of contact, management commitment, P2 Program Plan, P2 success stories, employee suggestions, material exchange program, list of people interested in car pooling, and current P2 activities.

- Offsite visits: The P2 Project Office traveled to its’ offsite location at Los Alamos, New Mexico to promote pollution prevention, waste minimization, and recycling awareness. In addition, pollution prevention reporting requirements for the site were established.

- Training: Management and 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).

VOLUME AND TOXICITY REDUCTION

Table 6.4 is an overview of the estimated RCRA hazardous waste and toxicity reduction through implementation of P2, waste minimization, and recycling activities during CY 1999. The waste reduction activities eliminated an estimated 107 metric tons (mton) of RCRA hazardous waste.

RECYCLING ACTIVITIES FOR CALENDAR YEAR 1999

Through recycling, hazardous and solid waste disposal can be significantly reduced or eliminated, reducing costs associated with disposal, shipping, and labor. Table 6.5 lists the recycling activities that occurred at all DOE/NV.

6.4 HAZARDOUS MATERIALS SPILL CENTER (HSC)

The HSC was established in the Frenchman Basin 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. The HSC was designed and equipped to, (1) discharge a measured volume of a hazardous fluid at a controlled rate on a specially prepared surface; (2) monitor and record downwind gaseous concentrations, operating data, and close-in/downwind meteorological data; and (3) provide a means to control and monitor these functions from a remote location.

The HSC operates under Permit 13990037X and has the capability of releasing large volumes of cryogenic and non-cryogenic liquids at rapid rates through a 152 m (500-ft) spill line to the experimental area supporting the tank farm. Spill rates for the cryogenic system range from 1,000 to 26,000 gallons per minute (gpm) with the capability to release the entire contents of both tanks in two minutes. The non-cryogenic system can release fluids at rates of 500 to 5,000 gpm (1.9 to 19 m^3/min), with the capability of releasing the entire 90.8 m^3 (24,000 gallons) in five minutes.

Test sponsors can vary intake air temperature, humidity, release rate, and release volume in a 2.4 x 4.8 x 25.3 m (8 x 16 x 96 ft) wind tunnel. There are two spill pads available for use in contained open air releases of volumes of 0.19 to 3.8 m^3 (50 to 1,000 gallons). Test Area 4 has been added primarily to provide the testing capability for determining the efficacy of totally encapsulated chemical protective suiting materials when exposed to high concentrations of toxic and hazardous gaseous materials. In addition, Test Area 4 has two stacks used for controlled low concentration releases for chemical sensor test and evaluation.

DOE/NV provides the facilities, security, and technical support, but all costs are borne by the organization conducting the tests. The plans for each test series were examined by an Advisory Panel that consisted of DOE/NV and EPA's R&IE-LV professional personnel augmented by personnel from the organization performing the tests.

For each test, the R&IE-LV provides an advisor on offsite public health and safety for the Operations Controller's Test Safety Review Panel. At the beginning of each test series and, at other tests depending on projected need, a field monitoring technician from the EPA with appropriate air sampling equipment is deployed downwind of the test at the NTS boundary to measure chemical concentrations that may have reached the offsite area. Samples are collected with a hand-operated Dräger pump and sampling tube appropriate for the chemical being tested. Not all tests are monitored by R&IE-LV, if professional judgement indicates that, based on previous experience with the chemical and the proposed test parameters, NTS boundary monitoring is unnecessary. The EPA monitors at the NTS boundary, in contact by two-way radio, are always placed at the projected cloud center line.

During 1999, there were eight projects conducted at the HSC: (1) Effluent Tracking Experiment - ORCA Episode using ten materials released from a stack in February and March; (2) the Chemical Agent Dual Detector Integration Experiment I (CADDIE I) using four stimulants released from a stack for airborne detection in March; (3) the Osprey I experiments testing ground based sensors with four materials released from a stack at very low concentrations in May; (4) the CADDIE II episode using four stimulants conducted in May; (5) Remote Sensor Test Range-Nighthawk I Episode using 20 materials in August and September; (6) the Frostproof stream environmental fate study for a simulated biological agent in October at the Cambric Ditch; (7) the Osprey II experiments testing ground based and airborne sensors with four materials released from a stack at very low concentrations in October; (8) Remote Sensor Test Range-Nighthawk II Episode using four materials in December. All of the tests supported involved low chemical release quantities. No offsite monitoring was performed by R&IE-LV personnel in 1999.

6.5 WASTE MANAGEMENT ACTIVITIES

RADIOACTIVE WASTE

Low-level radioactive waste (LLW) from the DOE-approved generators is disposed of at two locations on the NTS. Packaged LLW is disposed of at the Area 5 Radioactive Waste Management Site (RWMS-5) in shallow pits and trenches. LLW in large containers and unpackaged bulk waste from environmental restoration projects are buried in selected subsidence craters at the Area 3 RWMS (RWMS-3). Hazardous, transuranic (TRU), and mixed TRU wastes are stored aboveground pending shipment to offsite permitted disposal facilities.

RWMS-5 WASTE MANAGEMENT OPERATIONS

The RWMS-5 is used for the disposal of radioactive waste generated at the NTS and at offsite DOE and U.S. Department of Defense facilities. LLW is accepted for disposal from generators that have received approval from DOE Headquarters and DOE/NV (NTS 1996). Disposal of mixed waste is still restricted to waste generated by DOE/NV.

LLW, mixed waste, and small quantities of TRU waste have been disposed of in 22 shallow pits and trenches since disposal operations began in 1960. The shallow pits and trenches range in depth from 4.6 to 14.6 m (15 to 48 ft). Filled pits and trenches are covered by a 2.4 m (8 ft) alluvium cap pending final closure of the site.

LLW disposed of prior to implementation of RCRA (CFR 1984) by DOE in 1986 may contain low levels of hazardous constituents. A single disposal unit, Pit 3, has interim status as a mixed waste disposal unit for NTS generated wastes that meet the RCRA Land Disposal Restrictions (LDR) requirements. Low-level mixed waste generated on the NTS is stored on the TRU waste storage pad until characterization is complete. If the waste meets or has been treated to meet LDR requirements, it may be disposed of in Pit 3.

TRU mixed waste is stored in a covered building on a specially constructed RCRA-designed pad. In 1998, the Waste Examination Facility (WEF) began operations to certify this stored TRU mixed waste for disposal at the Waste Isolation Pilot Plant in New Mexico. Low-level radioactive mixed waste is also currently stored on the TRU waste storage pad.

In 1999, the RWMS-5 received 9.00×10^3 m^3 (3.18×10^5 ft^3) of waste containing a total of 1.5×10^6 Ci (5.6×10^4 TBq) of reportable radionuclides. This represents an increase in volume and activity from the previous year because of more shipments from Fernald (see Table 6.6). The trend in bulk disposal at each RWMS is shown in Figures 6.6 and 6.7. Tritium accounted for more than 99.9 percent of the total radioactivity disposed of in 1999 (see Table 6.7). Uranium-238, ^{234}U, and ^{238}Pu were the next most important radionuclides in the 1999 inventory.

Monitoring activities at the RWMS-5 in 1999 included measurement of radioactivity in air and groundwater, measurement of gamma and neutron radiation fields, and soil moisture monitoring. Air samples were

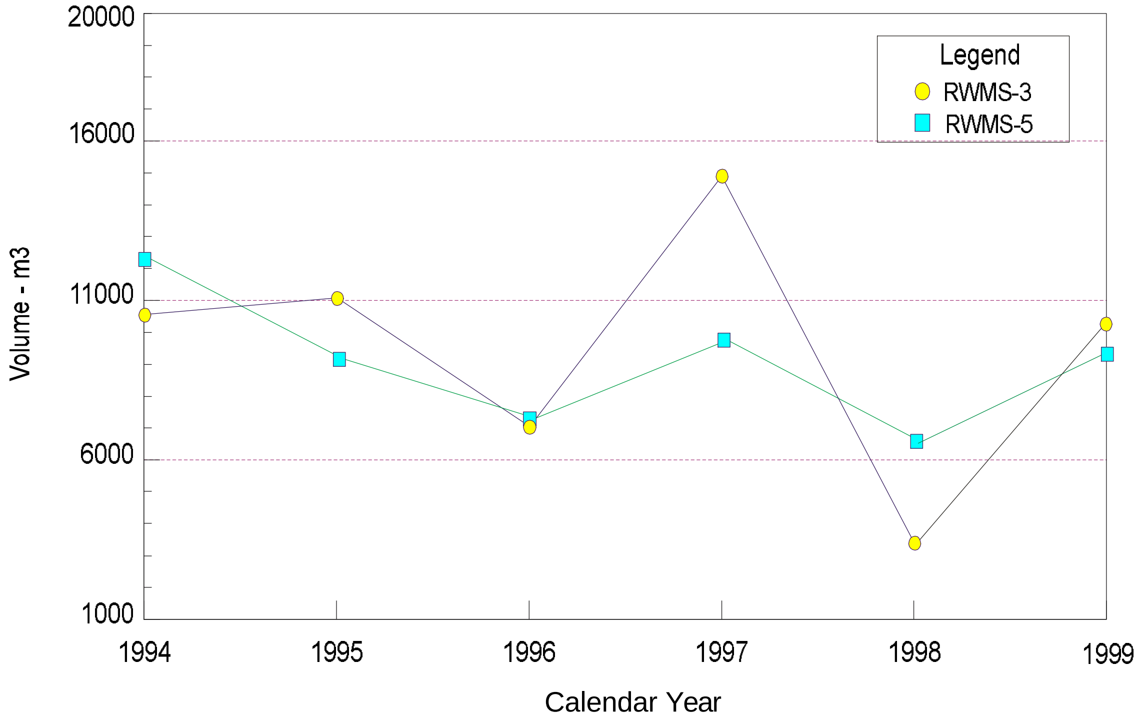


Figure 6.6 Total Volume of Waste Disposed of at RWMS-3 and RWMS-5

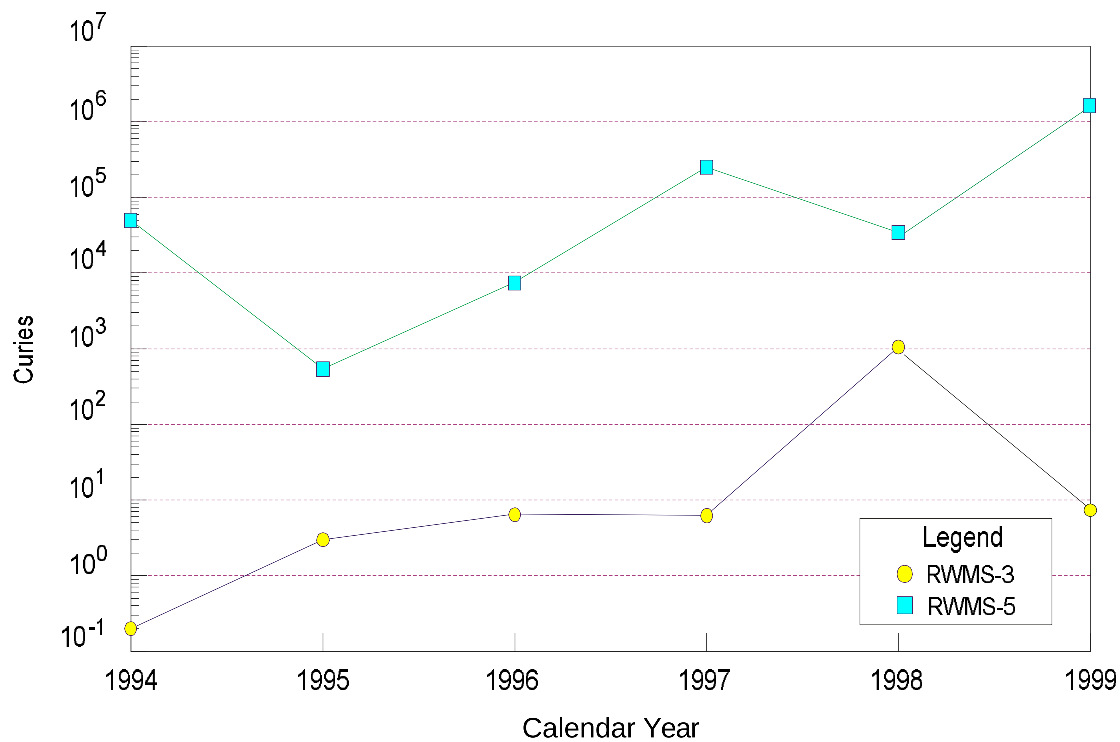


Figure 6.7 Total Curies Disposed of at RWMS-3 and RWMS-5

analyzed for gross alpha and gross beta radiation, photon-emitting radionuclides, plutonium, and tritium. Tritium and $^{239+240}Pu$ were the only man-made airborne radionuclides detected at the RWMS-5. All airborne radionuclide concentrations were a small fraction of DOE allowable limits. Airborne tritium at the RWMS-5 probably originates from disposed LLW. The highest annual average tritium concentration determined from samples collected in 1999, 4.3×10^{-12} µCi/mL, was 0.043 percent of the Derived Concentration Guide (DCG). Refer to Section 4.4 for details pertaining to the change in sampling methods in 1999.

Airborne $^{239+240}Pu$ was not detected at the WEF and inside the TRU Storage Building in 1999. All $^{239+240}Pu$ results for the perimeter of the RWMS-5 were less than the MDC. Groundwater samples were analyzed for RCRA parameters, gross alpha, gross beta, tritium, and photon emitting radionuclides. No man-made radionuclides or hazardous chemicals were detected in groundwater. Gamma radiation fields were monitored by thermoluminescent dosimeters (TLDs). Neutron radiation fields at the perimeter of the TRU waste storage pad were monitored by proton recoil dosimeters. Radiation exposures above background were measured at RWMS-5, but only at locations where radioactive waste is stored or remained exposed in active disposal units. Infiltration of wetting fronts below the depth of waste disposal units was not detected by soil moisture monitoring.

The results of air monitoring are described further in Chapter 4 and the results of water monitoring are described in Chapter 5.

RWMS-5 PERFORMANCE ASSESSMENT (PA)

The DOE 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 and a comparison of those risks to established performance objectives. A PA has been completed, reviewed, and approved for the RWMS-5 (Shott et al., 1997a). The PA helps to identify the processes that could cause detectable releases of radioactive materials to the accessible environment during operation of the site. The only release pathway expected at the RWMS-5 in the near term is diffusion of volatile radionuclides through the operational cap to the atmosphere. Tritium is the most abundant volatile radionuclide disposed of at the RWMS-5. PA models indicate that nonvolatile radionuclides may eventually be detected in soil excavated by burrowing animals and in the tissues of deep-rooted vegetation growing on disposal unit covers. Site characterization data and modeling studies indicate that transport of nonvolatile radionuclides from the waste to the uppermost aquifer is extremely unlikely because of the thick dry vadose zone, low precipitation, and high potential evapotranspiration at the site.

RWMS-5 monitoring results are generally consistent with PA results. Tritium, the volatile radionuclide with the largest inventory, is routinely detected in air samples at the RWMS-5 at levels that are a small fraction of the DCGs. Since maintenance operations keep operational covers vegetation free, deep-rooted vegetation samples are not routinely available for analysis. Tritium is the only radionuclide that has been detected in previous analyses of cap vegetation. Groundwater monitoring results confirm that groundwater beneath the RWMS-5 remains uncontaminated. Monitoring of soil moisture content confirms that infiltrating precipitation does not percolate through the disposal unit operational caps because it evaporates and returns to the atmosphere.

RWMS-3 WASTE MANAGEMENT OPERATIONS

The RWMS-3 is used for the disposal of bulk waste. Packaged bulk LLW is accepted from approved onsite and offsite generators.

Unpackaged bulk LLW from NTS environmental restoration projects also has been accepted and disposed of. Disposal is in subsidence craters formed by underground nuclear tests. The subsidence craters range in depth from 15 to 24 m (49 to 78 ft) and are filled by alternating layers of stacked waste packages and 1 m (3 ft) of clean alluvium. Waste disposed of at the RWMS-3 tends to have a lower activity concentration than waste disposed of at the RWMS-5 because bulk waste tends to be generated by environmental restoration projects.

Waste disposal operations at the RWMS-3 began in the U-3ax crater in 1968. The U-3ax crater was eventually joined with U-3bl to form the U-3ax/bl disposal unit. This unit received mostly unpackaged LLW from NTS nuclear testing operations. The U-3ax/bl disposal unit was filled in 1987 and covered with a 2.4-m (8-ft) thick temporary closure cap. This disposal unit is a mixed waste management unit as mixed waste is known to have been disposed of. Waste disposal operations moved to the U-3at crater in 1988 and was joined with the U-3ah crater to form the U-3ah/at disposal unit. This disposal unit remained open in 1999 and contains LLW only. Disposal of unpackaged plutonium contaminated soil, from sites on the NAFR, about 14 mi (22 km) east of Goldfield, Nevada began in the U-3bh crater in 1997. The U-3bh disposal unit remained open in 1999. Radioactivity in air, gamma radiation fields, and soil moisture content were monitored at the RWMS-3 during 1999. Plutonium was the only man-made airborne radionuclide detected at the RWMS-3. The airborne plutonium likely originates from the resuspension of soils contaminated by atmospheric nuclear weapons tests. Gamma radiation fields were monitored by TLDs. Exposure rates greater than background at the RWMS-3 were attributed to surface contamination from past atmospheric nuclear weapons tests. Soil moisture monitoring did not detect the infiltration of wetting fronts below the depth of waste disposal units.

During 1999, the RWMS-3 received 9.07×10^3 m^3 (3.20×10^5 ft^3) of waste containing 9 Ci (0.3 TBq) of activity (see Table 6.8). This represents an increase in volume and a significant decrease in the activity disposed of, compared to the previous year (see Table 6.9). The predominant radionuclides disposed of in 1999 were ^{238}U (44 percent) and ^{234}U (43 percent). The remainder of the activity was predominately ^{90}Sr, ^{137}Cs, ^{3}H, ^{235}U, and ^{230}Th.

RWMS-3 PERFORMANCE ASSESSMENT (PA)

A PA has been conducted for the RWMS-3 (Shott et al., 1997b). Release pathways at the RWMS-3 are expected to be the same as at the RWMS-5 because of the similar site conditions and disposal operations. However, the inventory of radioactive materials disposed of at the RMWS-3 is much less than that disposed of at the RWMS-5. The RWMS-3 inventory of ^{3}H, which is the most likely radionuclide to be released, is significantly less than at the RWMS-5, so the potential for detecting releases of radioactivity is also significantly less. Moreover, the interpretation of environmental monitoring results at the RWMS-3 is confounded by the presence of significant soil contamination from atmospheric nuclear tests. Airborne tritium monitoring at the RWMS-3 was discontinued in 1997 because all results were less than the minimum detectable concentration (MDC). Interpretation of environmental monitoring data from the RWMS-3 and comparison of environmental monitoring results with PA results is difficult because of the small RWMS-3 radionuclide inventory and the presence of contamination from nuclear testing.

HAZARDOUS WASTES

NTS OPERATIONS

Hazardous wastes generated on the NTS are accumulated at a location east of the RWMS-5, the Hazardous Waste

Accumulation Site, before shipment to an offsite treatment, storage, and disposal facility. Hazardous waste generation activities at the NTS are performed under EPA Identification (ID) Number NV3890090001. The NTS continues to be regulated by the 1995 NTS RCRA Hazardous Waste Operating Permit Number NEV HW009 for the general operation of the facility and the specific operation of the Hazardous Waste Storage Unit (HWSU) and the Explosive Ordnance Disposal Unit.

Three permit modifications have occurred since October 1, 1996. These modification include changes in the NTS training program and personnel changes in the Area 5 and Area 11 Emergency Management Plans. The Pit 3 Mixed Waste Disposal Unit located in the RWMS-5 continues to operate under RCRA Interim Status.

The NTS also has a Nevada Hazardous Materials Storage Permit Number 13-94-0034-X, issued by the state Fire Marshall. This permit is renewed annually when a report required by the state's Chemical Catastrophe Prevention Act is submitted.

NON-NTS OPERATIONS

Four EPA Generator ID numbers have been issued to five non-NTS operations. In addition, three local ID numbers were required at one operation. Hazardous waste is managed at all locations, by using satellite accumulation areas. Three operations have centralized accumulation areas. All hazardous and industrial wastes are transported offsite to RCRA-permitted facilities for approved treatment and/or disposal.

SOLID WASTE

At the NTS there are three nonhazardous waste landfills that have state of Nevada Operating Permits, i.e., the Area 6 Hydrocarbon Disposal Site, the Area 9 U-10c Solid Waste Disposal Site, and the Area 23 Solid Waste Disposal Site. There are no monitoring requirements for non-hazardous solid waste disposed of at the NTS in the three landfills; however, before the waste is disposed of, it is weighed.

During 1999, there were approximately 13,910 tons of waste disposed of at the NTS, as shown in Table 6.10. The permitting process considers groundwater protection at these locations.

At the Area 23 Class II Municipal and Industrial Solid Waste Disposal Site, a groundwater monitoring well has been installed. This well also serves to satisfy monitoring requirements for the Mercury sewage lagoon system. An initial baseline water sample was collected in August 1997, and compliance monitoring continued in 1998.

6.6 PERMITS FOR NTS OPERATIONS

Federal and state permits have been issued to DOE/NV and to BN (Table 6.11). These permits are required for the conduct of such DOE/NV activities as hazardous and solid waste storage and disposal for certain ecological studies 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 North Las Vegas Facility (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.

DOE/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, S19301, to BN that allows collection of wildlife samples.

Table 6.1 Number of Horses Observed on the NTS by Age, Class, Gender, and Year, 1995 - 1999

	Number of Individuals Observed									
Age Class	1995		1996		1997		1998		1999	
Foals	1		1		3		8		5	
Yearlings	3		0		0		0		0	
Adults	M	F	M	F	M	F	M	F	M	F
2 Year	0	0	0	1	0	0	0	0	0	0
3 Year	0	0	0	0	0	1	0	0	0	0
> 3 Years	22	29	21	24	19	20	16	21	11	20
Total (excluding foals)	54		46		40		37		31	

Note: (M = male; F = female)

Table 6.2 Raptor Species that Occur and Breed on the NTS

Raptor Species	Common Name
Aquila chrysaetos	Golden eagle
Asio otus	Long-eared owl
Buteo jamaicensis	Red-tailed hawk
Buteo swainsoni	Swainson's hawk
Falco mexicanus	Prairie falcon
Falco sparverius	American kestrel
Speotyto cunicularia	Burrowing owl
Tyto alba	Barn owl

Table 6.3 Seasonal Data from Selected Natural Water Sources on the NTS Collected - 1999

Water Source	Date	Surface Area of Water (m^2)[a]	Surface Flow Rate (L/Min)[b]	Disturbance at Spring
Cane Spring	10/22	10	2.7	None
Cane Spring	01/20	125	3	Soil cave-in into cave pool
Cane Spring	04/15	56	2.3	None
Captain Jack Spring	10/29	18	2.4	grazing/trampled vegetation
Captain Jack Spring	02/09	15	2.1	grazing/trampled vegetation

Table 6.3 (Seasonal Data from Selected Natural Water Sources on the NTS Collected - 1999, cont.)

Water Source	Date	Surface Area of Water (m^2)[a]	Surface Flow Rate (L/Min)[b]	Disturbance at Spring
Coyote Spring	04/14	1	0	None
Cottonwood Spring	05/12	2	0	None
Gold Meadows Spring	10/20	200	NM[c]	grazing/trampled vegetation
Gold Meadows Spring	01/21	100	NM	grazing/trampled vegetation
Gold Meadows Spring	07/26	0	NM	grazing/trampled vegetation
Little Wildhorse Seep	04/21	0	0	grazing/trampled vegetation
Little Wildhorse Seep	05/05	2	NM	grazing/trampled vegetation
Pahute Mesa Pond	05/05	2,275	NM	None
Rattlesnake Seep	05/05	3	NM	None
Reitmann Seep	10/29	1.5	0.04	None
Reitmann Seep	01/26	1.5	0.05	None
Tippipah Spring	10/08	295	6	None
Tippipah Spring	01/13	260	5.4	None
Tippipah Spring	04/05	380	3.6	None
Topopah Spring	10/22	28	0.8	None
Topopah Spring	02/04	36	0.7	None
Topopah Spring	05/03	69	0.28	None
Wahmonie Seep No. 1	04/01	30	3.6	None
Wahmonie Seep No. 2	04/01	4	NM	None
Wahmonie Seep No. 3	04/01	0	0	None
Wahmonie Seep No. 4	04/01	35	NM	None
Whiterock Spring	10/20	6	2.8	None
Whiterock Spring	01/14	175	1.9	None
Wildhorse Seep	04/21	0	0	grazing/trampled vegetation
Wildhorse Seep	05/05	2	NM	grazing/trampled vegetation
Yucca Playa Pond	10/08	0	0	None
Yucca Playa Pond	01/20	23,000	NM	None

(a) m^2 - Square meters.
(b) L/min - Liters per minute.
(c) NM - Not measurable due to diffused flow.

Table 6.4 Pollution Prevention Results, Volume and Toxicity Waste Reduction - 1999

Activity	Accomplishment	Waste and Toxicity Waste Type	Reduction
Recycle/Reuse	Batteries shipped offsite to be recycled.	Hazardous	22.90 Mg[(a)]
Recycle/Reuse	Scrap metal term sale of lead.	Hazardous	4.54 Mg
Recycle/Reuse	Sent spent intact fluorescent light bulbs offsite to be recycled (result of a PPOA).	Hazardous	4.14 Mg
Recycle/Reuse	Approximately 300 gallons of Diesel fuel were removed from an excessed generator and recycled.	Hazardous	1.13 Mg
Recycle/Reuse	Bulk used oil - sent off site to be recycled.	Hazardous	64.34 Mg
Material Exchange	An estimated 850 pounds of copy machine supplies, of which approximately 50 percent contained hazardous materials, were either redistributed for reuse or returned to the vendor for recycling.	Hazardous	0.39 Mg
Material Exchange	An estimated 850 pounds of copy machine supplies, of which approximately 50 percent contained hazardous materials, were either redistributed for reuse or returned to the vendor for recycling.	Hazardous	.39 Mg
Material Exchange	Paint destined for disposal was used to paint the roofs of several portable shelters.	Hazardous	0.17 Mg
Material Exchange	Fifty cans of spray paint, destined for disposal, were returned to Nevada Test Site painters supply to be used for future projects.	Hazardous	0.02 Mg
Recycle/Reuse	20,825 pounds of used oil and used oil and water mixtures from the Project Shoal site were sent off site for recycling.	Hazardous	9.44 Mg
Source Reduction	The printed circuit board laboratory at BN's offsite location, Special Technology Laboratory in California, was decommissioned, thereby eliminating the sodium persulfate/phosphoric acid waste stream of approximately 55 gallons per year	Hazardous	.21 Mg
TOTALS:			176.89 Mg

(a) Mg = megagram = metric ton = 2205 lb.

Table 6.5 Ongoing Recycling Activities - 1999

Activity	Waste Type	Quantity (Mg)[a]
Mixed Paper -paper, cardboard, newspaper, and magazines	Solid	312.5
Aluminum Cans	Solid	1.6
Scrap Metals -ferrous, non-ferrous, and light steel	Solid	711.0
Scrap Metal -lead	Hazardous	4.50
Toner Cartridges	Solid	1.5
Batteries	Hazardous	22.9
Fluorescent Light Bulbs	Hazardous	4.1
Tires	Solid	21.8
Wood pallets	Solid	10.2
Shipping Materials -styrofoam, bubble wrap, boxes	Solid	4.2
Diesel Fuel	Hazardous	1.1
Used Oils	Hazardous	73.8
Total		1169.2

(a) Mg = megagram = metric ton = 2205 lb.

Table 6.6 Low-Level Waste Disposed of at the RWMS-5, 1993 - 1999

Calendar Year	Volume of LLW Disposed (m^3)	Activity of LLW Disposed (Ci)
1993	8,104	3.0×10^4
1994	12,300	5.2×10^4
1995	9,171	5.6×10^2
1996	7,212	7.7×10^3
1997	9,360	2.8×10^5
1998	6,388	3.7×10^4
1999	8,846	1.5×10^6

Table 6.7 Inventory of Radionuclides (>1 mCi) Disposed of at the RWMS-5 in 1999

Radionuclide	Activity (Ci)	Percent of Total Activity
^{227}Ac	9.8×10^{-3}	6.7×10^{-7}
^{241}Am	9.8×10^{-2}	6.7×10^{-6}
^{195}Au	4.8×10^{-6}	3.3×10^{-10}
^{133}Ba	1.7×10^{-2}	1.2×10^{-6}
^{207}Bi	1.5×10^{-6}	1.0×10^{-10}
^{14}C	7.1×10^{-4}	4.9×10^{-8}
^{109}Cd	5.1×10^{-2}	3.5×10^{-6}
^{139}Ce	2.3×10^{-5}	1.6×10^{-9}
^{252}Cf	1.9×10^{-3}	1.3×10^{-7}
^{244}Cm	1.1×10^{-5}	7.6×10^{-10}
^{57}Co	1.1×10^{-3}	7.9×10^{-8}
^{60}Co	7.9×10^{-2}	5.4×10^{-6}
^{51}Cr	1.0×10^{-5}	7.2×10^{-10}
^{137}Cs	1.2×10^{-1}	8.3×10^{-6}
^{134}Ba	4.3×10^{-4}	2.9×10^{-8}
^{152}Eu	8.3×10^{-5}	5.7×10^{-9}
^{154}Eu	3.7×10^{-6}	2.5×10^{-10}
^{55}Fe	2.4×10^{-4}	1.7×10^{-8}
^{203}Hg	6.2×10^{-6}	4.3×10^{-10}
^{131}I	1.1×10^{-4}	7.7×10^{-9}
^{40}K	4.5×10^{-3}	3.1×10^{-7}
^{3}H	1.5×10^{6}	1.0×10^{2}
^{54}Mn	1.3×10^{-3}	8.9×10^{-8}
^{22}Na	1.9×10^{-3}	1.3×10^{-7}
^{63}Ni	5.0×10^{-3}	3.5×10^{-7}
^{231}Pa	1.2×10^{-3}	8.5×10^{-8}
^{210}Pb	8.5×10^{-4}	5.9×10^{-8}
^{147}Pm	8.0×10^{-5}	5.5×10^{-9}
^{210}Po	5.0×10^{-4}	3.4×10^{-8}
^{238}Pu	2.6×10^{0}	1.8×10^{-4}
^{239}Pu	5.3×10^{-1}	3.7×10^{-5}
^{240}Pu	1.2×10^{-1}	8.2×10^{-6}
^{241}Pu	8.8×10^{-1}	6.1×10^{-5}
^{242}Pu	1.1×10^{-5}	7.5×10^{-10}
^{226}Ra	4.3×10^{-3}	3.0×10^{-7}
^{113}Sn	3.7×10^{-6}	2.5×10^{-10}
^{85}Sr	8.3×10^{-5}	5.7×10^{-9}
^{90}Sr	5.9×10^{-1}	4.0×10^{-5}
^{99}Tc	6.7×10^{-6}	4.6×10^{-10}
^{228}Th	1.1×10^{-3}	7.4×10^{-8}
^{229}Th	2.1×10^{-4}	1.5×10^{-8}
^{230}Th	1.7×10^{-2}	1.1×10^{-6}
^{232}Th	4.8×10^{-2}	3.3×10^{-6}
^{204}Tl	4.3×10^{-5}	3.0×10^{-9}
^{232}U	3.1×10^{-4}	2.1×10^{-8}
^{233}U	6.0×10^{-2}	4.1×10^{-6}
^{234}U	1.3×10^{1}	9.0×10^{-4}
^{235}U	1.1×10^{0}	7.7×10^{-5}
^{236}U	5.9×10^{-3}	4.0×10^{-7}
^{238}U	9.3×10^{1}	6.4×10^{-3}
^{88}Y	2.2×10^{-5}	1.5×10^{-9}
Total	1.5×10^{6}	1.0×10^{2}

Table 6.8 Low-Level Waste Disposed of at the RWMS-3, 1993 - 1999

Calendar Year	Volume of LLW Disposed of (m^3)	Activity of LLW Disposed of (Ci)
1993	10,070	2.4×10^{-1}
1994	10,550	2.1×10^{-1}
1995	11,070	3.1×10^{0}
1996	7,109	7.7×10^{0}
1997	15,990	1.4×10^{1}
1998	3,330	2.3×10^{2}
1999	9,175	9.0×10^{0}

Table 6.9 Inventory of Radionuclides (>0.1 Ci) Disposed of at the RWMS-3 in 1999

Radionuclide	Activity (Ci)	Percent of Total Activity
^{3}H	2.6×10^{-1}	2.9×10^{-2}
^{137}Cs	2.5×10^{-1}	2.7×10^{-2}
^{90}Sr	1.5×10^{-1}	1.6×10^{-2}
^{238}U	3.9×10^{0}	4.3×10^{-1}
^{234}U	3.9×10^{0}	4.3×10^{-1}
^{230}Th	1.1×10^{-1}	1.2×10^{-2}
^{235}U	1.8×10^{-1}	2.0×10^{-2}
Total	8.75×10^{0}	9.64×10^{-1}

Table 6.10 Quantity of Wastes Disposed of in Solid Landfills - 1999

	Quantity (in tons)		
Month	Area 9	Area 23	Area 6
January - March	1060	300	25
April - June	2890	342	45
July - September	2230	674	3
October - December	991	2970	2370
Totals	7,170	4,290	2,450

Table 6.11 Permits Required for NTS Operations - 1999

EPA Generator ID

NV3890090001	NTS Activities

NTS Permits

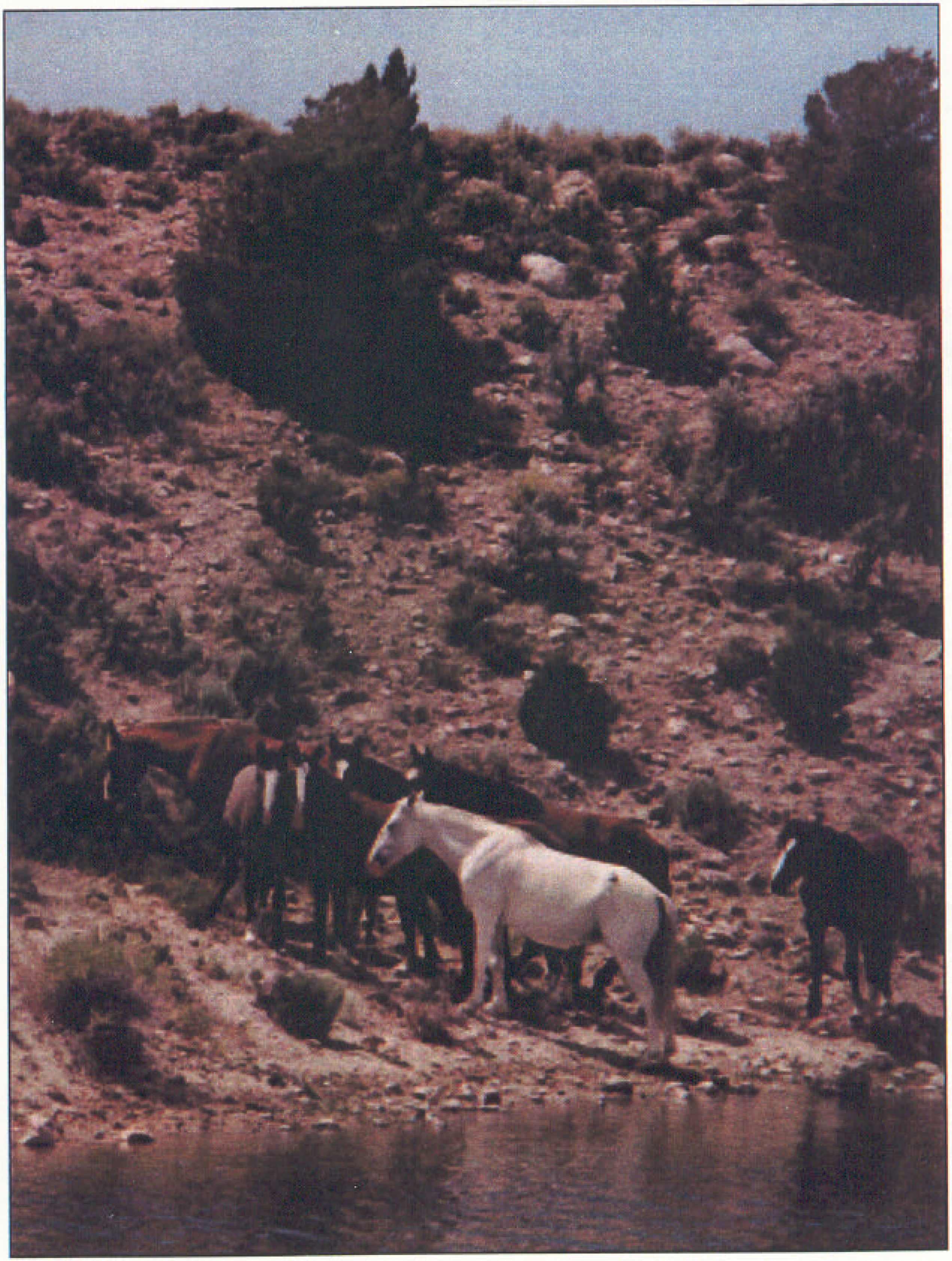
Permit No.	Areas	Expiration Date
NEV HW009	NTS Hazardous Waste Management (RCRA)	05/01/2000
SW 13 097 02	Area 6 Hydrocarbon Disposal Site	Post Closure
SW 13 097 03	Area 9 U-10c Solid Waste Disposal Site	Post Closure
SW 13 097 04	Area 23 Solid Waste Disposal Site	Post Closure
13-99-0034-X	NTS Hazardous Materials	02/29/2000
13-99-0037-X	HSC Hazardous Materials	02/29/2000
S19301	Scientific Collection of Wildlife Samples	12/31/2000
MB008795-0	USFWS -- Desert Tortoise Incidental Take Authorization	12/31/2000

Off-NTS Permits

03-99-0265-X	North Las Vegas Facility Hazardous Materials	02/29/2000
03-99-0266-X	Remote Sensing Laboratory Hazardous Materials	02/29/2000

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



Wild Horses on the NTS (No date Provided)

7.0 DOSE ASSESSMENT

The oversite for the Nevada Test Site (NTS) operations, conducted by the U.S. Environmental Protection Agency's (EPA's) Radiation and Indoor Environments National Laboratory in Las Vegas (R&IE-LV), measured no radiation exposures attributable to NTS operations during 1999. However, using onsite emission measurements and calculated resuspension data as input to the EPA's Clean Air Package 1988 (CAP88-PC) model, a potential effective dose equivalent (EDE) to the maximally exposed individual (MEI) was calculated to be 0.12 mrem (1.2 x 10^{-3} mSv) to a hypothetical resident at Springdale, Nevada, located 58 km (36 mi) west-northwest of Control Point 1 (CP-1) on the NTS. This is only 1.2 percent of the National Emission Standards for Hazardous Air Pollutants (NESHAP) regulatory limit of 10 mrem/yr for airborne radioactive emissions from the NTS. The calculated population dose (collective EDE) to the approximately 36,000 residents living within 80 km (50 mi) from each of the NTS airborne emission sources was 0.38 person-rem (3.8 x 10^{-3} person-Sv). Oversite data indicated an external exposure to the MEI of 143 mrem/yr (1.43 mSv/yr) from normal background radiation. A conservative EDE of 0.63 mrem/yr (6.3 x 10^{-4} mSv/yr to this individual by NTS pathways was also estimated from the summation of the above inhalation dose to the MEI, the estimated dose from the ingestion of milk (0.010 mrem/yr) and the EDE estimated from the ingestion of meat from the hunting of wild life (doves, rabbits, and deer) migrating offsite from a contaminated site on the NTS. This maximized dose estimate, excluding background, is less than 1 percent of the 100 mrem/yr dose limit for the general public.

The application of Biota Concentration Guides to the radionuclide inventories in NTS surface soils determined from past radiological surveys indicated that the radiation doses to terrestrial biota on the NTS are within limits recommended by the Biota Dose Assessment Committee sponsored by the U.S. Department of Energy (DOE). The concentrations of ^{90}Sr and ^{137}Cs were found to be the major contributors to the doses to terrestrial biota. The area suspected of contributing the highest biota dose is Area 10. Since the radionuclide content of the E Tunnel ponds sediment have not been characterized, a similar evaluation for the aquatic biota at this location could not be completed.

7.1 ESTIMATED DOSE FROM NTS ACTIVITIES

The potential radiation doses to offsite residents resulting from work activities on the NTS may be caused through the following pathways:

- Inhalation of airborne radioactivity from operational releases and resuspension of surface contamination.
- Ingestion of meat from migratory wild game animals which drank water and ate vegetation containing test-related radioactivity while residing on the NTS.
- Ingestion of milk from cows feeding from pasture on which radioactive fallout was deposited from past airborne releases of radioactivity at the NTS or from foreign nuclear tests.

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

- Ingestion of locally grown food crops and meats in areas which received radioactive fallout from past nuclear test releases at the NTS and from world-wide fallout.

The dose assessment for 1999 excludes the last three pathways for the following reasons:

- In past reports and also indicated by the results for water samples reported in Chapter 5, no test-related radioactivity has migrated offsite in groundwater to cause a radiation dose to offsite residents.

- Due to recent budget cuts and reorganization, no sampling of milk, meat, and food crops was performed in 1999. No significant concentrations of test-related radioactivity are anticipated in these media; however, periodic sampling of milk and food crops is required by the Routine Radiological Environmental Monitoring Plan (RREMP) and will be done during the next calendar year. Based upon conclusions of the RREMP, sampling of wild game was chosen instead of locally produced meat.

In the past, two methods for estimating the EDE to offsite residents were used. The first method used effluent release estimates based upon onsite monitoring data or calculated resuspension of deposited radioactivity which were used as inputs to EPA's CAP88-PC computer model. The model then estimated the EDEs for all locations within a 80 km radius for each individual release point. The total EDE for each location was then determined by summing the contributions from all onsite sources during the year to determine compliance with the NESHAP limit of 10 mrem/yr EDE to the MEI in the offsite area. The second method used offsite monitoring data with documented assumptions and dose conversion factors to calculate the EDE from NTS emissions, naturally occurring ^{7}Be, and ^{85}Kr from worldwide sources. As past reports have shown the EDEs from ^{7}Be and ^{85}Kr to be insignificant (<0.001 mrem/yr) and ^{85}Kr is no longer monitored onsite due to no detectable emissions, the second method will only compare the EDEs calculated from measured concentrations of radioactivity by offsite monitoring with the EDEs determined from estimated NTS emissions. As in the past, the EDEs determined by both methods will be compared to offsite gamma exposures resulting from background radiation (from cosmic, terrestrial, and worldwide fallout radiations).

ESTIMATED DOSE USING OPERATIONAL RELEASES AND CALCULATED NTS EMISSIONS

Onsite source emission measurements, as provided by the DOE Nevada Operations Office, are listed in Chapter 4, Table 4.5, and include tritium and plutonium. These are estimates of releases made at the point of origin. Meteorological data collected by the Air Resources Laboratory, Special Operations and Research Division (ARL/SORD) were used to construct wind roses and stability arrays for the following areas: Mercury, Area 12, Area 20, Yucca Flat, and the Radioactive Waste Management Site in Area 5. A calculation of estimated dose from NTS emissions was performed using EPA's CAP88-PC model (DOE 1997c). The results of the model indicated that the hypothetical individual with the maximum calculated dose from airborne NTS radioactivity would reside at Springdale, Nevada, 58 km (36 mi) west-northwest of CP-1. The maximum dose to that individual could have been 0.12 mrem (1.2×10^{-3} mSv) (Grossman 2000). For comparison, data from the PIC monitoring network indicated an exposure of 143 mrem (1.43 mSv) from background gamma radiation occurring in that area. The population living within a radius of 80 km (50 mi) from the airborne sources on the NTS was estimated to be 36,517 individuals, based on estimated population data. The collective population dose within 80 km (50 mi) from each of these sources was calculated to be 0.38 person-rem (3.8×10^{-3} person-Sv). Activity concentrations in air that would cause these calculated doses are much higher than actually detected by the offsite monitoring network. For example, most of the 0.12 mrem of the calculated EDE to the MEI is due to plutonium. The annual average plutonium concentration in air that would cause this EDE is 3.5×10^{-17} µCi/mL (1.3 µBq/m^3); this is about 13 times the annual average plutonium concentration in air (0.27×10^{-17} µCi/mL [0.1 µBq/m^3] [Chapter 4, Table 4.15]) measured at Beatty, Nevada, (nearest community). Table 7.1 summarizes the annual contributions to the EDEs due to 1999 NTS operations as calculated by use of CAP88-PC and the radionuclides listed in Chapter 4, Table 4.5.

Input data for the CAP88-PC model included meteorological data from ARL/SORD and effluent release data calculated from monitoring results and from resuspension estimates. These release data are known to be estimates, and the meteorological data are mesoscale, e.g., representative of an area approximately 40 km (25 mi) or less around the point of collection. However, these data are considered sufficient for model input, primarily because the model itself is not designed for complex terrain such as that on and around the NTS. Errors introduced by the use of the effluent and meteorological data are small compared to the errors inherent in the model. The model results are considered over-estimates of the dose to offsite residents. This has been confirmed by comparison with the offsite monitoring results.

COMMITTED EFFECTIVE DOSE EQUIVALENT (CEDE) 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. For this reason, the analytical results for the water and vegetation samples discussed in Chapter 10 were used to estimate the CEDE to what is considered to be the most critical offsite individual, a hunter consuming meat from three game species: mourning dove (Zenaida macroura), black-tailed jack rabbit (Lepus californicus), and mule deer (Odocoileus hemionus). The samples were collected at two locations where the radioculide concentrations in the environment were the highest: the vegetation and surface water at the E Tunnel Ponds in Area 12 and the vegetation in the Area 5 Cambric Ditch (normally dry). The CEDE was calculated from a pathway model by Kennedy and Strenge (1992) into which the radionuclide concentrations measured in the vegetation and pond water were inputted.

Assuming that the game animals fed on vegetation in the Cambric Ditch, the total potential CEDE to a hypothetical hunter resulting from the consumption of the edible parts of all three species (based upon state bag limits) was calculated to be 0.05 mrem (5×10^{-4} mSv) per year. Assuming that the game animals fed and drank at the E Tunnel Pond, the CEDE was calculated to be 0.5 mrem/y (5×10^{-3} mSv) (Table 7.2). The latter dose estimate is higher than the dose estimates based upon actual radionuclide measurements of deer samples reported in the annual reports for 1990 to 1995 (see Table 7.3). This was expected because the pathway model is conservative, the animals were assumed to feed and drink only in a highly contaminated area, and the estimate is based upon the bag limits for all three animal species.

ESTIMATED DOSE USING MONITORING NETWORK DATA

As shown in Table 4.14, the highest offsite annual average concentration of $^{239+240}$Pu was measured at Rachel by R&IE-LV and

BN. The higher concentration reported by BN was used to calculate the potential CEDE to a hypothetical individual at this location. Although Springdale was the location of the MEI, as determined from the CAP88-PC estimate from NTS airborne emissions, no air sampler was operated at Springdale, so an EDE could not be calculated from measured concentrations. The nearest air sampler to Springdale is at Beatty, 14 km (9 mi) south of Springdale, which is too far away to be used.

Since airborne tritium was not sampled at Rachel, an annual average of the results of samples collected at Indian Springs and Amargosa Valley was used. Also, as no milk samples were collected offsite during 1999, an average of the ^{90}Sr concentrations reported for the EPA Milk Surveillance Network for the years 1995 to 1998 was used.

The concentrations of radioactivity detected by the offsite monitoring networks and used in the dose calculations are shown in Table 7.2. These concentrations are converted to a dose by using the assumptions and dose conversion factors described below. The dose conversion factors assume continuous presence at a fixed location and no loss of radioactivity in storage or handling prior to ingestion of materials. The assumptions used in the calculation of the CEDEs were as follows:

- Adult respiration rate = 8,400 m^3/yr from International Commission on Radiological Protection Publication (ICRP) 21 (ICRP 1975).
- Milk intake (average for 20 and 40 yr old) = 110 L/yr (ICRP 1975).

The CEDE conversion factors were obtained from “Internal Dose Conversion Factors for Calculation of Dose to the Public” (DOE 1988). Those used here are:

- ^{3}H: 6.4 x 10^{-8} mrem/pCi (ingestion or inhalation).
- ^{90}Sr: 1.4 x 10^{-4} mrem/pCi (ingestion).
- $^{238,239+240}$Pu: 3.7 x 10^{-4} mrem/pCi (ingestion, f_1=10^{-4}); 3.1 x 10^{-1} mrem/pCi (inhalation, Class Y).

The algorithm for the internal dose calculation is:

- (concentration) x (intake in volume [mass]/unit time) x (CEDE conversion factors) = CEDE.

As an example calculation, the following is the result of breathing a concentration of tritium in air of 3.8 pCi/m^3:

- (3.8 pCi/m^3) x (8,400 m^3/yr) x (6.4 x 10^{-8} mrem/pCi) = 2.0 x 10^{-3} mrem/yr.

However, in calculating the inhalation CEDE from ^{3}H, the value must be increased by 50 percent to account for skin absorption (ICRP 1979). The total dose in one year, therefore is 2.0 x 10^{-3} x 1.5 = 3.0 x 10^{-3} mrem/yr.

Dose calculations from the offsite data and CAP88-PC estimate for the MEI are summarized in Table 7.2. As shown at the bottom of this table, the individual CEDEs, from the various pathways, added together give a total of 0.11 mrem/yr (1.1 x 10^{-3} mSv/yr) at Rachel and 0.13 mrem/yr (1.3 x 10^{-3} mSv/yr) at Springdale. These doses are small compared to the gamma radiation background measured by pressurized ion chambers (PICs) at Rachel and at Beatty (nearest PIC to Springdale), which indicated doses of 146 mrem/yr (1.46 mSv/yr) and 143 mrem/yr (1.43 mSv/yr), respectively.

The annual average concentration of $^{239+240}$Pu used in the CEDE calculation for Rachel (2.8 x 10^{-5} pCi/m^3, 1.0 x 10^{-6} Bq/m^3) was determined from samples collected by BN. The annual average from samples collected from the EPA sampler at Rachel was 1.4 x 10^{-6} pCi/m^3 (5.2 x 10^{-8} Bq/m^3).

The higher concentration by the BN sampler is possibly due to the fact that it was operated only for six months from July through December 1999, when the climate was drier and more favorable for the resuspension of surface soil. Both averages are higher than all other sampling locations because Rachel was in the path of most radioactive emissions from nuclear tests during the 1950's and 1960's.

7.2 ONSITE BIOTA DOSES

There are deposits of radioactivity in the soil of the NTS that may cause radiation doses to any biota that exist within it boundaries. There are no natural rivers or streams on the NTS, but there is a set of tunnel drainage ponds that have existed for many years and may support some aquatic organisms. Although the soil contamination on the NTS is well characterized, the contamination in the sediment of the tunnel drainage ponds is not. Therefore, only those contaminated NTS locations with non-aquatic biota were evaluated by a “screening” technique to determine whether radiation doses to biota are in compliance with guidelines specified in a recent DOE regulatory standard created by the Biota Dose Assessment Committee (DOE 2000). According to this standard, an area is in compliance if the sum of the ratios of maximum radionuclide concentrations in a medium such as soil to a biota concentration guide (BCG) is less than one. The results of the evaluation are as follows.

The principal contributors to the biota doses were determined to be ^{90}Sr and ^{137}Cs, because their BCGs were smaller by a factor 1/35 to 1/20,000 times the guides of other radionuclides found on the NTS. The concentrations of radioactivity in Ci/mi^2 determined from previous surveys (DOE 1991d) were converted to pCi/g by assuming a soil density of 1.5 g/cm^3 and a depth of penetration of 3 cm for the transuranics and 30 cm for the mobile radionuclides.

The NTS areas with the highest concentrations of ^{90}Sr and ^{137}Cs were then chosen, and the ratio of the soil concentration to the BCG was calculated for all radionuclides found by surveys and the ratios summed. Since the sum for the areas with the highest concentrations were less than one, all other areas would also be less than one. The location with the highest radionuclide concentrations, Area 10, had a ratio sum of only 0.325.

7.3 SUMMARY

Based upon the estimated airborne emissions of radioactivity from the NTS for all possible sources, the MEI was determined with CAP88-PC software to be at Springdale, Nevada, 58 km (36 mi) west-northwest of CP-1. The CEDE to a hypothetical receptor at Springdale was calculated to be 0.12 mrem/yr (1.2 x 10^{-3} mSv/yr). The total calculated CEDE, including contributions to the dose from ^{90}Sr in milk (doses from onsite emissions of tritium were already included in the CAP88-PC estimate) was 0.13 mrem/yr (0.0013 mSv/yr).

The offsite environmental surveillance systems operated around the NTS detected no radioactivity attributed to the NTS except for the high volume air samplers, which consistently detected concentrations of airborne $^{239+240}$Pu above the minimum detectable concentration. The highest annual average concentration was from high-volume air filter samples collected at Rachel, which had a calculated CEDE of 0.096 mrem/yr (9.6 x 10^{-4} mSv/yr). When summed with the CEDEs from airborne tritium and ^{90}Sr in milk estimated from other network data, the total CEDE at Rachel would be 0.11 mrem/yr (1.1 x 10^{-3} mSv/yr).

Assuming that a resident at Springdale also harvested wild game (doves, rabbits, and deer) which migrated offsite after drinking and feeding at radioactively contaminated locations on the NTS and received the estimated CEDE of 0.5 mrem/yr (0.005 mSv/yr), the total CEDE at Springdale becomes 0.63 mrem/yr (0.0063 mSv/yr), which is 0.6 percent of the 100 mrem/yr limit for the general public as specified by DOE regulations. For comparison, the natural radiation background measured by PICs located at Beatty (nearest PIC to Springdale) indicated a dose of 143 mrem/yr (1.43 mSv/yr).

An evaluation of radiation doses to terrestrial biota was conducted based upon the radionuclide concentrations in soil determined from past surveys at the NTS. From a comparison of the magnitudes of the BCGs for radionuclides in the soil, ^{90}Sr and ^{137}Cs were found to be the principal contributors to doses to biota. The results of the evaluation found all NTS terrestrial areas to be in compliance with a recent draft of a DOE standard for evaluating radiation doses to aquatic and terrestrial biota (DOE 2000). The location which would contribute the highest dose to terrestrial biota was Area 10. Since the radionuclide content of the E Tunnel ponds sediments have not been completely characterized, an evaluation of dose to aquatic biota could not be completed in time for this report. The E Tunnel ponds, the location of the only aquatic biota that exists in a contaminated environment on the NTS, will be evaluated next year.

Table 7.1 NTS Radiological Dose Reporting Table for Calendar Year 1999

Pathway	Dose to Maximally Exposed Individual (mrem)	(mSv)	Percent of DOE 100-mrem Limit	Estimated Population Dose (person-rem)	(person-Sv)	Population within 80 km	Estimated Natural Population Dose (person-rem)
Air+Milk +Wild Life[(a)]	0.63	0.0063	0.63	0.38	0.0038	36,517	5,220
Air only	0.12	0.0012	1.2[(b)]	0.38	0.0038	36,517	5,220

(a) According to Chapter 10, the conservative CEDE of 0.5 mrem/yr from wild life is unlikely because the migration of wild life is usually within the NTS boundaries.
(b) The 10 mrem limit of the NESHAPs was used for the air pathway.

Table 7.2 Summary of Data Used in Dose Calculations - 1999

Medium	Radionuclide	Concentration	Mrem/Year	Comment
Air	^{3}H	3.8 [(b)] (0.14)	0.0030	Concentration is average of BN offsite results
	$^{239+240}Pu$	2.8×10^{-5} [(b)] (1.0×10^{-6})	0.096[(C)]	Highest offsite average conc. (Rachel, Nevada)
	$^{239+240}Pu$	-	0.12 [(c)]	CEDE at Springdale calculated by CAP88-PC
Milk	^{90}Sr	0.67 [(a)] (0.025)	0.010	Concentration average for network results 1995 to1998
	^{3}H	0	0	Not Analyzed
Wild Life	^{3}H, ^{137}Cs, ^{90}Sr ^{238}Pu, $^{239+240}Pu$,	-	0.5[(d)]	See Table 10.1 for concentrations

TOTAL CEDE for Rachel (air CEDEs from tritium and plutonium + milk CEDE) = 0.11 mrem/yr
TOTAL CEDE for Springdale (CEDE by CAP88-PC + milk CEDE) = 0.13 mrem/yr

(a) Units are pCi/L and (Bq/L).
(b) Units are pCi/m^3 and (Bq/m^3).
(c) Corrected to include contribution to the EDE by ^{241}Am.
(d) EDE of 0.5 mrem from wildlife was based upon pathway dose model and radionuclide concentrations measured in water and vegetation collected at E Tunnel pond. The MEI was assumed to harvest State bag limits for doves, rabbits, and deer. Study referred to in Chapter 10 indicated that the migration of these animals is unlikely.

Table 7.3 Comparison of 1999 EDEs from Wild Game with Past Estimates

Year	Sample Type	EDE (mrem/year)
1990	Deer	0.004
1991	Deer	0.027
1992	Deer	0.014
1993	Deer + Chukar	0.053
1994	Deer	0.00047
1995	Deer	0.0087
1996	(Not Sampled)	-
1997	(Not Sampled)	-
1998	(Not Sampled)	-
1999	Rabbit, dove, deer[a]	0.5

(a) Not sampled; EDE calculated from pathway dose model.

8.0 LABORATORY QUALITY ASSURANCE

It is the policy of the U.S. Department of Energy Nevada Operations Office (DOE/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 and nonradiological parameters to ensure that data produced by the laboratory meets customer-and regulatory-defined requirements. Data quality is assured through process-based QA, procedure-specific QA, data quality objectives (DQOs), and performance evaluation programs (PEPs). The external QA program for radiological data consists of participation in the Quality Assessment Program (QAP) administered by the DOE Environmental Measurements Laboratory (EML), the InterLaB RadCheM™ Proficiency Testing Program directed by Environmental Resource Associates, 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). External radiation measurement QA for the onsite program is assessed by participation in the DOE's Laboratory Accreditation Program (DOELAP) and intercomparisons provided by the DOE Environmental Measurements Laboratory every two to three years. EPA's Radiation and Indoor Environments National Laboratory-Las Vegas (R&IE-LV) offsite thermoluminescent dosimeter (TLD) programs consists of participation in the National Voluntary Laboratory Accreditation Program (NVLAP), operated by the National Institute of Standards and Technology (NIST). The nonradiological data QA program was accomplished by using commercial laboratories with appropriate certification or accreditation by state or government agencies.

The environmental surveillance program off the Nevada Test Site (NTS) was performed by R&IE-LV. The QA program developed by R&IE-LV, for the Offsite Radiological Safety Program (ORSP), meets all requirements of EPA policy and also includes applicable elements of the requirements and regulations of DOE/NV QA. The ORSP QA program defines DQOs, which are statements of the quality of data a decision maker needs to ensure that a decision based on these data is defensible.

8.1 POLICY

Environmental surveillance, conducted onsite by Bechtel Nevada (BN) and offsite by EPA's R&IE-LV, is governed by the DOE QA policy as set forth in DOE Order 5700.6C (DOE 1991a). 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

In addition, R&IE-LV meets the EPA policy which states that all decisions which are dependent on environmental data must be supported by data of known quality. The EPA's policy requires participation in a centrally managed QA Program by all EPA elements as well as those monitoring and measurement efforts supported or mandated through contracts, regulations, or other formalized agreements. Further, the EPA's policy requires participation in a QA Program by all EPA organizational units involved in environmental data collection. The QA policies and requirements of R&IE-LV are summarized in the "Quality Management Plan" Office of Radiation and Indoor Air (EPA 1996). The QA policies and requirements specific to the ORSP are documented in the "Quality Assurance Program Plan for the Center for Environmental Restoration, Monitoring, and Emergency Response and the Center for Radioanalysis and Quality Assurance for the Offsite Environmental Monitoring Program," (EPA 1998). The requirements of these documents establish a framework for consistency in the continuing application of QA standards and implementing procedures in support of the ORSP. Administrative and technical implementing procedures based on these QA requirements are maintained in appropriate manuals or are described in standard operating procedures of the R&IE-LV.

8.2 OVERVIEW OF THE LABORATORY QA PROGRAM

The BN Analytical Services Laboratory (ASL) implements the requirements of the DOE Order 414.1A through integrated quality procedures. The quality of data and results is ensured through both process-based and procedure-specific QA.

Procedure-specific QA begins with the development and implementation of work instructions (WIs), which contain the analytical methodologies and required quality control samples for a given analysis. Personnel performing a given analysis are trained and qualified for that analysis, including the successful analysis of a quality control sample. Analysis-specific operational checks and calibration standards traceable to either the NIST or the EPA are required. Quality control samples, e.g., spikes, blanks, 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. Initial data processing is performed by the analyst or health physicist generating the data. An independent review is then performed by another analyst or health physicist to ensure that data processing has been correctly performed and that the reported analytical results correspond to the data acquired and processed. Supervisory review of data is required prior to release of the data to sample management personnel for data verification. 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 sample management personnel ensures that analytical results meet project requirements. Data discrepancies identified during the data review and verification processes are documented on data discrepancy reports (DDRs). DDRs are reviewed and compiled quarterly to discern systematic problems. Data checks are made by Environmental Surveillance of BN for internal consistency, proper identification, transmittal errors, calculation errors, and transcription errors.

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.

Similar procedures and methodologies are used by R&IE-LV to ensure the quality of environmental radiological data collected off the NTS.

8.3 DATA AND MEASUREMENT QUALITY OBJECTIVES

DATA QUALITY OBJECTIVES

DQOs delineate the circumstances under which measurements are made and define the acceptable variability in the measured data (EPA 1994). DQOs are based on the decision(s) to be made, the range of sampling possibilities, what measurements will be made, where the samples will be taken, how the measurements will be used, and what calculations will be performed on the measurement data to arrive at the desired result(s). Associated measurement quality objectives (MQOs), which define acceptable variability in the measured data, are established to ensure the quality of the measurements.

DECISIONS TO BE MADE

The primary decisions to be made, based on radiological environmental surveillance measurements, are whether, due to NTS activities (1) any member of the general public, outside the site boundaries, receives an effective dose equivalent (EDE) that exceeds regulatory limits; (2) there is detectable contamination of the environment; or (3) there is a biological effect. A potential EDE to a member of the public from NTS activities is much more likely to be due to inhalation or ingestion of radionuclides which have reached the person through one or more pathways, such as transport through the air (inhalation exposure), or through water and/or foodstuffs (ingestion exposure), than to be due to external exposure. A pathway may be quite complex; e.g., the food pathway could include airborne radioactivity falling on soil and plants, also being absorbed by plants, which are eaten by an animal, which is then eaten by a member of the public. At the NTS, because of the depth of aquifers, negligible horizontal or vertical transport, lack of surface water flows and little rain, very sparse vegetation and animal populations, lack of food grown for human consumption, and large distances to the nearest member of the public, the airborne pathway is by far the most important for a possible EDE to a member of the public.

Decisions made based on nonradiological data are related to waste characterization, extent and characterization of spills, compliance with regulatory limits for environmental contaminants, and possible worker exposure(s).

RANGE OF SAMPLING POSSIBILITIES

Determination of the numbers, types, and locations of radiological sampling stations is based on factors such as the location of possible sources, isotopes of concern, wind and weather patterns, the geographical distribution of human populations, the levels of risk involved, the desired sensitivity of the measurements, physical accessibility to sampling locations, and financial constraints. The numbers, types, and location of nonradiological samples are typically defined by regulatory actions on the NTS and are determined by environmental compliance or waste operations activities. Workplace and personnel monitoring to determine possible worker exposures is conducted by Industrial Hygienists and Health Physicists from the Environment, Safety and Health Division (ESHD) of BN.

MEASUREMENTS TO BE MADE

Radioanalyses are made of air, water, or other media samples to determine the types and amounts of radioactivity in them. These measurements are then converted to radioactivity concentrations by dividing by the sample volume or weight, which is measured separately. Nonradiological inorganic or organic constituents in air, water, soil, and sludge samples are analyzed and reported by commercial laboratories under contract to BN. Methods and procedures used to measure possible worker exposures to nonradiological hazards are defined by Occupational Safety and Health Administration or National Institute of Occupational Safety and Health protocols.

Typical contaminants for which BN ESHD personnel collect samples and request analyses are asbestos, solvents, and welding metals. Sample media, which are analyzed, include urine, blood, air filters, charcoal tubes, and bulk asbestos.

SAMPLING LOCATIONS

The locations of routine radiological environmental surveillance sampling both on and off the NTS are described in Chapters 4 and 5 of this report. Onsite sampling methodologies are described in BN's Environmental Management Procedures, and offsite methodologies by similar R&IE-LV procedures. The locations of nonradiological environmental sampling and monitoring are determined through site remediation and characterization activities and by permit requirements.

USE OF THE MEASUREMENTS

There are several techniques to estimate the EDE to a member of the public. One technique is to measure the radionuclide concentrations at the location(s) of interest and use established methodologies to estimate the EDE a person at that location could receive. Another technique is to measure radionuclide concentrations at specific points within the site and to use established models to calculate concentrations at other offsite locations of interest. The potential EDE to a person at such a location could then be estimated. Another technique is the one used for most of the environmental surveillance data measured at the NTS.

CALCULATIONS TO BE PERFORMED

The EDE of greatest interest is the EDE to the maximally exposed individual (MEI). The MEI is located, where, based on measured radioactivity concentrations and distances from all contributing NTS sources, the calculational model gives the greatest potential EDE for any member of the public. The assumptions used in the calculational model are conservative; i.e., the calculated EDE to the MEI most certainly exceeds the EDE any member of the public would actually receive. The model used at the NTS is EPA’s CAP88-PC, a wind dispersion model approved for this purpose (DOE 1997c).

MEASUREMENT QUALITY OBJECTIVES (MQOs)

MQOs are commonly described in terms of representativeness, comparability, completeness, precision, and accuracy. Although the assessment of the first two characteristics must be essentially qualitative, definite numerical goals may be set and quantitative assessments performed for the latter three.

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 EDE to a member of the public when measured radioactivity concentrations are put into the model. An environmental monitoring plan for the NTS, “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 we have in our 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 WIs. Standard reporting units and a consistent number of significant digits are used. Instruments are calibrated using NIST-traceable sources. Each batch of field samples is accompanied by a spiked sample with a known quantity of the compound(s) of interest. Extensive QA measures are used for all analytical processes.

COMPLETENESS

Completeness is defined as the percentage of samples collected versus those which had been scheduled to be collected, or the percentage of valid analysis results versus the results which would have been obtained if all samples had been obtained and correctly analyzed. Realistically, samples can be lost during shipping, handling, preparation, and analysis, or not collected as scheduled. Also data entry or transcription errors can be made. The BN completeness objectives for all radiological samples and analyses have been set at 90 percent for sample collection and 85 percent for analyses, or 75 percent overall. R&IE-LV's completeness objective for the Long-Term Hydrological Monitoring Program is 80 percent and for the other networks it is 90 percent.

Completeness for inorganic and organic analyses is based on the number of valid results received versus the number requested.

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, and of some types of water samples. For TLDs, precision is assessed from variations in the three $CaSO_4$ elements of each environmental TLD. Precision is expressed quantitatively as the percent relative standard deviation (%RSD); i.e., the ratio of the standard deviation of the measurements to their mean converted to percent. The smaller the value of the %RSD, the greater is the precision of the measurement. The precision objectives are shown in Table 8.1. They are a function of the concentration of radioactivity in the samples; i.e., the analysis of samples with concentrations near zero will have low precision, while samples with higher concentrations will have proportionately higher precision.

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 ASL are done by performing measurements on special QA samples 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 ASL 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 accuracy of the analytical procedures. 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. Percent bias is the complement of percent accuracy; i.e., percent bias = 100 minus percent accuracy. The smaller the percent bias, the more accurate are the measurements. Table 8.2 shows the accuracy objectives of the ASL and of the R&IE-LV.

Measurements of sample volumes should be accurate to ± 5 percent for aqueous samples (water and milk) and to ± 10 percent for air and soil samples. The sensitivity of radiochemical and gamma spectrometric analyses must allow no more than a 5 percent risk of either a false negative or false positive value. Control limits for accuracy, monitored with matrix spike samples, are required to be no greater than ± 20 percent for all gross alpha and gross beta analyses and for gamma spectrometric analyses.

Both the R&IE-LV and ASL participate in several interlaboratory PEPs, such as EML's QAP and the DOELAP for TLDs. EPA's Radiation Quality Assurance Program Performance Evaluation Study (PES) program was discontinued for 1999.

The accuracy of the TLD program is tested every two or three years by DOELAP or by NVLAP. This involves a three-part, single blind performance testing program followed by an independent onsite assessment of the overall program. Both BN and R&IE-LV participate in their respective accrediting agency's program.

Once the data have been finalized, they are compared to the MQOs. Completeness, accuracy, and precision statistics are calculated. If data fail to meet one or more of the established MQOs, they may still be used in data analysis; however, the data and any interpretive results must be qualified. Current and historical data are maintained in an access-controlled database.

All sample results exceeding the traditional natural background activity range are investigated. If data are found to be associated with a non-environmental condition, e.g., a check of the instrument using a calibration source, the data are flagged and are not included in calculations of averages, etc. Only data verified to be associated with a non-environmental condition are flagged; all other data are used in calculation of averages and other statistics, even if the condition is traced to a source other than the NTS.

8.4 RESULTS FOR COMPLETENESS, PRECISION, AND ACCURACY

Summary data for completeness, precision, and accuracy are provided in Tables 8.3 to 8.6, respectively. Complete data used in these MQO's for 1999 are from published reports by EML's QAP (DOE 1998b and 1998c) and other reports from NIST and Environmental Resource Associates (ERA).

COMPLETENESS

The analysis completeness data for calendar year 1999 are shown in Table 8.3. These percentages represent all analyses which were carried to completion and include some analyses for which the results were found to be invalid for other reasons. Had objectives not been met for some analyses, other factors would be used to assess acceptability, e.g., fit of the data to a trend or consistency with results from samples collected before and after.

The completeness MQOs for the onsite networks were met or exceeded in all cases. For the offsite networks, the MQOs were met or exceeded except for the pressurized ion chamber (PIC) network. Failure of the

PIC network was due to the loss of telemetry systems for the majority of 1999. Access to PIC data for CTLP stations through satellite telemetry was restored to EPA in the fall of 1998 and was discontinued again at the end of February 1999. Completeness of PIC data for this two-month period approached 100 percent. Secondary data collection systems were used for the remainder of the 1999 calendar year. Those data are not included in this summary as it does not meet minimum quality requirements due to reduced maintenance support of aging equipment and data storage media. EPA personnel collected and reviewed PIC chart media each week for spikes or other anomalies. No significant deviations from the expected background exposure rates were identified.

PRECISION

From replicate samples collected and analyzed throughout the year, the %RSD was calculated for various types of analyses and sampling media. The results of these calculations are shown in Table 8.4 for both the onsite and offsite networks. In addition to examination of %RSDs for individual duplicate pairs, an overall precision estimate was determined by calculating the pooled standard deviation, based on the algorithm given in Taylor (1987). To convert to a unitless value, the pooled standard deviation was divided by the grand mean and multiplied by 100 to yield a %RSD. The table presents the pooled data and estimates of overall precision. The pooled standard deviations and %RSD indicate the estimated achieved precision for sample results.

For the R&IE-LV, precision data for all analyses were well within their respective MQOs, except for plutonium. Plutonium results were rechecked and are believed to be valid. Six of nine duplicate pairs collected had results greater than the analysis MDA for $^{239+240}$Pu. Of these six, one sample had a significantly high %RSD value contributing to the high average. The remaining five duplicate pairs have an average deviation of less than 20 percent. None of the duplicate pairs collected had result values above the analysis MDA for ^{238}Pu. The R&IE-LV data presented in Table 8.4 include only laboratory and field duplicate pairs that exceeded the MDC.

For the ASL, the reason for the low precision in some of the analyses was the low activity in these environmental samples. The few that were useful for calculation of precision barely exceeded the MDC.

ACCURACY

The ASL and R&IE-LV accuracy objectives were measured through participation in the interlaboratory comparison and QAPs discussed below.

RADIOLOGICAL PERFORMANCE EVALUATION RESULTS

The external radiological PEs consisted of participation in the QAP conducted by DOE/EML and the PES conducted by ERA. These programs serve to evaluate the performance of the radiological laboratory and to identify problems requiring corrective actions.

Summaries of the 1999 results of the QAPs conducted by the offsite organizations are provided in Tables 8.5 and 8.6. The column or section in each table labeled percent bias is the accuracy of analysis and may be compared to the objectives listed in Table 8.2. The individual radionuclide recoveries are listed in tables which may be found in the DOELAP, MAPEP, and EML reports.

Accuracy, as percent difference or percent bias is calculated by:

$$\%BIAS = \left(\frac{C_m - C_a}{C_a}\right) 100$$

where:

$\%BIAS$ = *percent bias*
C_m = *measured sample activity*
C_a = *known sample activity*

The R&IE-LV failed the accuracy MQO in 2 of the 28 analyses attempted in the INEL/MAPEP study. One of the two analyses was outside of the bias MQO but was within the acceptable range for the study. In the EML QAP, all of the eight analyses performed were within the DQO of ± 20 percent. In 1999, the EPA discontinued the EPA Radiological QA PE program. Therefore, no results are shown for that program. R&IE-LV is currently enrolled in and retains accreditation by NVLAP. QA checks are routinely performed to ensure compliance with applicable performance standards.

None of BN's ASL results exceeded the 3 normalized deviation limits for the 50 analyses attempted. The MQOs for accuracy in analysis of DOE/EML and NIST samples were not met in 8 of the 44 analyses attempted. Three of the analyses that failed the MQOs for accuracy were for radionuclides (^{106}Ru-one and ^{244}Cm-two) that were not detected in the environment.

CORRECTIVE ACTIONS IMPLEMENTED IN RESPONSE TO PERFORMANCE EVALUATION PROGRAMS

BN results were generally within the control limits determined by the program sponsors. Results which were not within acceptable performance limits were investigated and corrective actions taken to prevent reoccurrence.

In the R&IE-LV, the 1999 results that did not meet analysis criteria were investigated to determine the cause of the reported error. Corrective actions were then implemented.

COMPARABILITY

The EML/QAP provides results to each laboratory participating in each study that includes a grand average for all values, excluding outliers. A normalized deviation statistic compares each laboratory's result (mean of three replicates) to the known value and to the grand average. If the value of this statistic (in multiples of standard normal deviate, unitless) lies between control limits of -3 and +3, the accuracy (deviation from known value) or comparability (deviation from grand average) is within normal statistical variation.

The onsite ASL results in the EML QAP were acceptable. There were only two instances in which the ASL results were greater than the MQO.

Table 8.1 Precision Objectives Expressed as Percents

Analysis	Conc. > 10 MDC	4 MDC ≤ Conc. ≤ 10 MDC
ASL		
Gross Alpha	±30	±60
Gross Beta	±30	±60
Gamma Spectrometry	±30	±60
Scintillation Counting	±30	±60
Alpha Spectrometry	±20	±50

Note: The precision objective for TLDs at environmental levels is 10 percent.

Analysis	Conc. > 10 MDC	4 MDC ≤ Conc. ≤ 10 MDC
R&IE-LV		
Conventional Tritium	±10	±30
Strontium (in milk)	±10	±30
Thorium	±10	±30
Uranium	±10	±30
Enriched Tritium	±20	±30
Strontium (in other media)	±20	±30
Plutonium	±20	±30

Table 8.2 Accuracy Objectives Expressed as Percent Bias

Analysis	Conc. > 10 MDC	4 MDC ≤ Conc. ≤ 10 MDC
ASL		
Gross Alpha	±20	±50
Gross Beta	±20	±50
Gamma Spectrometry	±20	±50
Scintillation Counting	±20	±50
Alpha-Spectrometry	±20	±50
TLDs	Meet DOELAP Criteria	
R&IE-LV		
Tritium, Conventional	±10	±30%
Strontium (Milk)	±10	±30%
Thorium	±10	±30%
Uranium	±10	±30%
Tritium, Enriched	±20	±30%
Strontium (other media)	±20	±30%
Plutonium	±20	±30%
TLDs	Meet NVLAP Criteria	

Table 8.3 Analysis Completeness Data for Calendar Year - 1999

Analysis	Medium	Completeness Percent BN	Completeness Percent R&IE-LV
Gross Alpha/Beta	Low Volume Particulate Air Filter	99.6	98.0
Plutonium	High Volume Particulate Air Filter	100.0	90.3
Plutonium	Low Volume Particulate Air Filter	99.7	(a)
Gamma Spectrometry	Low Volume Particulate Air Filter	100.0	98.0
Gamma Spectrometry	Low Volume Charcoal Air Filter	(a)	98.0
Gamma Spectrometry	High Volume Particulate Air Filter	99.7	90.3
Tritiated Water	Air	99.2	(a)
Gross Alpha	Potable Water Taps	100.0	(a)
Gross Beta	Potable Water Taps	100.0	(a)
Gamma Spectrometry	Potable Water Taps	100.0	(a)
Tritiated Water	Potable Water Taps	100.0	(a)
Plutonium	Potable Water Taps	100.0	(a)
Gross Beta	Wells, Ponds	86.5	(a)
Plutonium	Wells, Ponds	86.5	(a)
Gamma Spectrometry	Wells, Ponds	86.5	93.5
Tritiated Water	Wells, Ponds	86.5	95.1
Strontium-90	Wells, Ponds	86.5	(a)
Pressurized Ion Chamber	Ambient Radiation	(a)	15.7(b)
TLDs, Environmental	Ambient Radiation	97.1	96.0
TLDs, Personnel	Ambient Radiation	(a)	99.0

(a) Analyses not performed.
(b) Telemetry data only.

Table 8.4 Precision Estimates from Replicate Sampling - 1999

Analysis	Number of Replicate Analyses	Precision Estimate %RSD
	ASL	
Gross Alpha in Air	96	18.7
Gross Beta in Air	98	14.8
Gamma in Air	16	11.3
Pu in Air	18	230
Tritium in Air	48	63.0
Gross Alpha in Potable Water	4	33.8
Gross Beta in Potable Water	15	6.64
HTO in Tunnel Effluent	6	1.84
Pu in Tunnel Effluent	6	17.0
TLDs	330	6.4
	R&IE-LV	
Gross Alpha in Air	143	28.9
Gross Beta in Air	166	17.1
Gamma Spectrometry (Low-Vol ^{7}Be)	18	25.1
Gamma Spectrometry (Hi-Vol ^{7}Be)	9	37.4
Plutonium in Air (Hi-Vol)	6	41.2(a)
Tritium in Water (enriched)	16	6.7
Tritium in Water (unenriched)	28	4.3

(a) One of the six plutonium duplicate samples had a %RSD greater than 100 percent for the pair. Average %RSD for the remaining five pairs is 19.6 percent.

Table 8.5 Accuracy of R&IE-LV Radioanalyses (EML QAP and PES MAPEP) - 1999

Percent Bias Range for Analysis of EML QAP Samples

Analysis	No.	Air	Soil	Vegetation	Water
Antimony	1	-10.25	(a)	(a)	(a)
Americium	3	(a)	-2.11	7.05	-2.88
Cobalt	6	-11.93 - 3.08	(a)	(a)	-5.95 - -5.53
Cesium	4	-11.19 - 1.17	(a)	(a)	-4015 - -4.03
Curium	1	(a)	(a)	-18.1	(a)
Manganese	1	-9.91	(a)	(a)	(a)
Plutonium	6	-2.13 - 7.17	1.52	1.85	-1.05 - 0.73
Ruthenium	1	-19.83	(a)	(a)	(a)
Strontium	1	(a)	(a)	(a)	-1.16
Tritium	2	(a)	(a)	(a)	-13.12 - 1.65
Uranium	2	(a)	(a)	(a)	-22.97 - -13.39

(a) No sample.

Percent Bias Range for Analysis of MAPEP QAP Samples

Analysis	No.	Air	Soil	Vegetation	Water
Americium	1	(a)	-4.63	(a)	(a)
Cesium	1	(a)	(a)	(a)	1.21
Cobalt	1	(a)	(a)	(a)	-3.21
Manganese	1	(a)	(a)	(a)	2.51
Plutonium	4	(a)	1.58	(a)	-7.59 - 1.58
Strontium	1	(a)	(a)	(a)	-15.44
Zinc	1	(a)	(a)	(a)	3.85

(a) No sample.

Table 8.6 Comparability of ASL Radioanalyses (ERA PEP, EML PEP, and NIST) - 1999

Percent Bias Range for Analysis of ERA PEP Samples

Analysis of Water Samples	No.	BN/ASL Average pCi/L	EPA QA Known	Normalized Deviation[a] Grand Avg.
Gross Alpha	5	20.2 - 83.7	24.0 - 77.4	-0.68 - 0.46
Gross Beta	5	20.9 - 248	20.0 - 278	-0.69 - 0.95
Tritium	2	5,230 - 19,900	6,130 - 21,000	-1.78 - -0.41
^{60}Co	4	58.7 - 103	53.8 - 99.6	-0.42 - 1.25
^{65}Zn	2	228 - 367	199 - 313	1.31 - 2.21
^{89}Sr	3	13.7 - 23.2	16.4 - 27.0	-1.25 - -0.94
^{90}Sr	3	13.1 - 35.1	18.2 - 40.2	-0.73 - -0.48
^{134}Cs	4	10.8 - 63.1	12.3 - 73.4	-1.77 - -0.24
^{137}Cs	4	74.8 - 222	72.2 - 209	-0.14 - 1.67
^{131}I	1	24.5	23.3	0.52
^{133}Ba	2	68.1 - 101	66.6 - 98.2	0.37 - 0.99
^{226}Ra	5	3.39 - 15.5	4.05 - 16.5	-1.05 - 5.85
^{228}Ra	5	2.15 - 13.1	2.17 - 10.0	-0.86 - 6.36
U (Natural)	5	12.6 - 52.4	12.4 - 53.0	-0.17 - 2.02

Table 8.6 (Comparability of ASL Radioanalyses [ERA PEP, EML PEP, and NIST] - 1999, cont.)

Percent Bias Range for Analysis of EML PEP Samples

Analysis	No.	Air	Soil	Vegetation	Water
Gross Alpha	2	-5.78 - 1.24	(a)	(a)	-7.59 - -3.67
Gross Beta	2	-8.97 - 7.52	(a)	(a)	-5.45 - 27.4(b)
Tritium	2	(a)	(a)	(a)	-0.87 - 7.37
^{40}K	2	(a)	2.00 - 3.46	20.7(b) - 35.1(b)	(a)
^{54}Mn	1	5.18	(a)	(a)	(a)
^{57}Co	2	-13.6 - -5.17	(a)	(a)	3.05 - 7.05
^{60}Co	2	-13.5 - -2.83	(a)	-0.57 - 6.29	(a)
^{90}Sr	2	-34.37 - 4.17	-8.95 - 3.08	-0.56 - 3.53	-23.0(b) - -5.81
^{125}Sb	1	-13.37	(a)	(a)	(a)
^{106}Ru	1	-46.2(c)	(a)	(a)	(a)
^{137}Cs	2	-13.6 - -3.11	-1.47 - -1.14	-6.14 - 3.00	3.82 - 6.67
^{212}Bi	1	(a)	-7.86	(a)	(a)
^{212}Pb	2	(a)	5.16 - 11.8	(a)	(a)
^{214}Bi	2	(a)	-12.6 - -5.18	(a)	(a)
^{214}Pb	2	(a)	1.13 - 7.50	(a)	(a)
^{228}Ac	2	(a)	-0.81 - 0.11	(a)	(a)
^{238}Pu	2	018.5 - -12.4	(a)	(a)	-1.65 - 6.22
^{239}Pu	2	-11.3 - -5.88	-11.9 - -1.87	-17.4 - -4.42	-1.61 - 2.08
^{234}U	2	0.0 - 9.09	-3.32 - 8.95	(a)	7.81 - 12.7
^{238}U	2	-18.0 - 12.3	2.07 - 8.42	(a)	18.3 - 18.9
^{241}Am	2	-17.9 - -6.30	-15.4	-9.71 - 9.03	1.15 - 17.7
^{244}Cm	2	(a)	(a)	27.3 - 34.1(c)	(a)

(a) No sample.
(b) Result with bias > 20 percent.
(c) Result > 20 percent; however this radionuclide is not detected in the NTS environment.

Percent Bias for Analysis of NIST PEP Samples

Analysis	No.	Air	Soil	Water
^{90}Sr	1	-6.2	11.4	-3.6
^{238}Pu	1	-3.9	-6.0	3.1
^{238}U	1	-4.4	-4.7	3.1
^{241}Am	1	-5.2	-7.2	13.8

9.0 DATA QUALITY ASSESSMENT AND ANALYSIS

Several levels of data review and screening are used to characterize the quality of the data. The procedures used to characterize the data were changed in mid 1999 when the use of a computerized information management system was initiated; the "Bechtel Environmental Integrated Data Management System" (BEIDMS). Prior to this change, the data were received from the laboratory as an American Standard Code for information Interchange (ASCII) file containing 33 fields of data variables that describe a sample and the analyses performed on that sample. There was one line of data for each sample submitted to the laboratory and one file for each type of sample and analysis; for example, there is a file for gross alpha in air. These files were received monthly or quarterly depending upon the frequency of sample collection. After the use of BEIDMS was initiated, the data were still received as an ASCII file, but the format and content of the file changed.

During the first half of 1999, the files received from the laboratory were screened by a data validation computer program that runs on a personal computer. This program has 15 modules, one for each type of sample and analysis. The modules subjected each line of data to between 6 and 14 checks of data values. A line of data that failed a check was copied to an output file with a notation identifying the check that failed. All modules check for valid sampling location names and identification numbers. Result values, error values, minimum detectable concentrations (MDCs), and sample volumes or weights were checked to determine if they fall within expected ranges of values. The modules also counted the number of samples in the file for each sampling location and compared this count to the number of sample records that should be in the file. The output files were reviewed by the sampling manager and appropriate actions were taken. The actions taken include correcting the data entries and calculations, submitting samples for reanalysis, collecting additional samples to verify unexpected conditions, and inspection and repair of sampling apparatus.

After the use of BEIDMS commenced, an interface program was used to enter the data into BEIDMS from the ASCII file received from the laboratory. Files of Structured Query Language (SQL) statements are used within BEIDMS to perform most of the data validation checks that the 15 module data validation program performed. The use of the modular program was discontinued. The output from the SQL files was used in the same way as the output of the modular validation program. Corrections are made to the data within BEIDMS. The data are periodically exported from BEIDMS into a spreadsheet program on a personal computer. The data copied to the spreadsheet are combined into monthly, quarterly, or annual files, and submitted for statistical review. Most data files are reviewed statistically when the data for a full quarter of a year are available. The statistical review looks for trends in the data, outliers, clustering of data values, and consistency with historical levels. Descriptive statistics and plots of the data are provided for management review.

All data for a year are available at about the end of the first quarter of the next year. The data are archived in BEIDMS and prepared for inclusion in the annual report. An extensive statistical analysis of each data set is performed and these analyses are summarized in this chapter of the annual report.

9.1 AIR SAMPLE DATA

GROSS ALPHA IN AIR

In 1999, 1441 weekly gross alpha in air samples and duplicates from 29 locations on the Nevada Test Site (NTS) and Nellis Air Force Range (NAFR) were collected and analyzed. Descriptive statistics for the results and duplicates from individual sampling locations are given in Table 9.1. The median MDC for 1999 was 1.85×10^{-15} µCi/mL for the NTS locations and 47 percent of the results and duplicates were less than their individual MDCs. 9.1 is a time series plot of all data values from 1999. This plot indicated a slight trend of increasing values over the entire year, starting at an average value of about
1.6×10^{-15} µCi/mL and ending at an average value of about 4.0×10^{-15} µCi/mL. This plot also showed that most of the data values were between 0 and 5×10^{-15} µCi/mL, with a few higher values. The highest values are from samples collected at Bunker 9-300.

A one-way analysis of variance (ANOVA) on the square root of the data (the square root of the gross alpha in air data has a normal statistical distribution) versus sampling location found a significant difference among sampling locations. An examination of location mean values using Tukey's pairwise comparisons to adjust for simultaneous inferences found two clusters of mean values; Bunker 9-300 formed one cluster and all the remaining locations formed the second cluster. The mean gross alpha level at Bunker 9-300 in 1999 is 4.64×10^{-15} µCi/mL and the mean for all the other locations combined is 2.35×10^{-15} µCi/mL.

Gross alpha in air data have been collected since the middle of 1996. Three and one-half years of data are insufficient for an analysis of historical trends, however a few observations about short term trends can be made. Data are available from 25 sampling locations on the NTS used in 1999. Of these, 14 have data for the three and one-half years that gross alpha in air has been measured. Figure 9.2 presents boxplots of the available gross alpha historical data. The 1999 gross alpha activities are higher than the 1998 activities at all locations except one (Radioactive Waste Management Site Area 9 [RWMS 9] south). The 1999 alpha activities are also higher than the 1997 activities at all locations. The general pattern over the years in gross alpha in air activities is a decrease from 1996 to 1997, then successive increases from 1997 to 1998 and from 1998 to 1999. The annual averages for all locations on the NTS for 1996 (six months of data), 1997, 1998, and 1999 are: 2.14, 1.72, 1.78, and 2.39 µCi/mL $\times 10^{-15}$ respectively.

GROSS BETA IN AIR

Gross beta is analyzed on the same glass-fiber filters that are used for gross alpha analysis. In 1999, 1,441 gross beta samples and duplicates were analyzed. Descriptive statistics for each sampling location are given in Table 9.2. The median MDC for 1999 was 4.04×10^{-15} µCi/mL for the NTS locations and only one of the 1,441 results and duplicates were less than their individual MDCs (E-MAD north for the sample beginning on June 1, the MDC was high because of low sample volume due to a power outage).

The sampling dates were grouped by the month that sampling began, and then a two-way ANOVA was performed to test for significant differences among months and among sampling locations. This statistical test found significant differences for both factors. The differences between months indicates that there was a statistically significant trend within 1999.

Figure 9.3 is a time series plot of all the gross beta results by sample week. The solid line in this figure is a "locally weighted scatter plot smoother line," which is a statistical tool for visualizing any trend that may be in the data. This line appears to

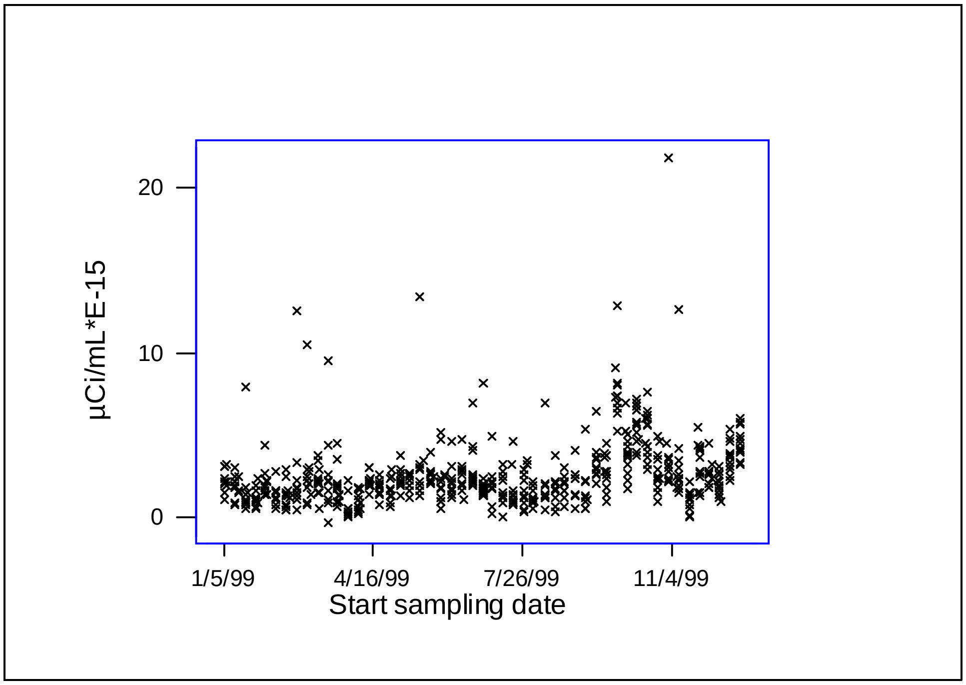


Figure 9.1 Time Series Plot of 1999 Gross Alpha in Air Results

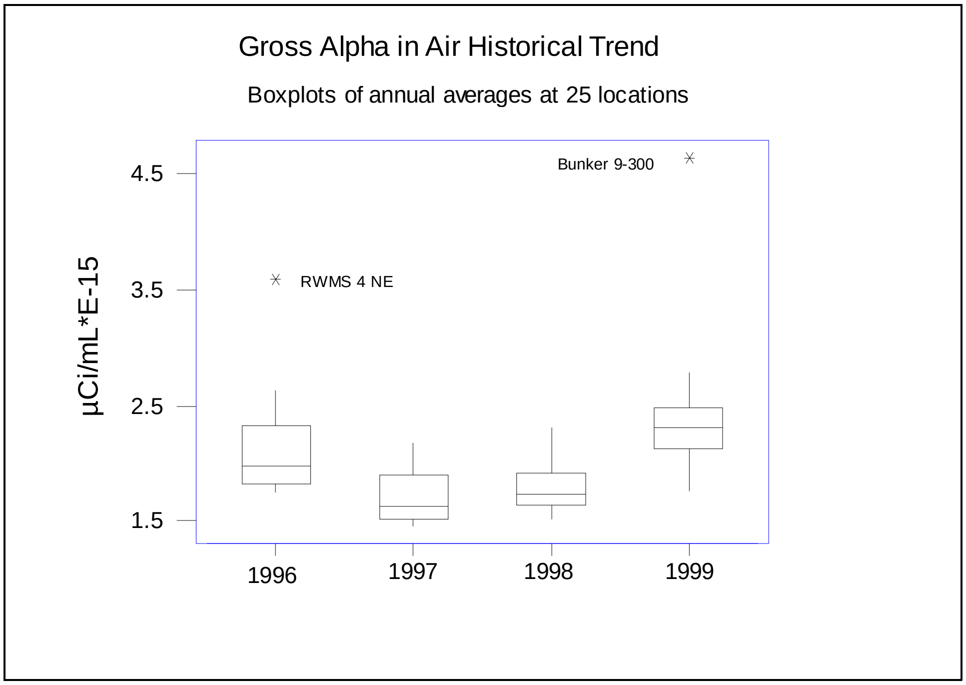


Figure 9.2 Boxplot of Historical Gross Alpha Annual Averages

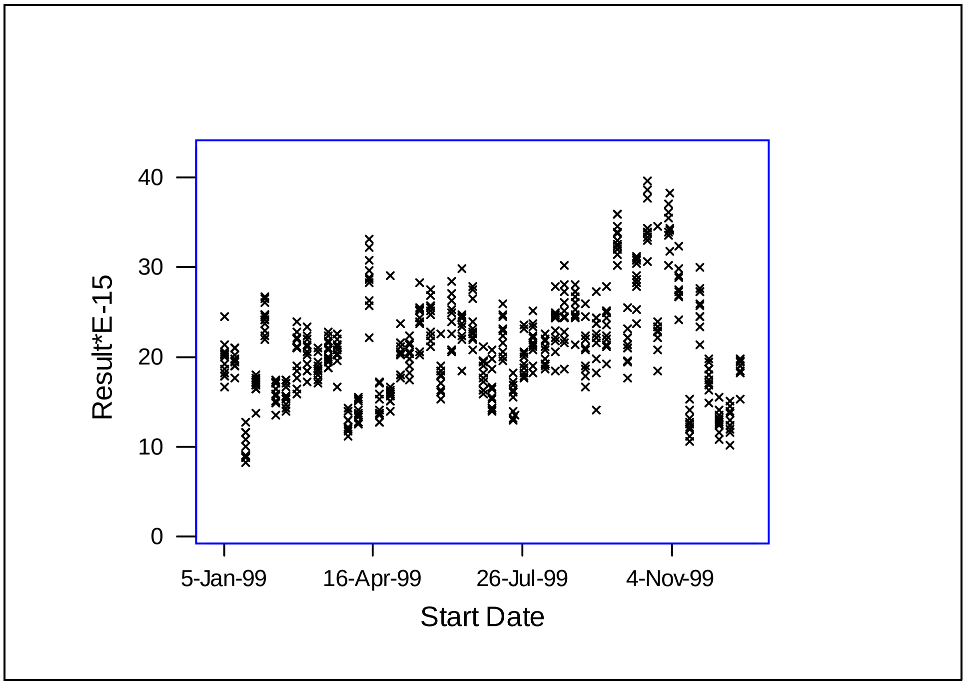


Figure 9.3 Time Series Plot of 1999 Gross Beta in Air Results

show a trend with increasing gross beta levels from January to mid October and then a decreasing trend.

The two-way ANOVA also found statistically significant differences between sampling locations. The sampling location means were examined for any clustering of values, and no clusters were found. There is a pattern of gradually increasing mean values from the lowest mean at RWMS 9 south to the highest mean at RWMS Transuranic Building north. A Tukey's simultaneous test for differences between locations found only that the two highest location means are significantly different from the two lowest location means.

In previous annual reports historical trend was analyzed using data from three sampling locations that had been in continuous use since 1966 and two locations that had been in continuous use since 1997. These five locations are the Area 2 Complex, Well 5B in Area 5, CP-6 in Area 6, Gate 700 south in Area 10, and Gate 293 in Area 11. Sampling at all five historical data locations was terminated in late 1998. In order to continue monitoring historical trend it is necessary to choose new sampling locations or choose a different method of analyzing historical trend. Four new "historical data" locations were chosen: three are close to historical locations that were terminated and one is in the middle of Yucca Flat. The 2-1 Substation in Area 2 was chosen as a replacement for the Area 2 Complex location. The substation is slightly less than two miles southeast of the complex and in similar geography. Data are available from the substation from 1988 to the present. The Yucca Complex location in Area 6 was chosen as a replacement for the CP-6 location. The complex is less than a mile northeast of CP-6 and about 600 feet lower in altitude than CP-6. Data are available from the complex from 1973 to the present. The EPA Farm in Area 15 was chosen as a replacement for the Gate 700 south location. The farm is less than two miles northwest of the gate and in similar geography. Data are available from the farm from 1979 to the present. Finally, the BJY location was chosen because it is close to the middle of Yucca Flat. BJY is about one-half mile south of the junction of Areas 1, 3,4, and 7. Data are available from BJY from 1979 to the present.

Figure 9.4 is a time series plot of the annual averages from the five “former” locations plus the four “replacement” locations. The line in Figure 9.4 suggests a trend peaking in 1971, then a steady decrease in annual averages until 1975. The downward trend resumes in 1978 and continues until about 1983 when a level of about 20×10^{-15} µCi/mL was reached. Since 1982, the annual averages have remained at or slightly less than the 20×10^{-15} µCi/mL level, except for the peak in 1986. Three additional peaks are seen in Figure 9.4 that occur before 1982. A significant peak occurred in 1971 which was probably due to the BANEBERRY test that accidently vented following detonation on December 18, 1970. This test was located in the southwest section of Area 8. Peaks occurred in 1977 and 1981, which are probably due to foreign nuclear testing. The peak in 1986 is attributed to the accident at Chernobyl.

Since about 1982, gross beta in air levels have been uniformly low and essentially at world-wide background, except for the 1986 peak. Almost all values are above analytic MDCs; thus, the data values are valid measures of environmental conditions.

PLUTONIUM IN AIR

The glass-fiber filters that were used for weekly gross alpha and beta analysis and gamma spectroscopy were composited on a monthly basis and then analyzed for ^{238}Pu and $^{239+240}$Pu. Descriptive statistics for the results and duplicates from individual sampling locations are given in Table 9.3 for ^{238}Pu and in Table 9.4 for $^{239+240}$Pu. The median onsite MDC for ^{238}Pu in 1999 was 10.15×10^{-18} µCi/mL. Ninety-six percent of the onsite results were less than the MDC, and 57 percent were negative. The median onsite MDC for $^{239+240}$Pu was 10.05×10^{-18} µCI/mL. Nine percent of the onsite results were negative, and 51 percent were less than the MDC.

Probability plotting of the ^{238}Pu data indicated that the negative data are from a different statistical distribution than the positive data, and the positive data have a lognormal statistical distribution. Because of

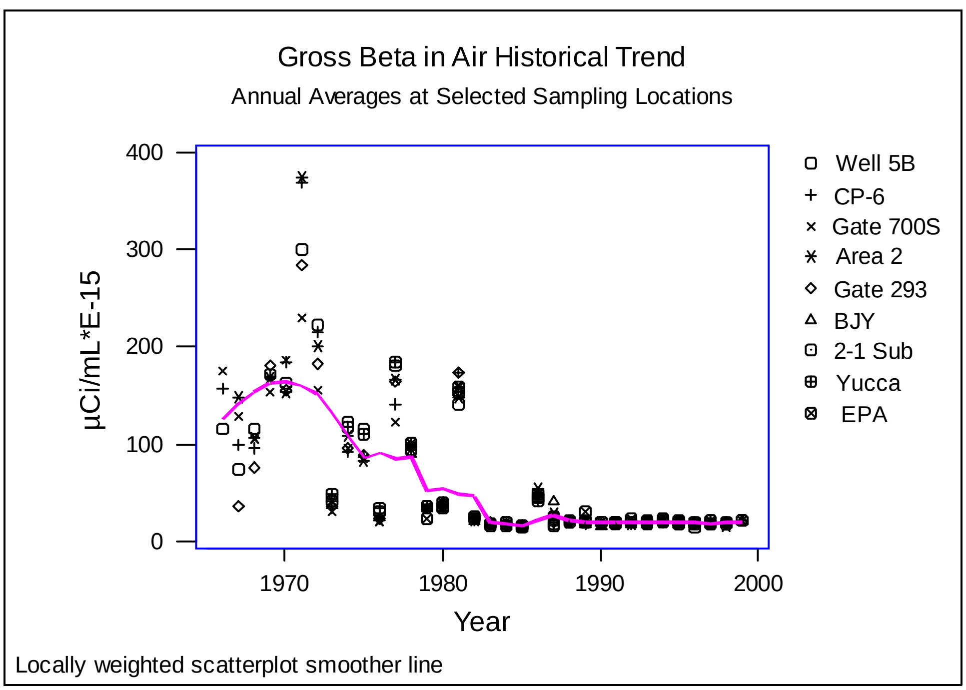


Figure 9.4 Historical Time Series for Selected Sampling Locations

this, and that almost all results are less than the MDC, only a few summary statistics were done for this isotope.

Those sampling locations that have ^{238}Pu concentrations above the MDC are typically locations that have historically shown relatively high concentrations. Bunker T-4 in Area 4 had above MDC results in July, August, and December 1999. This bunker is about 200 feet southwest of the T-4 tower location. Four atmospheric tests were conducted at this tower location in the 1950's: FOX on May 25, 1952, NANCY on March 24, 1953, APPLE-1 on March 29, 1955, and KEPLER on July 24, 1957. The 9-300 Bunker in Area 9 had above MDC results in February and April through November. This bunker is surrounded by 15 nuclear test locations. The closest two are approximately 500 feet northwest of the bunker and were underground tests: MANATEE on December 14, 1962, and APSHAPA on June 6, 1963. The other sample, with above MDC results, was collected at the RWMS 4 northeast sampling location in Area 5 in January 1999. This location has no history of high values.

Descriptive statistics for $^{239+240}Pu$ by sampling location are given in Table 9.4. The most striking features of this table are the great differences between the means and corresponding medians, large standard deviations, and relatively high maximum values. This pattern of statistics is characteristic of extremely skewed data. Probability plots of these data indicated a mixture of two statistical distributions. The data above zero have nearly a lognormal distribution and the data below equal to and below zero have an undetermined distribution. An examination of the data in the probability plots showed that the 12 highest values were from samples collected at the 9-300 Bunker.

The significance of the differences in $^{239+240}Pu$ concentrations among NTS operational areas can be assessed using ANOVA procedures. A one-way ANOVA was performed on the logarithms of the data; logarithms delete the negative data values. This analysis showed very significant differences among areas. The $^{239+240}Pu$ concentrations in Area 9 are significantly higher than all other areas. Area 9 contains one sampling location, the Bunker 9-300 location. The remaining areas can be arranged into several overlapping groups with no obvious clusters of mean values.

Plutonium in air data were first reported in the 1971 Annual Report. From 1971 to 1989 no distinction was made between ^{238}Pu and $^{239+240}Pu$, but it is known from the analytical method used that $^{239+240}Pu$ was being measured. In 1989, ^{238}Pu analyses began. Figures 9.5 and 9.6 plot historical annual averages from the four sampling locations that have data available from 1989 through 1999. Figure 9.5, containing ^{238}Pu annual averages, shows an exponential shaped decline from a level of about 6×10^{-18} µCi/mL in 1989 to almost zero in 1999. Figure 9.6, containing $^{239+240}Pu$ annual averages, indicates an almost constant trend over the entire time period of the figure. The highest value in Figure 9.6 is 150×10^{-18} µCi/mL, and the public derived concentration guide (DCG) is over 13 times higher at 2×10^{-15} µCi/mL.

TRITIUM IN AIR

Fourteen samplers for airborne tritiated water vapor were placed at locations on the NTS during 1999. In September, tritium sampling began at two offsite locations: Indian Springs High School and Amargosa Valley Community Center. Samples were typically collected over a two week period. Figure 4.1 shows the locations of the 1999 tritium in air sampling locations on a map of the NTS.

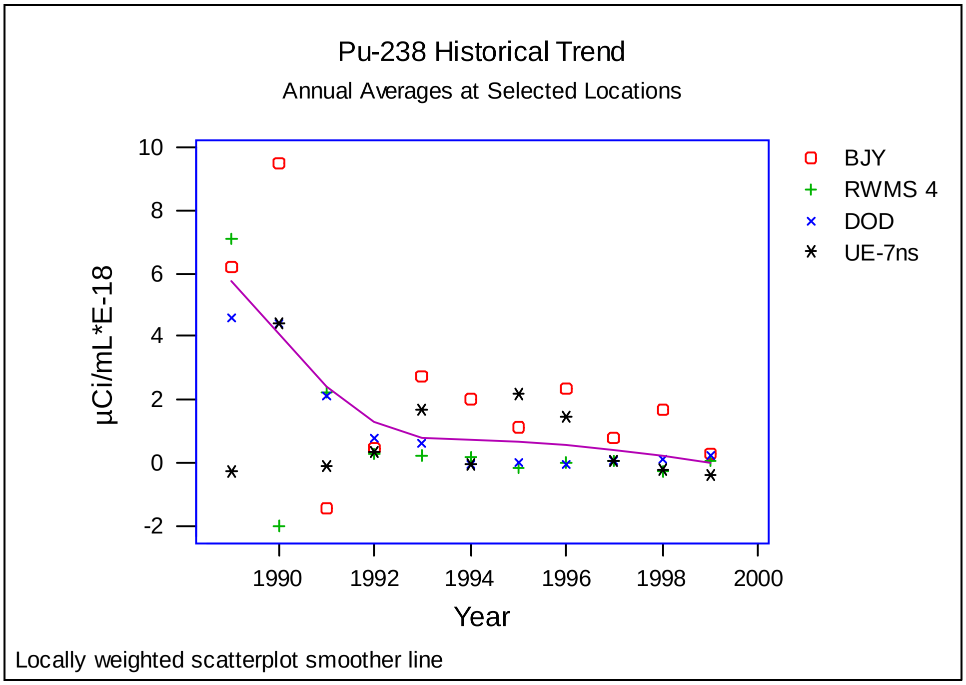


Figure 9.5 Time Series Plot of ^{238}Pu Annual Averages

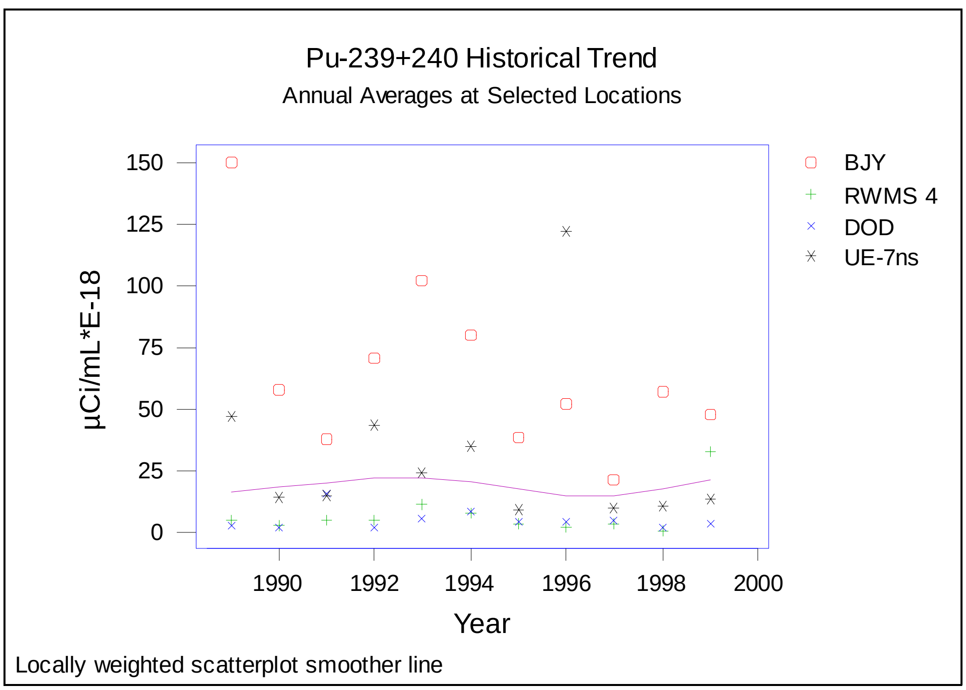


Figure 9.6 Time Series Plot of $^{239+240}$Pu Annual Averages

Table 9.5 gives descriptive statistics for the results and duplicates from the individual sampling locations. Note that the units used in this table differ from those used in all previous tables. Forty-six percent of the data values are below the individual MDCs, and 10 percent are negative. Most of the above MDC results are from the Greater Confinement Disposal (GCD) trailer, Building 5-6 of the RWMS, EPA Farm, SEDAN north, E Tunnel, and SCHOONER locations. The RWMS has storage for tritiated waste as well as other radiological waste materials. The EPA Farm is close to SEDAN north, which is a known source of low levels of tritium. Note that there are only three samples from the decontamination pad. The waste material stored at this pad was relocated at the beginning of 1999 and the decontamination facility was decommissioned.

Figure 9.7 is a time series plot of all the onsite tritium in air data for 1999. The high values seen during the summer months are from the SCHOONER sampling location. Historically, most tritium in air sampling locations have shown increased tritium levels during the hot summer months, and this pattern is most obvious in the SCHOONER data. The highest value in Figure 9.7 is from the BJY location. A review of the data suggest that for the sampling period beginning on September 7, 1999, the samples or data for BJY and SCHOONER were interchanged. No evidence of this could be found in the log books or other records, but for the statistical analyses reported here, the interchange was assumed to have occurred.

In Table 9.5, note that most of the medians are smaller than the corresponding means. This is characteristic of data that has a lognormal statistical distribution. Probability plots of the tritium in air data indicated that these data have a lognormal statistical distribution. A logarithmic data transformation will cause the higher values in Figure 9.7 to appear less remarkable. This transformation will also discard all negative data values; however, only 10 percent of these data are negative, and this is not a serious loss of information. A one-way ANOVA on the logarithms of these data indicated a significant difference among sampling locations. This analysis identified three groupings of sampling locations based on 1999 tritium in air levels. The group with the lowest tritium levels has data values that were usually less than the MDC. This group includes Stake T-18, Well 5B, BJY, the Waste Examination Facility (WEF) northeast, RWMS west, and RWMS south. The second group contains five sampling locations: RWMS GCD Trailer, Building 5-6, SEDAN north, E Tunnel pond, and the EPA Farm. This group contains tritium levels that are above MDC during the summer months. The final group contains a single location and is significantly different from all other groups, the SCHOONER location.

There are five locations that have been in continuous use since 1982 when tritium in atmospheric moisture data first appeared in NTS annual reports. These locations are: BJY, EPA Farm, RWMS 4 northeast, RWMS 7 west, and RWMS 9 south. Figure 9.8 is a historical time series plot of the median of the annual averages of these five locations. The median was used in this plot because for small sample sizes the median is a more robust estimator of central tendency than is the mean. Note that this plot has a logarithmic ordinate and that, using this scale, the data have approximately a linear decreasing trend. A linear regression on these data found a very good fit and also found that the medians for 1995 and 1996 were lower than expected. From this regression one can compute the time for tritium in air levels at the NTS to be reduced to one-half; this is four years. Since four years is about a third of the half-life of tritium, the tritium levels at the NTS are decreasing much faster than can be accounted for by radioactive decay alone.

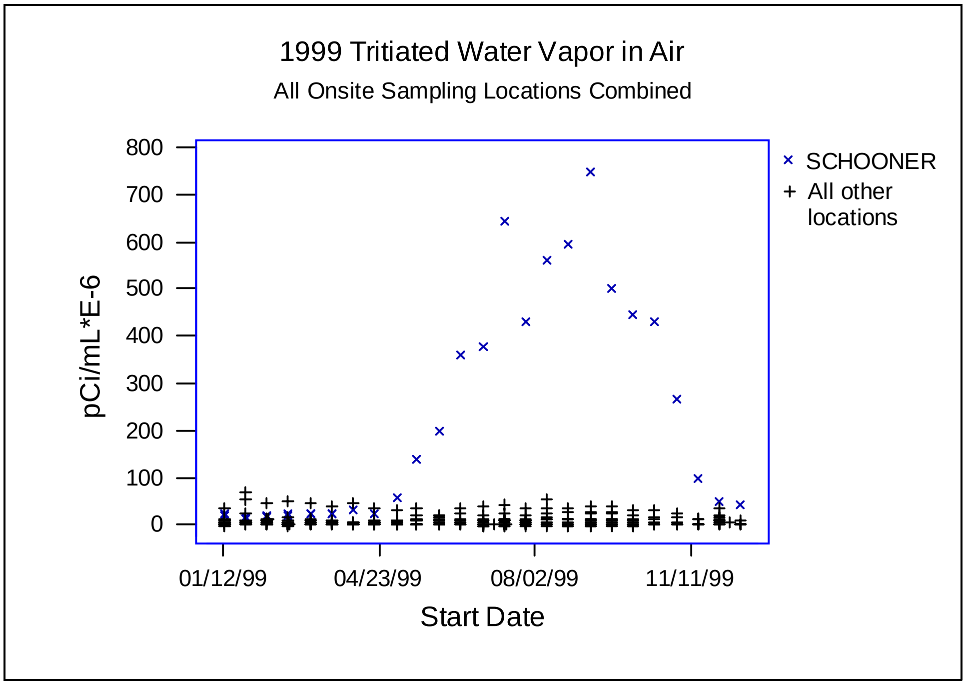


Figure 9.7 Time Series Plot of 1999 Tritium in Air Results

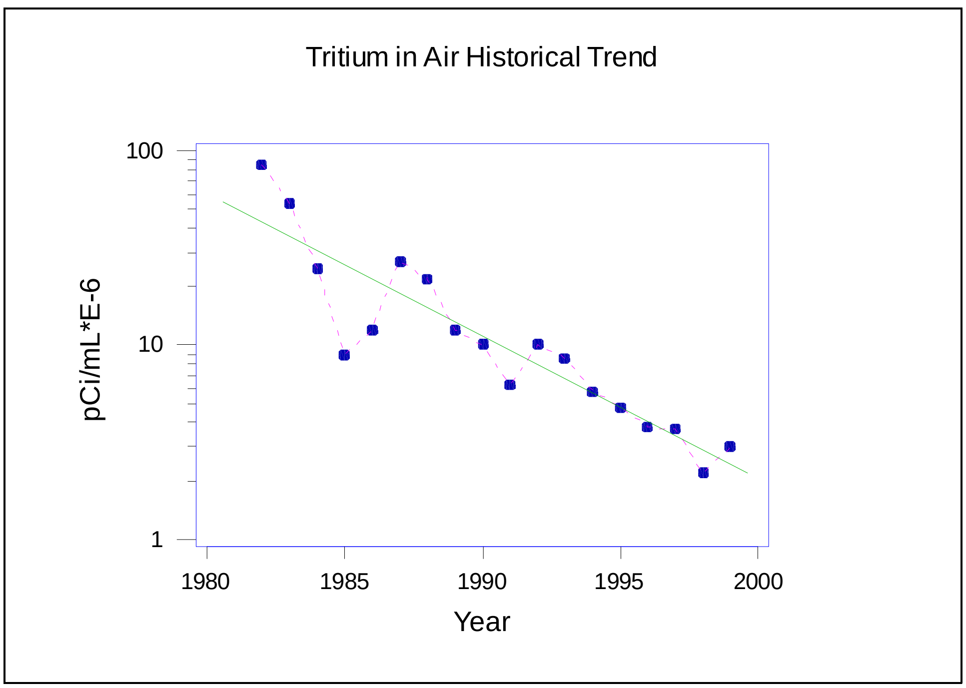


Figure 9.8 Historical Time Series for NTS Tritium in Air

GAMMA EMITTING RADIONUCLIDES IN ONSITE AIR

Naturally occurring radionuclides not in equilibrium at the time of counting, such as ^{208}Tl, ^{212}Pb, ^{214}Pb, ^{212}Bi, and ^{214}Bi, were not included in this report. This leaves no gamma emitting radioisotopes other than those listed in Table 9.6. Of the isotopes listed in this table, ^{137}Cs is man-made; the remaining are naturally occurring and in equilibrium. Descriptive statistics, in units of µCi/mL, for these radionuclides appear in Table 9.6.

GAMMA EMITTING RADIONUCLIDES IN OFFSITE AIR

Beginning in July of 1999, air samples were collected at six locations outside the NTS. This sampling is to provide data for the National Emission Standards for Hazardous Air Pollutants (NESHAP) annual reports. The air samplers used in this program differ from the samplers used for onsite air sampling. The onsite samplers filter air at a rate of 3 cubic feet per minute and the offsite samplers filter air at a rate of 40 cubic feet per minute.

The six offsite locations are in small communities surrounding the NTS. The air samplers are located in Alamo next to the bank, at the Amargosa Valley Community Center, in Beatty adjacent to the post office, in Goldfield adjacent to the post office, at the Indian Springs High School, and in Rachel near the café. Statistics for all these locations combined are given in Table 9.7.

As for the onsite air sampling data, naturally occurring radionuclides not in equilibrium at the time of counting, such as ^{208}Tl, ^{212}Pb, ^{214}Pb, ^{212}Bi, and ^{214}Bi, were not included in this report; this leaves no gamma emitting radioisotopes other than those listed in Table 9.7. Of the isotopes listed in this table, ^{137}Cs is man-made; the remaining are naturally occurring and in equilibrium. Descriptive statistics, in units of µCi/mL, for these radionuclides appear in Table 9.7.

9.2 THERMOLUMINESCENT DOSIMETER DATA

Thermoluminescent dosimeters (TLDs) were placed at 85 monitoring locations on the NTS during 1999. The dosimeters are exchanged quarterly and processed at the Bechtel Nevada Dosimetry Laboratory in Mercury, Nevada. Table 9.8 list the annual total mR/yr for each location. Typically TLDs are exchanged during the first week of each calendar quarter. It takes several work days to exchange all the TLDs, so the exposure duration for each location varies from one quarter to the next. The median exposure in 1999 was 98 days. The range of TLD exposures in 1999 was from 83 to 112 days.

For convenience, TLD locations are divided into four classes. Boundary locations are close to the perimeter of the NTS. Background locations are known to have no man-made radionuclide inventory. Operational locations are adjacent to stored radioactive materials. In 1999, the operational locations included the Areas 3 and 5 RWMS locations and the Decontamination Facility locations. The remaining TLDs are in the environmental monitoring class. Since the boundary locations were established in 1990, there have been no statistically significant differences in annual TLD exposure rates between the boundary locations and the background locations. Thus, the boundary locations are now included within the background class of locations.

Atypical values or outliers were identified, from probability plots and histograms of the data and subsets of the data, as data points plotting at some distance from most of the other data points in that subset. This process identified two distinct groups of TLD data values that have different statistical distributions. The group of non-atypical TLD sampling locations has data values with a normal statistical distribution and a mean value of 118 mR/yr, an upper limit of about 175 mR/yr. The second group contains seven data values from the atypical locations. Seven values are too few to establish a statistical distribution, but in previous years, when the operational locations were found to be grouped with the atypical locations, this group had a lognormal distribution. The 1999 atypical values range from 216 to 823 mR/year and have a median of 272 mR/year.

The seven data values that were judged to be atypical are listed in Table 9.9. The last column of this table, the “Area Mean”, gives the average annual exposure for the NTS area with the atypical values deleted. The 1999 atypical values had exposure rates above 200 mR/yr. The list in Table 9.9 is about the same as in previous years, except that RWMS south was not in the 1998 list. The locations in Table 9.9 are mostly in Yucca Flat in places known to be contaminated by early atmospheric testing of nuclear devices. The SEDAN west location is in the throw out from the crater. The tunnel ponds contain products from the nuclear tests performed within the tunnels.

The average 1999 exposure from the environmental, background, and boundary locations was 118 mR/yr. From 1994 to 1998 the NTS average exposures ranged from 117 to 128 mR/yr. The generally accepted value for worldwide background is 120 mR/yr.

A two-way ANOVA was performed on the non-atypical locations data to test for differences among NTS areas and quarters of the year. This analysis found very significant differences among the areas and no differences among quarters. This is the same pattern as has been found in the past several years. A one-way ANOVA was then used to identify the pattern of differences among areas. This analysis found no grouping or clustering of area mean values. When the area means were sorted by magnitude, the pattern seen was a gradual and consistent increase from a low value for Area 23 to the highest value for Area 30.

Area 30 contains one TLD location. It is the boundary station located at the junction of Cat Canyon Road and the road to the BUGGY test site. This location is as close to the west boundary as can now be reached in this region due to washed out roads. This is in a geographic region with high natural radiation levels from prehistoric lava flows. Aerial surveys of this region detect higher than background levels of ^{208}Th. The highest annual exposure of all environmental locations, excluding those mentioned previously at which annual exposures were atypical, is in Area 20 at Stake J-31. This stake is less than a mile north of two cratering tests, PALANQUIN and CABRIOLET.

Film badges were used during early activities on the NTS for ambient gamma exposure monitoring. TLDs replaced the film badges in 1977, with ten monitoring stations (locations) chosen to be near work sites. From 1977 to 1987, the TLDs used were manufactured by the Harshaw Chemical Company. In 1987, a changeover was made to TLDs manufactured by Panasonic. At the end of 1999, there were a total of 85 active TLD locations.

A three-way ANOVA was used to test for differences in mR/yr due to differences among years, differences among operational areas, and differences between location types (Background and Environmental locations with atypical values removed). The data were the annual mR/yr at each location for 1999 and the previous five years. The operational areas and types were included to remove those sources of error from the residual error and thus increase the power of the ANOVA. The results of this analysis were very significant for differences among years and types and no significant differences among areas. A simultaneous inference analysis of the differences among years identified two clusters of annual averages. The first cluster is composed of the data from 1994, 1995, and 1996 and has a mean value of 300 mR/yr. The second cluster contains the data from 1997, 1998, and 1999 and has a mean value of 169 mR/yr. The location types also clustered into two groups. The operational and atypical locations formed one group with a mean of 820 mR/year, and the control, background, and environmental locations formed the second group with a mean of 121 mR/year.

Figure 9.9 is a boxplot of the data by years for the environmental, background, and control locations. Boxplots consist of a box, whiskers, and outliers. A line is drawn across the box at the median. The bottom of the box is at the first quartile, and the top is at the third quartile value of the data. The whiskers are lines that extend from the top and bottom of the box to adjacent values. Adjacent values are the lowest and highest data values that are less than one and one-half times the interquartile range from the ends of the box. Outliers are data values outside the adjacent values and are plotted with an asterisk. Figure 9.9 shows minor differences between years. This figure does not seem to support the ANOVA finding of significant differences between years. However, this figure does not contain the data from operational and atypical locations and an examination of the historical data from these locations shows obvious decreases over the years used in the ANOVA.

9.3 WATER SAMPLE DATA

GAMMA EMITTING RADIONUCLIDES IN WATER

The only non naturally occurring radionuclide found by gamma spectroscopy in NTS water samples was ^{137}Cs. This isotope was found in seven samples and four duplicates. All but one of these are from Area 12 E Tunnel effluent and pond. The presence of non-naturally occurring radionuclides in E Tunnel waters is not surprising, since nuclear experiments formerly occurred within this tunnel. The other location at which ^{137}Cs was detected was the DAF Sewage Lagoon, where a sample collected on April 22 had a concentration of 1.2 x 10^{-9} µCi/mL. The ^{137}Cs was not detected in a second sample collected on April 29. Descriptive statistics for the E Tunnel data are presented in Table 9.10.

RADIUM IN WATER

Radium concentrations were measured quarterly at ten supply wells in 1999. Water samples from other types of sources are not analyzed for radium. Descriptive statistics

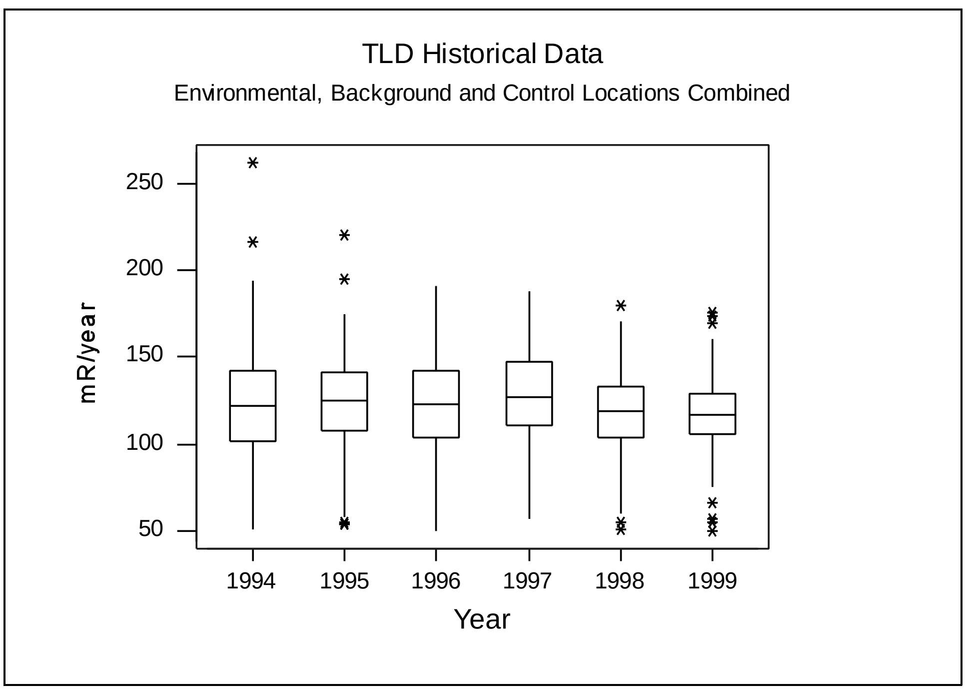


Figure 9.9 Historical Time Series of Boxplots of TLD Exposures

appear in Table 9.11. For ^{226}Ra, 90 percent of the results were less than the MDC, and for ^{228}Ra, 88 percent of the results were less than the MDC. Since 89 percent of all radium results are less than the MDC, only the summary statistics in Table 9.11 were computed.

STRONTIUM IN WATER

In 1999, ^{90}Sr concentrations were measured in samples from 15 locations on the NTS. An annual sample was collected from 6 tap water locations, 2 containment pond locations, and 7 sewage ponds. A total of 18 ^{90}Sr analyses were performed, including 3 duplicates. Descriptive statistics for each type of sampling location are given in Table 9.12

An examination of the data showed that all results were below the MDC, except the four from the E Tunnel; two samples and two duplicates. Water from inside the E Tunnel, where nuclear experiments formerly occurred, drains as an effluent and then into the pond. Thus, it is not surprising to find non-naturally occurring radionuclides in these waters.

Since all of the ^{90}Sr in water results from all locations excluding the containment ponds are less than the individual MDC, and 28 percent of those results are negative, any statistical analyses or further data descriptions are unreasonable. These data simply show, that except for the containment ponds, no ^{90}Sr was detected in NTS water samples.

URANIUM IN WATER

In 1998, the NTS's "Routine Radiological Environmental Monitoring Plan" (RREMP) was developed (DOE 1998a). This plan was published in December 1998. It contains no requirements for monitoring uranium in water; thus, uranium in water analyses were discontinued at the beginning of 1999.

GROSS ALPHA IN WATER

Two new types of wells were sampled in 1999; the Aquifer Monitoring Wells and the Underground Testing Area Wells (UGTA). These were added to comply with the RREMP. These wells were chosen to monitor the groundwater in the vicinity of underground nuclear testing areas. The aquifer monitoring is mostly a new program. UGTA is an ongoing effort of the Environmental Restoration program.

Gross alpha levels in water for 1999 were measured quarterly at 10 water supply wells, and annually at 2 containment ponds, 12 aquifer monitoring wells, 7 underground testing area wells, and 9 sewage ponds. Tap water samples were collected for alpha analysis at six locations. The sampling frequency varied by location from quarterly to annually. Descriptive statistics by location and type are given in Tables 9.13 and 9.14. The statistics for supply wells and tap water locations combined are approximately the same as those reported for 1996, 1997, and 1998. For the supply wells and tap waters combined, all results are positive and 20 percent are less than the MDC.

Figure 9.10 plots the alpha levels by sampling date in 1999 and type of location. This time series plot shows, that in general, the containment pond concentrations are higher than the other water types. There are no interesting time dependent patterns. The well and tap water data for each quarter are approximately uniformly spread over a range of zero to approximately 15×10^{-9} µCi/mL. The aquifer monitoring well data were left out of Figure 9.10. These data contain a few high values that would increase the range of the ordinate and thus obscure the patterns seen in this figure. The statistics for the aquifer monitoring wells are skewed by the 2120.0×10^{-9} µCi/mL sample from well UE-6e. This well produces muddy water samples so the results may be influenced by particulate matter.

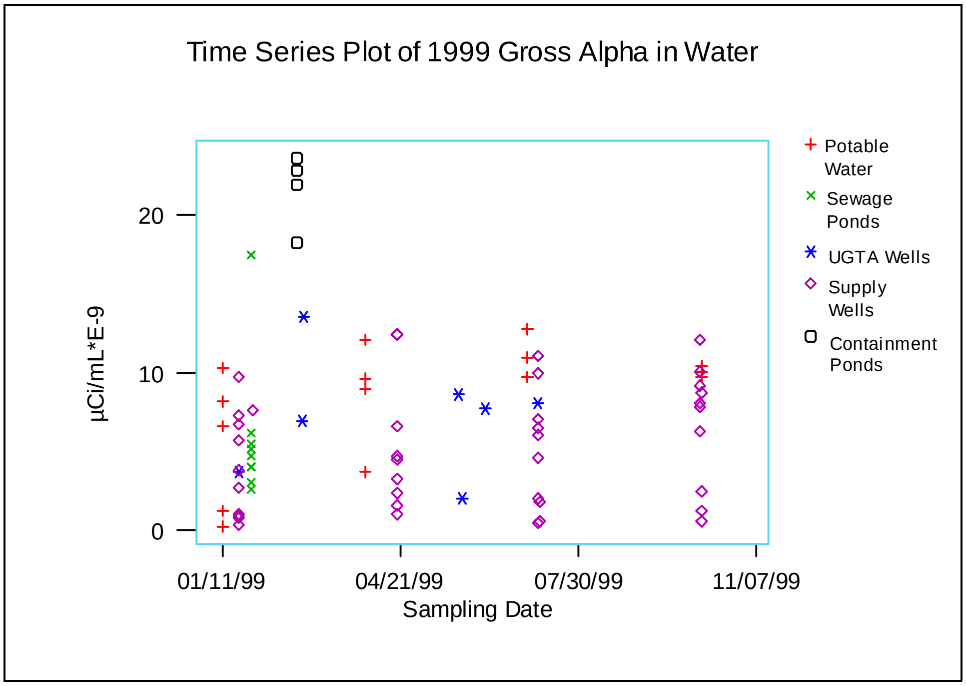


Figure 9.10 Time Series Plot of 1999 Gross Alpha in Water

ANOVA procedures are the statistical methods of choice to analyze the gross alpha in water data for significant differences among sampling locations and types of locations. These procedures require that the residuals have a normal statistical distribution. The residuals from the analyses discussed in the following paragraphs were checked for normality using probability plots, and they were found to have the required normal distribution if the data are transformed using logarithms.

The most appropriate ANOVA for the gross alpha in water data is a three-way analysis with factors of sampling location, type of location (wells or tap water end points), and quarter of the year in which the sample was collected. The locations are nested within the types, and these factors are crossed with the quarter factor. The data are rank deficient for such an analysis because of unbalanced nesting and empty cells due to the fact that many wells are sampled only annually. A two-way ANOVA can be done, predicting the logarithm of the results by water type and location nested within water type. This analysis found a significant difference among sampling locations and also significant differences among types of locations. A Tukey's simultaneous inference analysis found that the water types clustered into two groups: the containment ponds and aquifer monitoring wells formed one group, and the potable water, UGTA wells, sewage ponds, and supply wells formed the second group. The differences between the members of each group are not statistically significant.

The use of logarithms of the data values reduces the influence of the high values from the aquifer monitoring wells on the statistical results. A probability plot of the logarithms of all the data indicated that the gross alpha data set has a lognormal distribution. Thus using the logarithmic transformation of the data in the ANOVA is the appropriate thing to do.

The statistically significant differences of the water sampling locations does not imply that there are health physics concerns with the levels of gross alpha in the NTS drinking waters. The EPA drinking water limit for gross alpha is 15 × 10^{-9} µCi/mL, and all the drinking water and supply well averages are below this limit, as shown in Table 9.13. The probable causes of the gross alpha activity in these waters is the natural radium isotopes ^{226}Ra and ^{228}Ra.

Gross alpha measurements in tap water were begun in 1984 and data exist from 1984 through 1999 for only two sampling locations: the cafeterias in Areas 6 and 23. The Area 23 Cafeteria is also called the Mercury Cafeteria. Figure 9.11 is a time series plot of the annual averages from these two locations. This figure also contains a locally weighted scatterplot smoother line which shows the overall general trend in the data. This figure shows that the Area 6 Cafeteria gross alpha levels are slightly higher than the Area 23 Cafeteria levels and that there is a slight trend of increasing levels over the past 16 years at these two locations.

GROSS BETA IN WATER

Gross beta concentrations in water were measured at the same locations as gross alpha, for a total of 43 sampling locations. For gross beta, the supply wells, potable waters, sewage lagoons, and containment ponds were sampled quarterly. Descriptive statistics are presented in Tables 9.15 and 9.16. The values for the aquifer monitoring wells are skewed by a high value of 1,190 µCi/mL × 10^{-9} at UE-6e. As mentioned in the previous section, this well produces muddy water samples. The values in the table for the containment pond statistics are about an order of magnitude higher than the values from the wells and tap waters. This is to be expected since the containment ponds were constructed to contain the effluents from nuclear experiments performed inside a tunnel, and thus have a more concentrated source of radioactivity than other surface waters. The median MDC for all sampling locations and all sample collection dates is 1.29 × 10^{-9} µCi/mL. All sample results are positive (greater than zero) and 98 percent exceeded the individual MDCs. Figure 9.12 presents a time series plot of the 1999 gross beta in water results for supply wells and tap water end points.

Probability plotting was used to determine that the 1999 gross beta in water data have a lognormal statistical distribution, as was determined for gross beta in water results in previous years. An ANOVA was run using the logarithms of the results as the dependent variable, and quarter of sample collection, water type, and sampling location nested within water type as predictors. The UGTA and aquifer monitoring wells were not used in this analysis. They have data for only one quarter and they have obviously higher gross beta concentrations, as is shown in Tables 9.15 and 9.16. This analysis found no differences among the quarter of the year that samples were collected and very significant differences among the types of sampling locations and also very significant differences among locations. A Tukey's simultaneous inference analysis on the water types found that the potable water and supply well locations formed a single group, the sewage ponds are a second group, and the containment ponds are a third group of locations.

A one-way ANOVA using the logarithms of the results and sampling location was then used to determine the pattern of differences among the locations. This analysis found very significant differences between sampling locations but did not clearly identify the types of locations. When the locations were sorted on the magnitude of the location means, a gradual increase from the lowest mean to the highest is seen, and the groupings found by the Tukey's analysis have substantial overlap.

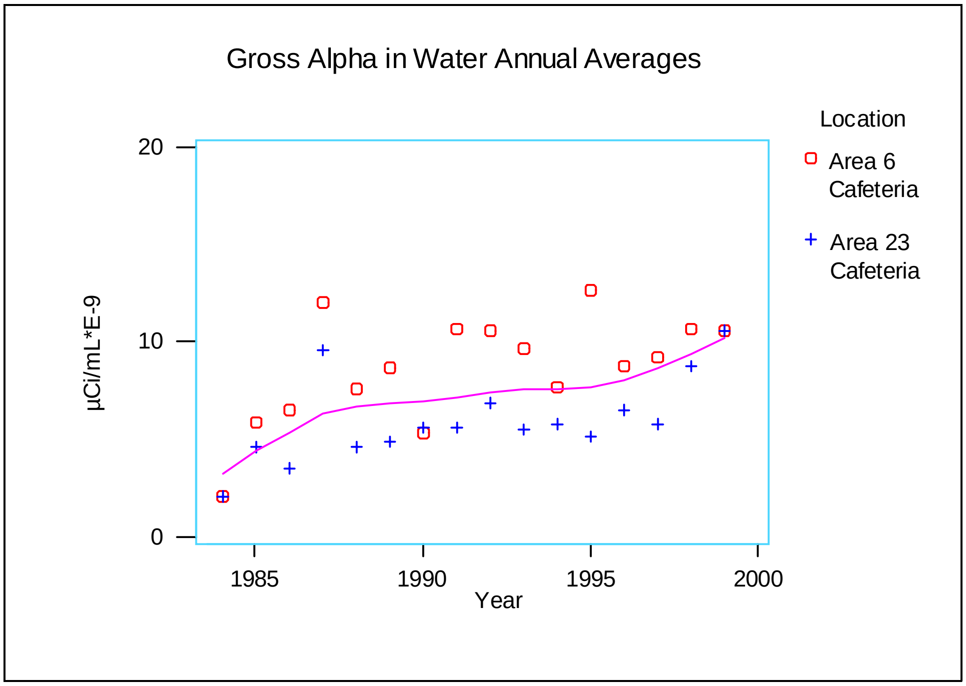


Figure 9.11 Historical Time Series for Gross Alpha in Water

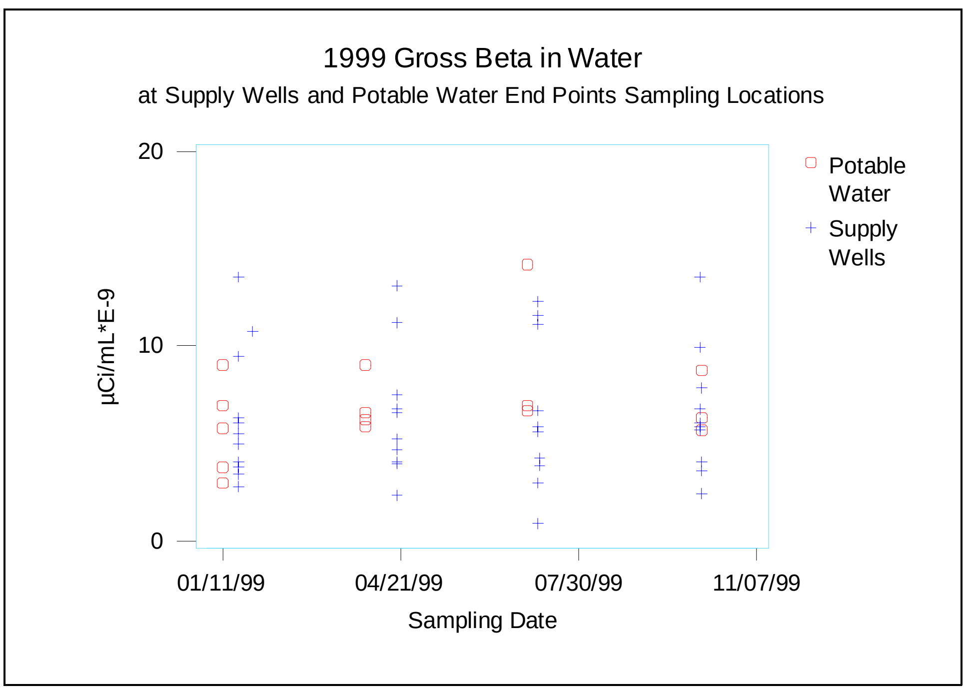


Figure 9.12 Time Series Plot of 1999 Gross Beta in Water

Gross beta in water measurements began in 1964, and data exist from 1964 through 1999 for only four sampling locations: the Area 6 Cafeteria, Area 23 Cafeteria (also called the Mercury Cafeteria), Well C-1, and Well 5C. Figures 9.13 and 9.14 present historical time series plots for these cafeterias and wells. In general, historical trends for levels of gross beta in water are not as clear as those of gross beta in air. Underground waters, such as samples from wells, would not have been affected by atmospheric nuclear testing. Gross beta in air shows declining levels since 1970, about the time atmospheric testing ended. No such trend is evident in the water data. There are obvious differences among sampling locations, but no long term trends are evident. There is a possible short term trend seen in Figure 9.13 for the tap water end points. Note that before 1996, the gross beta concentrations at the Area 6 Cafeteria were always higher than at the Area 23 Cafeteria. For 1996-1999, this pattern is reversed.

Except for the E Tunnel sampling locations, the gross beta and gross alpha activity in the water is probably due to naturally occurring radionuclides, and would be expected to be relatively constant over time at any given location but vary among locations because of local geological structure. This is the situation that has been observed at the NTS.

PLUTONIUM IN WATER

Water samples for ^{238}Pu and $^{239+240}$Pu measurement were collected in 1999 from nine supply wells, six tap water locations, eight sewage lagoons, two containment ponds, nine aquifer monitoring wells, and six UGTA wells. Annual samples were collected from all wells. Quarterly samples were collected from the sewage ponds and containment ponds. Three of the tap water locations were sampled quarterly and three annually. Descriptive statistics for each sampling location sampled quarterly and each sample type sampled annually for ^{238}Pu are given in Table 9.17 and in Table 9.18 for $^{239+240}$Pu.

An examination of the ^{238}Pu data and the statistics in Table 9.17 revealed that all concentrations were below the MDC except for the 14 containment pond results. Plutonium in the E Tunnel effluent is known to result from several nuclear experiments that were preformed within that tunnel. Water that seeps into the tunnel picks up contamination within the tunnel then exits the tunnel as effluent and is collected in the containment pond. The concentrations measured from the effluent and containment pond in 1999 are consistent with historical levels at these locations. Excluding the fourteen ^{238}Pu E Tunnel sample values that are above their MDC, 79 percent of the values are less than zero, and 82 percent of the values were within one standard deviation of zero. This situation indicates that the measurements represent only randomness in the analytical procedures, and no ^{238}Pu was actually found in the samples except at the E Tunnel. Thus, no further statistical analyses were performed.

$^{239+240}$Pu concentrations in water were measured using the same samples as were used for ^{238}Pu; thus, the same sampling pattern applies. The results were also similar. All but one of the results was below the MDC, except those from the E Tunnel containment ponds. $^{239+240}$Pu levels in the effluent and containment ponds are known to be elevated for the same reason ^{238}Pu levels are elevated. Again excluding the E Tunnel data, 71 percent of the values were less than zero; 56 percent of these results are within one standard deviation of zero; and 97 percent were within two standard deviations of zero. As for ^{238}Pu, no further statistical analyses of the $^{239+240}$Pu results were performed.

Annual averages for the plutonium isotopes in water have been reported since 1989. Two representative locations were chosen from each type of water sampling location, except only one containment pond location was used. Except for the Los Alamos National Laboratory (LANL) Sewage Lagoon, the chosen locations have data available for all years since plutonium concentrations were first included in annual reports, and are geographically dispersed within the NTS.

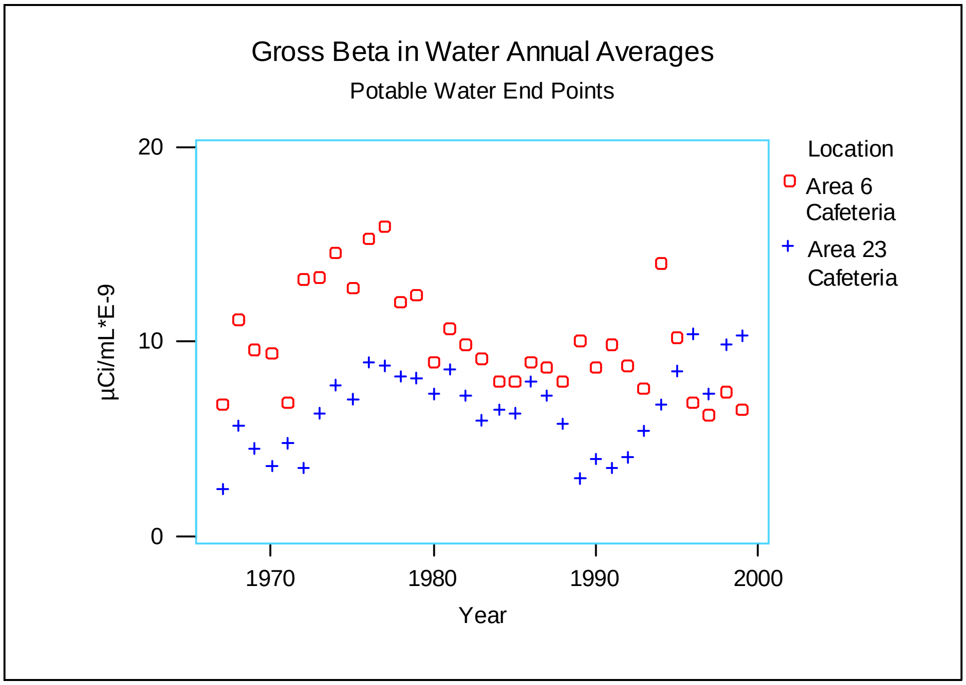


Figure 9.13 Historical Time Series Plot for Tap Water

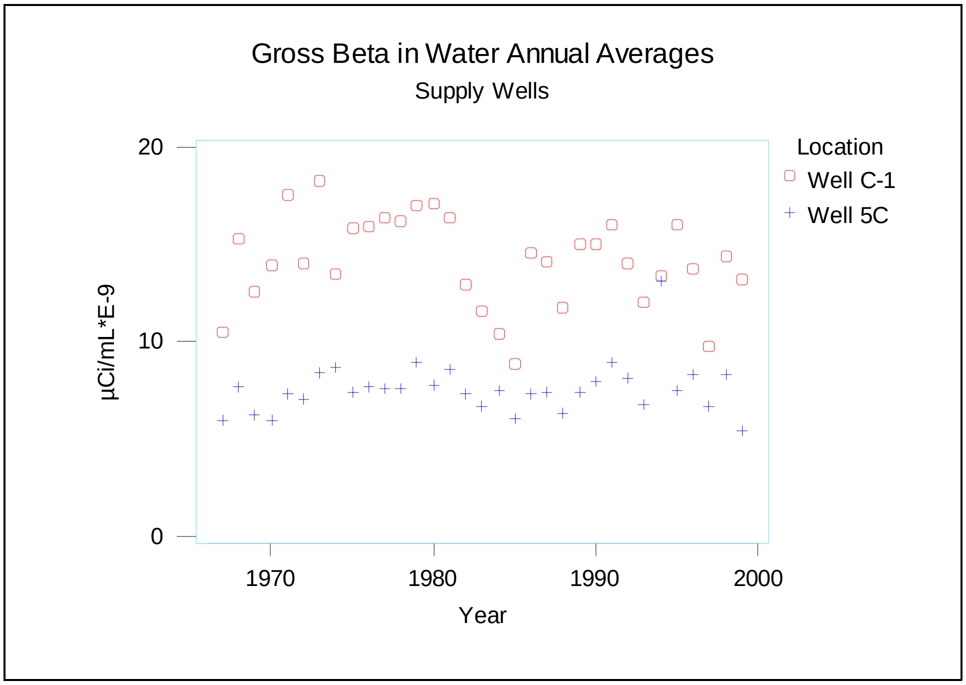


Figure 9.14 Historical Time Series Plot for Supply Wells

The chosen locations are identified in Tables 9.19 and 9.20, which contain the historical annual averages for the last ten years.

Most of the annual averages in these tables are below detection limits or below the MDC, but there are a few notable exceptions. Over the years, the median detection limit for both plutonium isotopes has been approximately 20×10^{-12} µCi/mL. Prior to 1996, the sensitivity of water analyses was reported as detection limits, and in 1996 this was changed to reporting the MDC. Thus it is appropriate to use detection limits when discussing historical plutonium concentrations in water.

The E Tunnel effluents have had highest plutonium levels of both isotopes for all the tabled years. These levels are from known sources, as discussed above. Note that, for both isotopes, the concentrations show a declining trend over time and the 1990 concentrations are about five times the 1999 concentrations for ^{238}Pu and about three times for $^{239+240}$Pu.

The Area 23 sewage lagoon contained both plutonium isotopes above the MDC of in 1996. These observations are discussed in the 1996 Data Report.

TRITIUM IN WATER

Two analytical procedures are used for tritium in water analyses. Most well waters are analyzed using an enriched tritium procedure. The remaining types are analyzed using a conventional tritium procedure. The enriched procedure is capable of measuring substantially lower levels of tritium and it is more accurate (smaller errors) than the conventional method; however, the enriched method is more expensive. Water samples for tritium analysis are usually collected quarterly, and some duplicate analyses were performed. Summary statistics for the samples analyzed using the enriched method are given in Table 9.21 and in Table 9.22 for samples analyzed using the conventional analytical method. In these two tables, if only one sample was analyzed in 1999 for a location, only the sample value and the MDC are listed.

Table 9.21 contains the offsite locations, a location type that is new for 1999. This type consist of 12 potable water locations that are private or public water supplies. They are mostly located in the Amargosa Valley, southwest of the NTS. Since only one sample was collected from each of these locations in 1999, Table 9.21 gives only the summary statistics for all these locations combined.

Examination of Tables 9.21 and 9.22 will reveal that almost all the maximum values are much less than the median MDC. The exceptions are the E Tunnel locations and four of the ten maxima from the UGTA and aquifer monitoring wells analyzed using the enriched method. The concentrations from E Tunnel samples are two orders of magnitude above the MDC and thus show a substantial tritium inventory. Hence, the tritium in water sampling locations can be divided into three groups: the two E Tunnel locations show a substantial inventory of tritium; the four aquifer monitoring and UGTA locations that had results above MDC form the second group which had one sample collected in 1999; and the final group contains all the remaining locations and had maximum values below the MDC.

Concentrations below the MDC represent randomness in the analytical procedure rather than providing information about tritium inventories. Eighty-seven percent of the results reported in Tables 9.21 and 9.22 are less than the corresponding MDC. Thirty-nine percent of the results that are below MDC are also negative. The below MDC data will not be analyzed in this report. Also, the four results from the UGTA and aquifer monitoring wells analyzed using the enriched method will not be analyzed. Four numbers are insufficient for any meaningful statistical analysis.

Tritium in the E Tunnel effluent is known to result from the several nuclear experiments that were performed within that tunnel. Water that seeps into the tunnel picks up contamination within the tunnel then exits the tunnel as effluent and is collected in the containment ponds. The concentrations measured from the effluent and containment ponds in 1999 are consistent with historical levels at those locations.

Tritium in water annual averages are available starting in 1989. In general, annual averages have been below detection limits and MDCs, except for the E Tunnel locations. (Before 1996 detection limits were reported; in 1996 and later, MDCs were reported.) In the 11 years from 1989 through 1999, tritium levels in the E Tunnel Effluent have ranged from 8.3×10^{-4} to 2.2×10^{-3} µCi/mL.

Table 9.1 Descriptive Statistics for 1999 Gross Alpha in Air by Sampling Location, (µCi/mL × 10^{-15})

Sampling Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	Median MDC
NTS Locations							
Area 1, BJY	51	2.42	2.03	1.30	0.19	6.37	1.85
Area 2, 2-1 Substation	61	2.33	1.96	1.60	0.28	8.73	1.85
Area 3, Bunker 3-300	50	2.52	1.92	1.68	0.48	8.50	1.85
Area 3, U-3ah/at North	52	2.43	2.02	1.50	0.58	8.60	1.85
Area 3, U-3ah/at South	62	2.44	2.17	1.50	0.58	8.60	1.85
Area 3, U-3bh North	51	2.79	2.33	1.78	0.58	9.71	1.84
Area 3, U-3bh South	50	2.32	1.89	1.67	-0.48	9.07	1.84
Area 3, Well ER-3-1	53	2.27	2.13	1.44	0.25	7.28	1.85
Area 4, Bunker T-4	50	2.39	2.23	1.60	0.30	8.19	1.85
Area 5, DOD Yard	52	2.09	1.62	1.44	0.29	7.04	1.85
Area 5, RWMS 4 Northeast	63	2.53	2.18	1.63	0.38	8.26	1.84
Area 5, RWMS 9 South	11	1.76	1.83	0.63	0.68	3.04	1.84
Area 5, RWMS 7 West	51	2.77	2.34	1.58	0.02	9.11	1.85
Area 5, Transuranic Bldg. North	51	2.53	2.10	1.61	0.29	7.71	1.85
Area 5, WEF Northeast	51	2.28	1.93	1.39	0.29	7.99	1.85
Area 5, WEF Southwest	51	2.26	1.77	1.55	0.38	8.07	1.85
Area 6, Yucca	64	2.23	1.92	1.49	0.20	8.90	1.85
Area 7, UE-7ns	48	1.99	1.63	1.28	0.39	6.68	1.85
Area 9, Bunker 9-300	62	4.64	3.47	3.72	0.93	21.80	1.85
Area 10, SEDAN north	51	2.41	2.22	1.37	0.48	6.92	1.85
Area 15, EPA Farm	63	2.53	2.03	1.74	0.48	6.92	1.85
Area 18, LITTLE FELLER 2 North	51	2.08	1.88	1.30	0.02	6.97	1.85
Area 20, CABRIOLET	64	2.07	1.98	1.32	0.10	7.41	1.85
Area 20, SCHOONER	54	2.14	1.97	1.34	-0.29	7.39	1.85
Area 25, E-MAD North	62	2.31	2.17	1.58	0.02	8.11	1.91
All NTS locations combined	1329	2.45	2.04	1.75	-0.48	21.80	1.85
NAFR Locations							
Area 13, Project 57	49	2.13	1.81	1.49	0.30	7.98	1.87
Area 52, CLEAN SLATE II	24	2.77	2.43	1.59	0.87	7.30	1.83
Area 52, CLEAN SLATE III	24	3.35	2.65	2.11	0.57	9.07	1.82
Area 52, DOUBLE TRACKS	15	2.08	2.15	0.67	1.04	3.48	1.00
All NAFR locations combined	112	2.52	2.12	1.65	0.30	9.07	1.84

Table 9.2 Descriptive Statistics for 1999 Gross Beta in Air by Sampling Location, (µCi/mL × 10^{-15})

Sampling Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	Median MDC
NTS Locations							
Area 1, BJY	51	21.82	21.40	5.68	10.70	37.10	4.05
Area 2, 2-1 Substation	61	22.25	21.80	5.88	10.00	35.40	4.05
Area 3, Bunker 3-300	50	20.41	19.95	5.82	8.75	37.70	4.02
Area 3, U-3ah/at North	52	18.87	18.95	5.36	9.09	33.80	4.05
Area 3, U-3ah/at South	62	19.92	19.45	5.15	8.27	34.40	4.05
Area 3, U-3bh North	51	21.62	21.60	5.79	11.60	34.60	4.05
Area 3, U-3bh South	50	20.23	20.25	5.87	9.04	38.30	4.05
Area 3, Well ER-3-1	53	20.68	20.10	5.97	8.75	38.70	4.05
Area 4, Bunker T-4	50	21.65	21.40	5.73	11.50	35.90	4.05
Area 5, DOD Pad	52	21.04	19.95	6.29	8.80	39.70	4.05
Area 5, RWMS 4 Northeast	63	22.36	21.60	6.04	11.20	38.60	4.03
Area 5, RWMS 9 South	11	18.85	18.70	3.26	13.20	24.40	4.05
Area 5, RWMS 7 West	51	21.71	20.90	6.61	9.66	40.00	4.03
Area 5, Transuranic Bldg. North	51	23.27	22.00	7.43	6.17	41.80	4.03
Area 5, WEF Northeast	51	22.09	21.70	6.66	8.51	40.00	4.04
Area 5, WEF Southwest	51	21.70	21.00	6.82	8.03	42.20	4.03
Area 6, Yucca	64	22.25	21.80	6.38	11.50	39.80	4.05
Area 7, UE-7ns	48	21.15	20.90	5.89	8.70	35.90	4.06
Area 9, Bunker 9-300	62	20.52	20.80	5.95	9.08	36.00	4.05
Area 10, SEDAN north	51	22.00	21.70	5.83	9.60	36.00	4.03
Area 15, EPA Farm	63	21.28	20.80	6.45	7.89	36.80	4.00
Area 18, LITTLE FELLER 2 North	51	20.12	20.20	6.02	10.10	36.50	4.02
Area 20, CABRIOLET	64	19.49	19.10	5.73	4.47	33.00	4.03
Area 20, SCHOONER	54	20.58	19.80	5.81	8.85	38.60	4.02
Area 25, E-MAD North	62	20.79	19.75	6.50	10.20	37.90	4.01
All NTS locations combined	1329	21.13	20.70	6.10	4.47	42.20	4.04
NAFR Locations							
Area 13, Project 57	49	14.25	13.70	4.04	5.90	27.00	4.00
Area 52, CLEAN SLATE II	24	17.89	17.25	5.05	10.20	30.30	3.43
Area 52, CLEAN SLATE III	24	22.16	20.10	7.17	13.90	37.10	3.42
Area 52, DOUBLE TRACKS	15	16.66	17.10	3.62	8.41	23.10	2.20
All NAFR locations combined	112	17.05	16.05	5.82	5.90	37.10	3.91

Table 9.3 Descriptive Statistics for 1999 ^{238}Pu in Air by Sampling Location, (µCi/mL × 10^{-18})

Sampling Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	Median MDC
NTS Locations							
Area 1, BJY	12	0.27	-0.61	1.75	-1.09	3.74	11.10
Area 2, 2-1 Substation	14	0.26	-0.46	1.27	-1.06	3.25	10.35
Area 3, Bunker 3-300	12	1.87	1.11	2.87	-0.90	7.19	9.94
Area 3, U-3ah/at North	12	2.37	1.22	3.02	-0.90	8.92	9.43
Area 3, U-3ah/at South	14	1.57	1.33	1.86	-0.93	5.23	10.45
Area 3, U-3bh North	12	-0.51	-0.76	0.95	-1.09	2.46	10.65
Area 3, U-3bh South	12	0.04	-0.59	1.53	-0.91	4.48	9.62
Area 3, Well ER-3-1	11	-0.66	-0.57	0.18	-1.05	-0.42	8.72
Area 4, Bunker T-4	12	8.34	4.73	9.78	1.01	29.40	9.91
Area 5, DOD Yard	12	0.22	-0.41	1.10	-0.77	2.70	9.62
Area 5, RWMS 4 Northeast	14	0.07	-0.58	2.49	-0.87	8.72	9.27
Area 5, RWMS 9 South	3	-0.68	-0.39	0.56	-1.33	-0.33	19.10
Area 5, RWMS 7 West	12	-0.43	-0.61	0.64	-1.00	1.51	10.13
Area 5, Transuranic Bldg. North	12	-0.65	-0.61	0.18	-0.99	-0.42	9.76
Area 5, WEF Northeast	12	-0.09	-0.69	1.76	-1.19	5.19	11.10
Area 5, WEF Southwest	12	0.10	-0.41	0.94	-0.86	1.46	10.10
Area 6, Yucca Complex	15	0.23	-0.49	1.26	-1.07	2.26	11.00
Area 7, UE-7ns	12	-0.40	-0.60	0.62	-1.03	1.30	9.95
Area 9, Bunker 9-300	14	14.28	13.75	8.58	2.08	27.30	9.22
Area 10, SEDAN North	12	3.45	2.85	2.70	-0.67	9.38	10.75
Area 15, EPA Farm	15	-0.12	-0.62	1.02	-1.15	1.65	11.70
Area 18, LITTLE FELLER 2 North	12	-0.37	-0.58	0.58	-0.83	1.06	9.19
Area 20, CABRIOLET	15	0.99	0.33	2.57	-1.28	7.94	11.10
Area 20, SCHOONER	12	2.09	2.99	2.23	-1.40	4.54	9.73
Area 25, E-MAD North	15	-0.37	-0.71	0.76	-1.11	1.19	10.40
All NTS locations combined	310	1.37	-0.50	4.50	-1.40	29.40	10.15
NAFR Locations							
Area 13, Project 57	12	1.92	-0.58	6.65	-0.99	22.70	10.55
Area 52, CLEAN SLATE II	7	0.75	1.23	1.43	-0.91	2.83	9.79
Area 52, CLEAN SLATE III	8	-0.52	-0.69	0.77	-1.16	1.24	10.02
Area 52, DOUBLE TRACKS	4	0.31	0.30	1.06	-0.80	1.46	11.55
All NAFR locations combined	31	0.82	-0.51	4.23	-1.16	22.7	10.50

Table 9.4 Descriptive Statistics for 1999 $^{239+240}$Pu in Air by Sampling Location, (μCi/mL × 10^{-18})

Sampling Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	Median MDC
NTS Locations							
Area 1, BJY	12	47.59	29.20	60.78	6.82	231.00	9.95
Area 2, 2-1 Substation	14	18.32	4.75	35.36	-0.65	132.00	10.25
Area 3, Bunker 3-300	12	139.27	77.70	120.89	9.46	382.00	9.88
Area 3, U-3ah/at North	12	214.92	204.50	113.84	48.80	492.00	9.54
Area 3, U-3ah/at South	14	182.60	147.50	108.14	42.30	376.00	10.45
Area 3, U-3bh North	12	62.15	47.80	54.11	12.20	217.00	10.55
Area 3, U-3bh South	12	57.60	50.65	45.43	1.17	169.00	9.62
Area 3, Well ER-3-1	11	5.50	2.88	5.39	0.94	19.00	8.72
Area 4, Bunker T-4	12	59.12	43.35	40.92	19.10	127.00	9.79
Area 5, DOD Yard	12	3.59	0.53	9.33	-0.77	32.40	9.54
Area 5, RWMS 4 Northeast	14	32.95	2.67	107.30	-5.33	405.00	9.27
Area 5, RWMS 9 South	3	1.71	-0.47	4.47	-1.25	6.86	18.80
Area 5, RWMS 7 West	12	4.10	1.59	5.26	-0.66	15.10	10.13
Area 5, Transuranic Bldg. North	12	4.42	1.38	6.30	0.94	23.10	9.69
Area 5, WEF Northeast	12	5.69	1.09	10.09	-0.88	32.10	11.00
Area 5, WEF Southwest	12	7.29	1.30	14.03	-0.64	44.10	10.10
Area 6, Yucca Complex	15	20.79	12.50	20.17	2.09	62.10	10.80
Area 7, UE-7ns	12	13.62	13.40	13.82	1.81	52.80	9.95
Area 9, Bunker 9-300	14	1339.93	1205.00	709.18	335.00	2490.00	8.83
Area 10, SEDAN North	12	45.00	37.35	26.58	11.40	99.90	10.65
Area 15, EPA Farm	15	11.09	8.92	10.59	1.07	43.70	11.50
Area 18, LITTLE FELLER 2 North	12	8.93	6.39	9.62	1.06	33.80	9.11
Area 20, CABRIOLET	15	2.58	1.10	3.72	-1.20	9.51	11.10
Area 20, SCHOONER	12	11.95	1.88	23.18	-0.64	65.10	9.58
Area 25, E-MAD North	15	6.20	1.40	11.60	-1.04	38.90	10.20
All NTS locations combined	310	99.80	10.10	315.80	-5.33	2490.00	10.05
NAFR Locations							
Area 13, Project 57	12	141.18	8.56	423.00	1.52	1480.00	10.65
Area 52, CLEAN SLATE II	7	119.14	129.00	70.18	33.60	223.00	10.20
Area 52, CLEAN SLATE III	8	7.19	2.39	12.00	-0.80	35.40	10.22
Area 52, DOUBLE TRACKS	4	1.54	1.95	1.68	-0.75	3.00	11.70
All NAFR locations combined	31	83.60	6.80	265.90	-0.80	1480.00	10.80

Table 9.5 Descriptive Statistics for 1999 Tritium in Air by Sampling Location, (pCi/mL × 10^{-6})

Sampling Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	Median MDC
NTS Locations							
Area 1, BJY	30	2.98	1.44	4.48	-1.29	19.90	2.72
Area 5, RWMS 4 Northeast	25	4.30	2.97	3.73	0.66	15.30	2.41
Area 5, RWMS 7 West	32	1.69	1.33	3.00	-1.84	11.90	3.06
Area 5, RWMS 9 South	31	1.61	0.79	2.53	-0.92	10.30	2.53
Area 5, RWMS Bldg. 5-6 Rm. 4	18	10.21	8.34	5.66	2.04	22.90	2.91
Area 5, RWMS GCD Trailer	18	29.73	32.55	17.64	4.47	70.20	2.79
Area 5, WEF Northeast	30	3.16	1.02	9.50	-0.61	52.10	2.23
Area 5, Well 5B	31	0.12	0.06	0.89	-2.30	1.88	2.66
Area 6, Decontamination Facility	3	3.42	3.87	1.05	2.22	4.16	2.72
Area 10, SEDAN north	31	15.62	10.20	12.05	1.49	40.80	2.46
Area 12, E Tunnel Pond	21	19.80	21.00	15.18	2.63	54.40	2.16
Area 12, Stake T-18	20	0.28	0.12	0.88	-2.09	2.27	2.49
Area 15, EPA Farm	32	10.57	9.79	4.15	3.76	27.00	3.20
Area 20, SCHOONER	31	201.57	50.70	233.24	12.00	749.00	2.25
All NTS locations combined	353	24.42	3.50	88.21	-2.30	749.00	2.54
All NTS locations except SCHOONER combined	322	7.37	2.21	11.20	-2.30	70.20	2.59
Offsite Locations							
Amargosa Valley	8	3.79	0.25	10.29	-0.58	29.20	2.24
Indian Springs	8	3.86	0.49	5.32	-0.53	11.30	2.31
All offsite locations combined	16	3.83	0.44	7.91	-0.58	29.20	2.24

Table 9.6 Descriptive Statistics for Radionuclides Detected by Gamma Spectroscopy in Onsite Air Samples in 1999, (µCi/mL × 10^{-15})

Nuclide	Number of Samples Containing	Mean	Median	Standard Deviation	Minimum	Maximum	Percent Result > MDC
^{7}Be	311	206.6	208.0	39.2	100.0	287.0	100
^{137}Cs	52	0.909	0.918	0.227	0.522	1.43	14
^{228}Th	12	2.06	2.12	0.540	1.01	2.88	75
^{235}U	4	44.0	4.72	40.0	2.69	164.0	25
^{238}U	11	112.7	122.0	35.6	35.2	163.0	36

Table 9.7 Descriptive Statistics for Radionuclides Detected by Gamma Spectroscopy in Offsite Air Samples in 1999, (µCi/mL × 10^{-15})

Nuclide	Number of Samples Containing	Mean	Median	Standard Deviation	Minimum	Maximum	Percent Result > MDC
^{7}Be	154	159.5	166.5	39.6	60.7	239.0	100
^{137}Cs	10	0.303	0.242	0.169	0.199	0.757	20
^{228}Th	5	16.1	14.9	5.96	9.39	25.6	100
^{235}U	1	59.7					0
^{238}U	6	37.9	38.7	8.5	25.6	48.1	0

Table 9.8 1999 TLD Gamma Exposure Rates - mR/yr

Sampling Location	Annual Total	Sampling Location	Annual Total
Area 1, BJY	91	Area 7, Reitman Seep	117
Area 1, Sandbag Storage Hut	108	Area 8, Stake K-25	100
Area 1, Stake C-2	112	Area 8, Road 8-02	121
Area 1, 1-300 Bunker	121	Area 8, Stake M-152	161
Area 2, Stake M-140	129	Area 9, 9-300 Bunker	119
Area 2, Stake N-8	726	Area 9, Papoose Lake Road	76
Area 2, Stake L-9	174	Area 9, V and G Road Junction	106
Area 2, Stake TH-58	88	Area 9, Crater U-9cw	94
Area 3, Stake OB-20-N, End of 3B Road	81	Area 10, SEDAN West	272
Area 3, LANL Trailers	108	Area 10, SEDAN East Visitors Box	130
Area 3, Stake A-6.5	141	Area 10, Circle and L Road	112
Area 3, RWMS North	116	Area 10, Gate 700 South	125
Area 3, RWMS East	141	Area 11, Stake A-21	122
Area 3, RWMS South	463	Area 12, T Tunnel No. 2 Pond	242
Area 3, RWMS West	121	Area 12, Upper N Pond	122
Area 3, U-3co North	216	Area 12, Upper Haines Lake (E Tunnel)	117
Area 3, U-3co South	153	Area 12, Gold Meadows	128
Area 3, Well ER-3-1	119	Area 15, EPA Farm	106
Area 3, RWMS Center	154	Area 15, Substation U15E	90
Area 4, Stake A-9	823	Area 18, Stake A-83	135
Area 4, Stake TH-48	115	Area 18, Stake F-11	139
Area 4, Stake TH-41	109	Area 19, Stake P-41	156
Area 5, Well 5B	106	Area 19, Stake C-27	149
Area 5, RWMS Northeast Corner	112	Area 19, Stake P-77	158
Area 5, RWMS Northwest Corner	120	Area 19, Stake R-26	152
Area 5, RWMS Southwest Corner	114	Area 19, Gate 19-3P, Kawich Canyon	152
Area 5, RWMS South Gate	106	Area 20, Stake J-31	176
Area 5, RWMS East Gate	136	Area 20, Stake J-41	128
Area 5, 3.3 Mi Southeast of Aggregate Pit	57	Area 20, Stake LC-4	156
Area 5, WEF West	123	Area 20, Stake A-118	142
Area 5, WEF South	123	Area 22, Army Well No. 1	75
Area 5, WEF East	117	Area 23, Building 650 Dosimetry	55
Area 5, WEF North	114	Area 23, Building 650 Roof	50
Area 5, Building 5-31	105	Area 23, Post Office	66
Area 6, CP-6	87	Area 25, NRDS Warehouse	113
Area 6, Yucca Oil Storage Area	111	Area 25, 25-4P Gate	121
Area 6, Stake OB-11.5	122	Area 25, HENRE	113
Area 6, DAF East	87	Area 25, Jackass Flats at 27 Roads	76
Area 6, DAF West	77	Area 25, Guard Station 510	117
Area 6, Decon Facility Northwest	130	Area 25, Yucca Mountain	127
Area 6, Decon Facility Southeast	124	Area 27, Cafeteria	126
Area 7, 7-300 Bunker	265	Area 30, Cat. Can. Rd at Buggy Turnoff	170
Area 7, Stake H-8	127		

Table 9.9 Listing of Atypical TLD Data Values for 1999

Sampling Location	Annual Total mR/yr	Area Mean mR/yr	Sampling Location	Annual Total mR/yr	Area Mean mR/yr
Area 2, Stake N-8	726	131	Area 7, 7-300 Bunker	265	122
Area 3, U-3co North	216	126	Area 10, SEDAN West	272	122
Area 3, RWMS South	463	126	Area 12, T-Tunnel Pond	242	122
Area 4, Stake A-9	823	112			

Table 9.10 Descriptive Statistics for Radionuclides Detected by Gamma Spectroscopy in Water in 1999 (µCi/mL × 10^{-9})

Nuclide	Number of Samples Containing	Mean	Median	Standard Deviation	Minimum	Maximum	Median MDC
^{137}Cs	11	182	191	78	49	291	16

Table 9.11 Descriptive Statistics for 1999 Radium in Water, (µCi/mL × 10^{-9})

Nuclide	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	Median MDC
^{226}Ra	41	1.21	1.05	1.45	-1.47	4.34	3.69
^{228}Ra	41	0.36	0.42	0.33	-0.31	1.18	0.95

Table 9.12 Descriptive Statistics for 1999 ^{90}Sr in Water, (µCi/mL × 10^{-9})

Sampling Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	Median MDC
Tap Waters	6	-0.02	-0.02	0.08	-0.12	0.07	0.28
Sewage Lagoons	8	0.11	0.12	0.10	-0.06	0.23	0.58
Containment Ponds	4	1.10	1.30	0.67	0.12	1.65	0.52

Table 9.13 Descriptive Statistics for 1999 Gross Alpha in Water by Sampling Location for Locations Sampled Quarterly, (µCi/mL × 10^{-9})

Sampling Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	Median MDC
SUPPLY WELLS							
Area 5, Well 5B	5	5.44	6.32	1.79	2.72	7.05	1.84
Area 5, Well 5C	4	7.83	8.45	4.50	2.02	12.40	1.90
Area 6, Well No. 4	2	7.46	7.46	5.15	3.81	11.10	1.81
Area 6, Well No. 4A	4	8.84	8.63	2.78	5.71	12.40	1.75
Area 6, Well C-1	4	10.48	11.04	2.37	7.33	12.50	3.68
Area 16, Well UE-16D	4	7.36	7.45	2.32	4.76	9.76	2.38
Area 18, Well HTH No. 8	4	0.66	0.57	0.27	0.43	1.05	1.20
Area 22, Army Well No. 1	5	6.02	6.69	2.01	3.28	7.89	1.90
Area 25, Well J-12	4	1.30	1.09	0.82	0.58	2.44	1.53
Area 25, Well J-13	5	1.61	1.64	0.64	0.92	2.52	1.65
All Supply Wells	41	5.52	5.71	3.89	0.43	12.50	1.83
TAP WATER							
Area 1, Building 101	1	3.73					1.99
Area 6, Cafeteria	4	9.97	10.55	2.35	6.67	12.10	1.70
Area 6, Building 6-900	4	9.37	9.41	0.93	8.25	10.40	1.68
Area 12, Ice House	1	0.30					1.05
Area 23, Mercury Cafeteria	4	10.64	10.06	1.47	9.64	12.80	1.77
Area 25, Building 4221	1	1.27					1.30
All Tap Water	15	8.35	9.79	3.75	0.31	12.80	1.70

Table 9.14 Descriptive Statistics for 1999 Gross Alpha in Water by Sampling Location for Locations Sampled Annually, (µCi/mL × 10^{-9})

Sampling Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	Median MDC
Containment Ponds	4	21.65	22.35	2.34	18.30	23.60	1.94
Sewage Ponds	9	5.90	4.79	4.49	2.61	17.50	3.43
Aquifer Monitoring Wells	12	213.61	7.50	603.74	0.10	2120.0	1.96
UGTA Wells	7	7.26	7.71	3.70	2.11	13.60	1.81

Table 9.15 Descriptive Statistics for 1999 Gross Beta in Water by Sampling Location, for Locations Sampled Quarterly (µCi/mL × 10^{-9})

Sampling Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	Median MDC
SUPPLY WELLS							
Area 5, Well 5B	5	10.66	11.10	0.91	9.47	11.60	1.23
Area 5, Well 5C	4	5.38	6.54	3.02	0.91	7.53	1.25
Area 6, Well No. 4	2	5.42	5.42	0.60	5.00	5.85	1.25
Area 6, Well No. 4A	4	6.10	9.96	0.46	5.72	6.76	1.22
Area 6, Well C-1	4	13.15	13.35	0.61	12.30	13.60	2.46
Area 16, Well UE-16d	4	6.70	6.69	0.95	5.55	7.88	1.56
Area 18, Well HTH No. 8	4	2.62	2.60	0.29	2.34	2.95	1.22
Area 22, Army Well No. 1	5	6.49	5.64	2.45	4.74	10.80	1.32
Area 25, Well J-12	4	4.02	4.03	0.07	3.92	4.09	1.22
Area 25, Well J-13	5	3.79	3.76	0.32	3.41	4.22	1.22
All Supply Wells	41	6.52	5.85	3.37	0.91	13.60	1.24
TAP WATER							
Area 1, Building 101	1	5.89					1.28
Area 6, Cafeteria	4	6.49	6.61	0.60	5.74	6.98	1.21
Area 6, Building 6-900	4	6.34	6.45	0.40	5.77	6.67	1.21
Area 12, Ice House	1	3.00					1.21
Area 23, Cafeteria	4	10.27	9.07	2.62	8.76	14.20	1.22
Area 25, Building 4221	1	3.77					1.21
All Tap Water	15	7.00	6.57	2.61	3.00	14.20	1.21
CONTAINMENT PONDS							
Area 12, E Tunnel Effluent	7	69.84	70.90	12.86	49.10	87.50	1.27
Area 12, E Tunnel Pond	7	64.89	65.10	3.44	60.30	68.80	1.30
All Containment Ponds	14	67.36	66.55	9.40	49.10	87.50	1.30
SEWAGE LAGOONS							
Area 5, RWMS Sewage	5	31.44	31.70	16.44	15.70	57.90	1.31
Area 6, DAF Sewage	5	23.62	22.10	4.69	19.00	28.70	1.83
Area 6, LANL Sewage	4	43.52	43.60	15.79	27.90	59.00	1.93
Area 6, Yucca Sewage	5	19.46	20.20	2.77	15.50	22.60	1.29
Area 22, Sewage	4	35.31	37.60	20.95	9.52	56.50	1.59
Area 23, Sewage	4	21.13	20.40	20.95	9.52	56.50	1.59
Area 25, Central Sewage	5	20.02	19.20	3.59	17.50	26.20	1.29
Area 25, Reactor Control	3	26.47	24.60	19.27	8.20	46.60	2.44
All Sewage Lagoons	35	27.20	22.30	13.67	8.20	59.00	1.40

Table 9.16 Descriptive Statistics for 1999 Gross Beta in Water by Sampling Location, for Locations Sampled Annually (µCi/mL × 10^{-9})

Sampling Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	Median MDC
Aquifer Monitoring Wells	12	127.48	7.30	337.32	0.81	1190.00	1.32
UGTA Wells	7	15.45	6.47	21.62	2.91	63.20	1.29

Table 9.17 Descriptive Statistics for 1999 ^{238}Pu in Water by Sampling Location, (µCi/mL × 10^{-12})

Sampling Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	Median MDC
Supply Wells	10	-1.47	-2.06	2.03	-2.36	4.28	20.45
Aquifer Monitoring Wells	11	-1.74	-2.33	2.35	-5.07	3.54	24.30
UGTA Wells	6	-0.09	-0.80	3.54	-3.50	5.18	21.30
Tap Water							
Area 1, Building 101	1	-2.75					20.70
Area 6, Cafeteria	4	-2.99	-2.55	1.56	-5.18	-1.69	21.25
Area 6, Building 6-900	4	-3.07	-2.60	1.83	-5.67	-1.39	21.55
Area 12, Ice House	1	-0.25					24.70
Area 23, Mercury Cafeteria	4	-0.93	-1.71	2.26	-2.68	2.37	19.75
Area 25, Building 4221	1	-4.47					29.90
All Tap Water	15	-2.36	-2.54	1.95	-5.67	2.37	20.70
Sewage Lagoons							
Area 5, RWMS Sewage Pond	3	-0.69	-1.99	2.61	-2.40	2.32	22.40
Area 6, DAF Sewage Pond	4	-1.07	-1.52	1.68	-2.58	1.34	18.35
Area 6, LANL Sewage Pond	3	-0.31	-0.16	1.46	-1.84	1.07	20.00
Area 6, Yucca Sewage Pond	4	-0.83	-0.80	1.80	-2.89	1.15	19.45
Area 22, Sewage Pond	3	-1.39	-2.55	2.36	-2.95	1.33	21.80
Area 23, Sewage Pond	3	1.31	-1.58	5.02	-1.59	7.11	18.70
Area 25, Central Sewage Pond	4	-2.48	-2.59	0.73	-3.25	-1.50	25.75
Area 25, Reactor Control Pond	2	-2.72	-2.72	0.47	-3.05	-2.39	25.35
All Sewage Lagoons	26	-1.01	-1.63	2.30	-3.25	7.11	20.35
Containment Ponds							
Area 12, E Tunnel Effluent	7	335.14	333.00	27.00	293.00	369.00	19.90
Area 12, E Tunnel Pond	7	326.14	316.00	52.02	265.00	425.00	20.00
All Containment Ponds	14	330.64	321.00	40.09	265.00	425.00	19.95

Table 9.18 Descriptive Statistics for 1999 $^{239+240}Pu$ in Water by Sampling Location, ($\mu Ci/mL \times 10^{12}$)

Sampling Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	Median MDC
Supply Wells	10	-2.80	-3.74	1.43	-4.44	-1.06	24.80
Aquifer Monitoring Wells	12	3.24	0.79	13.77	-5.31	45.60	27.70
UGTA Wells	5	-0.34	-1.09	5.98	-7.50	9.14	21.00
Tap Water							
Area 1, Building 101	1	-1.39					23.50
Area 6, Cafeteria	4	-3.65	-3.99	2.08	-5.61	-1.02	25.00
Area 6, Building 6-900	4	-3.82	-3.48	2.49	-7.00	-1.34	25.10
Area 12, Ice House	1	5.25					26.40
Area 23, Mercury Cafeteria	4	-2.98	-3.25	1.53	-4.40	-1.03	23.50
Area 25, Building 4221	1	-4.85					30.60
All Tap Water	15	-2.85	-3.00	2.89	-7.00	5.25	23.90
Sewage Lagoons							
Area 5, RWMS Sewage Pond	3	-2.60	-3.32	2.56	-4.72	0.25	25.60
Area 6, DAF Sewage Pond	4	0.56	-0.51	3.52	-2.39	5.64	21.50
Area 6, LANL Sewage Pond	3	-1.30	-2.37	2.99	-3.61	2.08	24.40
Area 6, Yucca Sewage Pond	4	6.20	5.10	9.61	-3.28	17.90	22.70
Area 22, Sewage Pond	3	2.62	3.38	5.22	-2.94	7.41	23.80
Area 23, Sewage Pond	3	1.44	1.52	1.90	-0.51	3.30	21.10
Area 25, Central Sewage Pond	4	-3.09	-3.42	1.42	-4.36	-1.14	28.80
Area 25, Reactor Control Pond	2	8.27	8.27	0.35	8.02	8.52	28.80
All Sewage Lagoons	26	1.22	-0.32	5.50	-4.72	17.90	23.30
Containment Ponds							
Area 12, E Tunnel Effluent	7	2895.71	2920.00	309.89	2350.00	3230.00	22.50
Area 12, E Tunnel Pond	7	2705.71	2680.00	234.23	2380.00	3040.00	22.60
All Containment Ponds	14	2800.71	2800.00	281.71	2350.00	3230.00	22.55

Table 9.19 Historical ^{238}Pu in Water Annual Averages at Selected Locations, ($\mu Ci/mL \times 10^{-12}$)

Location	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
WELLS										
Area 18, Well HTH No. 8	31.0	2.2	-12.0	4.8	-2.1	-1.7	-3.0	0.4	0.1	-2.1
Area 25, Well J-13	12.0	0.7	-5.0	-6.9	-0.7	-0.4	-2.9	-0.9	-1.8	-2.1
TAP WATER										
Area 6, Cafeteria	44.0	20.1	-2.3	0.0	1.7	2.6	-1.5	0.2	1.1	-3.0
Area 23, Cafeteria	12.0	18.6	5.0	0.0	1.3	1.5	-3.8	-1.1	-0.1	-0.9

Table 9.19 (Historical ^{238}Pu in Water Annual Averages at Selected Locations, [µCi/mL × 10^{-12}], cont.)

Location	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
SEWAGE LAGOONS										
Area 6, LANL Sewage					-0.7	5.9	-2.4	-1.7	-0.4	-0.3
Area 23, Sewage Lagoon	-14.5	1.3	-11.4	0.0	-1.3	1.3	13.9	-1.9	-0.1	1.3
CONTAINMENT PONDS										
E Tunnel Effluent	1616.7	732.5	660.0	450.0	687.3	323.0	355.8	388.0	232.5	335.1

Table 9.20 Historical $^{239+240}$Pu in Water Annual Averages at Selected Locations, (µCi/mL × 10^{-12})

Location	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
WELLS										
Area 18, Well HTH No. 8	-3.0	0.6	7.2	-8.2	2.5	-1.1	-3.5	0.1	-2.8	-3.9
Area 25, Well J-13	7.8	2.6	13.2	-6.9	2.1	-1.6	-1.1	-2.1	-2.5	-1.1
TAP WATER										
Area 6, Cafeteria	19.0	5.8	-0.9	2.3	0.5	0.9	-2.4	-1.8	2.0	-3.0
Area 23, Cafeteria	0.5	2.9	0.1	2.1	0.6	-0.1	-4.1	-2.3	0.0	-3.0
SEWAGE LAGOONS										
Area 6, LANL Sewage					3.2	-1.6	-0.7	7.5	1.2	-1.3
Area 23, Sewage Lagoon	3.5	16.1	1.8	7.1	9.0	5.0	818.9	11.7	0.7	1.4
CONTAINMENT PONDS										
E Tunnel Effluent	9223	9500	6275	4333	5343	5208	2840	3190	2018	2896

Table 9.21 Descriptive Statistics for 1999 Tritium in Water by Sampling Location, (µCi/mL × 10^{-9}) Enriched Analytical Method

Sampling Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	Median MDC
SUPPLY WELLS							
Area 5, Well 5B	5	2.49	1.77	3.50	-1.95	6.71	13.70
Area 5, Well 5C	4	0.92	-0.47	6.23	-4.49	9.12	12.60
Area 6, Well No. 4	2	-0.51	-0.51	3.87	-3.25	2.23	12.40
Area 6, Well No. 4A	4	-0.28	0.60	7.38	-10.10	7.80	15.85

Table 9.21 (Descriptive Statistics for 1999 Tritium in Water by Sampling Location, [µCi/mL × 10^{-9}] Enriched Analytical Method, cont.)

Sampling Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	Median MDC
Supply Wells, cont.							
Area 6, Well C-1	4	4.96	4.70	2.74	1.90	8.54	15.70
Area 16, Well UE-16D	4	-0.44	-0.65	1.88	-2.19	1.74	15.25
Area 18, Well HTH No. 8	4	3.02	3.16	2.70	-0.23	5.98	15.15
Area 22, Army Well No. 1	5	0.06	2.11	3.91	-6.42	3.14	12.50
Area 25, Well J-12	4	3.24	2.57	1.45	2.43	5.41	15.25
Area 25, Well J-13	5	0.16	0.85	4.76	-6.78	4.69	14.60
All supply wells combined	41	1.42	2.03	4.15	-10.10	9.12	14.70
AQUIFER MONITORING WELLS							
Area 3, USGS Water Well A	1	668.00					13.70
Area 17, USGS Well HTH-1	5	0.66	-0.15	1.72	-0.97	3.25	16.00
Area 18, UE-18r	2	0.94	0.94	1.30	0.02	1.86	15.55
Area 19, U-19bh	1	62.10					12.50
Area 20, Well PM-1	1	181.00					13.90
All aquifer monitoring wells combined	10	91.63	1.71	210.53	-0.97	668.00	15.55
UGTA WELLS							
Area 5, Well UE-5c	2	2.19	2.19	0.81	1.62	2.76	11.57
Area 6, ER-6-1	1	2.87					16.40
Area 12, ER-12-1	1	27.90					16.00
Area 19, UE-19c Water Well	1	3.42					13.20
Area 20, Well U-20	1	0.67					17.50
All UGTA wells combined	6	6.54	2.82	10.51	0.67	27.90	15.45
POTABLE WATER							
Area 1, Building 101	1	-0.58					16.70
Area 6, Cafeteria	4	-0.74	2.17	8.94	-13.70	6.40	16.00
Area 6, Building 6-900	4	-1.40	-0.64	4.75	-7.83	3.52	14.30
Area 12, Icehouse	1	-1.64					13.90
Area 23, Mercury Cafeteria	4	1.42	4.47	7.08	-9.12	5.87	15.00
Area 25, Building 4221	1	-3.10					15.40
All potable water combined	15	-0.55	0.09	5.88	-13.70	6.40	15.30
All offsite locations	12	2.43	2.61	1.66	-0.51	4.71	15.15

Table 9.22 Descriptive Statistics for 1999 Tritium in Water by Sampling Location, ($\mu Ci/mL \times 10^{-9}$) Conventional Analytical Method

Sampling Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	Median MDC
AQUIFER MONITORING WELLS							
Area 1, UE-1q	2	-7.76	-7.76	6.84	-12.60	-2.92	16.15
Area 4, UE-4t #1	1	7.20					20.00
Area 4, UE-4t #2	1	5.09					16.80
Area 4, USGS Test Well D	2	-3.62	-3.62	4.17	-6.57	-0.67	16.80
Area 6, UE-6e	1	14.40					33.70
All aquifer monitoring wells combined	7	0.56	-0.67	9.07	-12.60	14.40	16.80
UGTA WELLS							
Area 2, Water Well 2	1	-4.50					16.50
Area 3, ER-3-2	1	-4.06					16.80
All UGTA wells combined	2	-4.28	-4.28	0.31	-4.50	-4.06	16.65
SEWAGE LAGOONS							
Area 5, RWMS Sewage Pond	5	-58.48	-93.80	217.13	-341.00	248.00	747.00
Area 6, DAF Sewage Pond	5	11.48	-93.80	275.60	-166.00	500.00	799.00
Area 6, LANL Sewage Pond	4	-97.52	-71.10	104.02	-242.00	-5.86	773.00
Area 6, Yucca Sewage Pond	5	-40.30	0.41	166.89	-293.00	153.00	747.00
Area 22, Sewage Pond	4	76.90	60.60	92.77	-17.60	204.00	773.00
Area 23, Sewage Pond	4	63.55	90.60	187.91	-185.00	258.00	773.00
Area 25, Central Sewage Pond	5	-116.31	-124.00	69.64	-182.00	0.45	799.00
Area 25, Reactor Sewage Pond	3	-23.63	0.41	101.51	-135.00	63.70	747.00
All sewage ponds combined	35	-26.21	-41.20	167.77	-341.00	500.00	747.00
CONTAINMENT PONDS							
Area 12, E Tunnel Effluent	7	947286	954000	17356	912000	961000	736
Area 12, E Tunnel Pond	7	937286	944000	13659	914000	953000	736
All containment ponds combined	14	942286	945500	15877	912000	961000	736

10.0 Routine Sampling of NTS Biota

Biota sampling is a newly implemented activity described fully in the Routine Radiolgical Environmental Montoring Plan (RREMP). Preliminary sampling procedures for vegetation and animals were developed to guide field sampling (Analytical Services Laboratory LID L-E10.6 .P). Five sites were selected for sampling over the next five years. These sites are considered the most contaminated sites and are considered representative of the five types of contaminated sites present on the Nevada Test Site (NTS). These sites include E Tunnel Ponds, PALANQUIN, SEDAN, T2, and Plutonium Valley. Each site will be sampled once each five years to confirm low radionuclide levels (more frequently and intensely if levels are found to be higher than action levels).

Monitoring in 1999 was restricted to two contaminated locations: Cambric Ditch and E Tunnel Ponds, and two control sites, Cane Spring and Camp 17 Pond, respectively (Figure 10.1). Routine radiological monitoring of biota at the NTS in Fiscal Year (FY) 1999 commenced on August 8, 1999, and continued through October 14, 1999. 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 result 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.

Cambric Ditch located in Area 5 just west of Frenchman Flat, was selected for initial sampling even though it was not one of the five selected sites for long-term monitoring. It was selected because it was close to the base of operations at Mercury and would permit validation of animal trapping techniques without extensive travel. Groundwater, soil, and vegetation at Cambric Ditch had historically high levels of tritium due to prolonged pumping (1973 to 1992) from a contaminated underground water supply (Hunter and Kinnison, 1998). Additionally, it was scheduled for short-term discharge of well water during the fall of 1999 which provided an opportunity to evaluate the sensitivity of sampling and laboratory techniques. Cane Spring, a naturally occurring spring also in Area 5, was selected as a control site for Cambric Ditch. Vegetation at the Cane Spring was described by Hansen et al., (1997).

10.1 Vegetation Sampling

Woody vegetation was selected for sampling because it was reported to have deeper-penetrating roots with higher concentrations of tritium (Hunter and Kinnison, 1998), and additionally serves as a major source of browse for game animals that might eat such vegetation and migrate offsite.

Samples of salt cedar (*Tamarix ramosissima*), one of the more deeply rooted shrubs, were taken at four locations along the Cambric Ditch and at Cane Spring. No other living vegetation was observed at Cambric Ditch in the Fall of 1999. The first vegetation sample was near the well at the head of the ditch (Figure 10.2, see Table 10.1 for Universal Transverse Mercator [UTM] location coordinates). The second

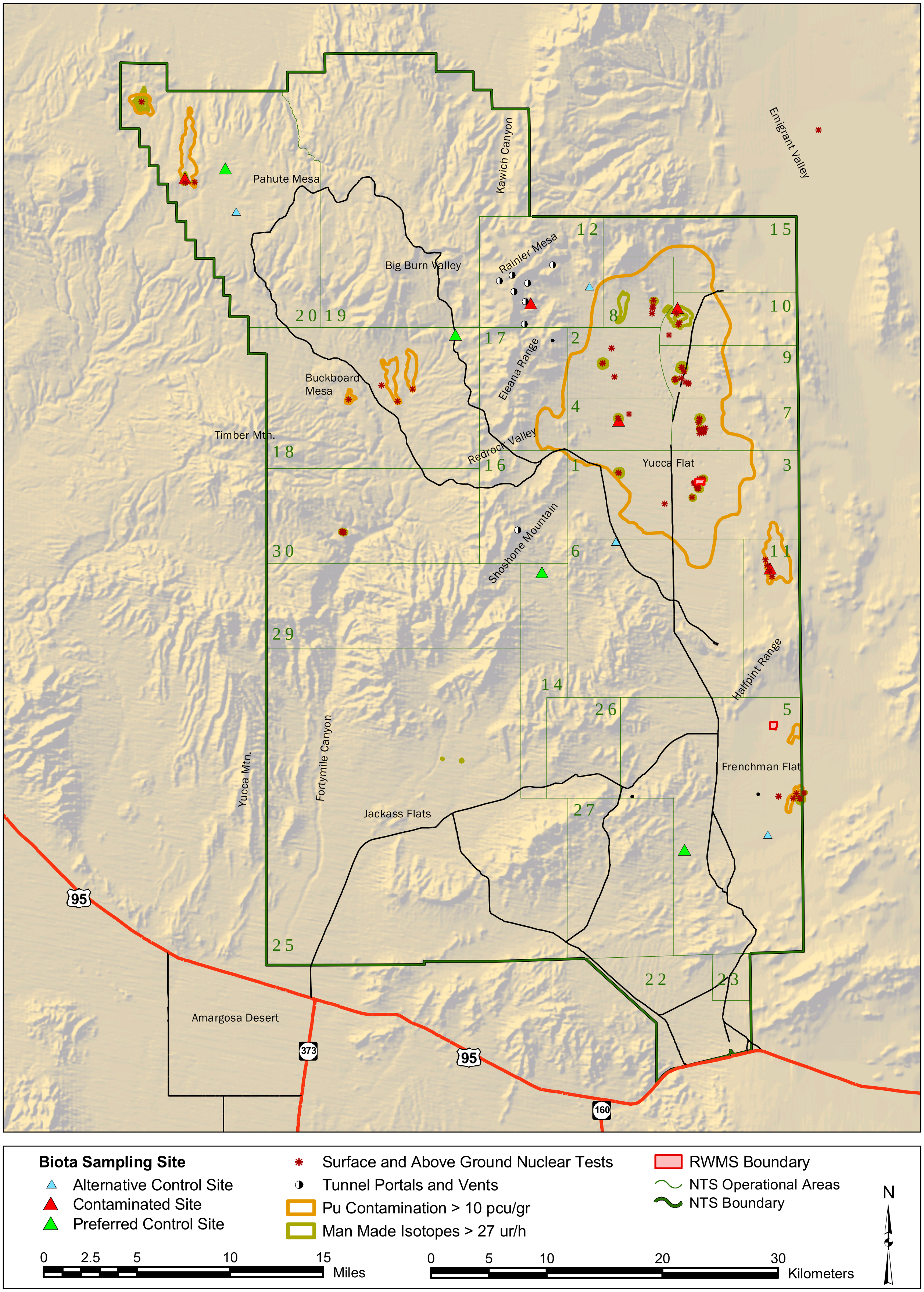


Figure 10.1 NTS Onsite Surface Biota Radiological Monitoring Sites - 1999

Figure 10.2 Salt Cedar Shrubs (Foreground) Sampled Near the Well Head at Cambric Ditch

sample was collected about 0.48 km (0.3 mi odometer reading) down stream from the well head. The third sample was taken approximately 1.13 km (0.7 mi) down stream from the well head. The fourth sample was collected approximately 1.61 km (1.0 mi) down stream from the well head near the dry pond (Figure 10.3) at the end of the ditch.

Vegetation was collected from shrubs adjacent to the ditch, but not located within the ditch because there was a high probability shrubs within the ditch would be removed by ditch-cleaning activities scheduled in the Fall of 1999. About 300 to 500 grams of fresh-weight plant material were collected from the current year's growth of green-leaf materials. Samples were stored in an ice chest and kept frozen until analyzed (DOE 1998a).

Plant samples of salt cedar were taken from Cane Spring (Figure 10.4) at one location. Samples were also taken of sandbar willow (*Salix exigua*) a codominant shrub species at another location at the control site and Goodding's willow (*Salix gooddingii*) was taken at a third location and was the dominant tree at the site.

Samples were taken on October 14, 1999, of dominant trees and shrubs at E Tunnel Ponds (Figure 10.5). Samples included saltcedar, rubber rabbitbrush (*Ericameria nauseosa*), and fourwing saltbush (*Atriplex canescens*). No dominant forbs were observed or sampled. Collection of plant samples within the restricted fenced area was taken at the same time as routine water samples and with the assistance of a radiological control technician.

Plant samples were taken on October 14, 1999, of dominant shrubs and one tree at the control site at Camp 17 Pond (Figure 10.6). These samples included rubber rabbitbrush (*Ericameria nauseosa*), big sagebrush (*Artemisia tridentata*), sandbar willow (*Salix exigua*), and Chinese elm (*Ulmnus parvifolia*), the dominant tree. No dominant forbs were observed or sampled at the pond.

Figure 10.3 Salt Cedar Shrub Sampled Approximately One Mile Downstream Near the Dry Pond

Figure 10.4 Cane Spring Showing Relative Location of Tall Woody Vegetation Sampled in 1999 (9-19-98)

Figure 10.5 E Tunnel Ponds Showing Adjacent Vegetation (7-23-97)


Figure 10.6 Camp 17 Pond Showing Adjacent Vegetation with Chinese Elm Tree on Back Side of Pond (8-4-88)

10.2 Animal Sampling

Animal trapping in FY 1999 consisted of about 20 trapping days. Trapping was directed to mourning doves (*Zenaida macroura*) and cottontail rabbits (*Sylvilagus audubonii*). Mourning doves are one of the few game animals that forage on the NTS and migrate offsite, thereby providing a possible pathway of radionuclides from the NTS to the public. The ecology of mourning doves is described in a report that also reports that a majority of mourning doves in Nevada migrate out of state and end up in south central Arizona, although evidence was also presented that some mourning doves maintain resident, non-migratory populations where there is sufficient water, feed, and mild climate (Baskett and et al.,1993).

Rabbits were chosen as surrogates for big game animals (deer and antelope) because they browse on similar vegetation. They have small home ranges and also forage longer in contaminated sites, thereby, giving them a higher potential than deer for being a "worst-case" (i.e., highest concentrations of radioisotopes) scenario at the selected site. In a study conducted by Giles and Cooper (1985) more than 62 buck, 51 does, and 10 fawns were tagged, about two-thirds of them fitted with radio telemetry, and monitored weekly for more than 4 years. They reported most deer migrating within the NTS between summer ranges on Rainier Mesa and Pahute Mesa and their wintering areas at Timber Mountain and Shoshone Mountain, thereby minimizing the chances of migrating offsite where they might be shot and taken as game.

Two wire traps were used for trapping mourning doves on the NTS. Eight additional traps were made with slight modifications in the openings to restrict the size of birds and other animals entering the traps. The traps were placed at the same location as the bait containers. Dead shrubs and trees were also occasionally used to camouflage the wire traps.

Predation of the bait was a problem at all sites. Bait was removed by small mammals, ants, and passerine birds. Even bait in a bird feeder on the top of 1-meter tall metal fence posts was removed by mice. There was also evidence that some trapped animals had been eaten in the trap during the night, leaving only feathers or fur.
An abundance of passerine birds were both observed during the pre-bait and trapping periods. Several types of passerine birds were also caught in the traps. Brown-headed cowbirds (*Molothrus ater*) were the most abundant species during trapping. While a few doves were observed in the general vicinity of the site, no doves were actually observed at the pre-bait stations nor caught in any of the traps. No doves were observed after September 30 and it was presumed that doves had left the NTS in their southern migration. The low mourning dove abundance noted this year on the NTS probably was a significant factor influencing poor trapping success.

Several cottontail rabbits were caught at Cambric Ditch, although none were caught at other sites. Only one rabbit was taken at Cambric Ditch for analyses prior to removal of vegetation within the ditch, the others were released. Trapping for doves and rabbits was also done at Camp 17 Pond, E Tunnel Ponds, and Well 5B unsuccessfully. No trapping was done at Cane Spring.

Future sampling efforts will be directed at increasing trap efficiency. Trap materials and design will be tested to determine the most suitable design. Baits will also be evaluated to determine the most cost-effective types and how to effectively bait the area prior to and during trapping. State and Federal permits will be secured to take other birds during FY 2000.

Results

Radionuclide activities in NTS Biota Samples in 1999 are shown in Table 10.1. While above background levels of activity for gamma emitters were detected for ^{40}K, a naturally occurring radioisotope, at some sites in vegetation samples during 1999, all samples had either no detectable or less than MDC concentrations of ^{137}Cs. Vegetation analyzed for ^{90}Sr had less than M.C. for all samples from Cambric Ditch and Cane Spring. Other samples collected at E Tunnel Ponds and Camp 17 Pond were also very low and near the levels of M.C.. The highest value for ^{90}Sr was 0.0736 $\pm$ 0.023 pCi/g at the Camp 17 Pond (control site). With one exception, all samples of ^{238}Pu and $^{239+240}Pu$ had less than M.C.. The exception was one sample of vegetation about 1.13 km (0.7 miles) down stream from the well at Cambric Ditch which had a $^{239+240}Pu$ activity of 0.000687 ± 0.00092 pCi/g with a minimum detectable concentration (M.C.) of 0.00045 pCi/g.

With one exception, vegetation samples analyzed for tritium from the control sites of Cane Spring and Camp 17 Pond had less than M.C.. The exception was a vegetation sample of rubber rabbitbrush taken from an upland area about 30 to 50 meters east of the Camp 17 Pond. It is not known why the sample was higher than other samples in the area, although Hunter and Kinnison (Hunter and Kinnison 1998) also reported unexplained higher levels of tritium than background levels in some areas not previously reported to have levels greater than detection levels of tritium.

Tritium activity levels at Cambric Ditch and E Tunnel ponds ranged from less than M.C. in rubber rabbitbrush at E Tunnel ponds to 659,000 $\pm$ 4,100 x 10^{-9} µCi/mL. The reported activity of water in the E Tunnel Pond 4 was 944,000 $\pm$ 0.489 x 10^{-9} µCi/mL and 912,000 x 10^{-9} µCi/mL for effluent coming out of the pipe into E Tunnel Pond 4 sampled on the same day. All tritium concentrations in the vegetation were less than those reported for the water and may suggest that vegetation may have been utilizing soil water from prior precipitation that had lower tritium concentrations. Site environmental reports suggest that the mean tritium in the E Tunnel to be gradually increasing since 1995.

Tritium activity at Cambric Ditch ranged from 103,000 $\pm$ 1,600 x 10^{-9} µCi/mL to 415,000 $\pm$ 3,100 x 10^{-9} µCi/mL along a decreasing gradient downstream from the well. It is uncertain why samples taken in 1999 were nearly an order of magnitude higher than those reported by Hunter and Kinnison in 1998. It is possible that the random nature of their sampling versus the more deliberate location of samples taken in 1999 may help explain the difference.

Tritium activity in the only desert cottontail collected at Cambric Ditch was 34,400 $\pm$ 990 x 10^{-9} µCi/mL for muscle tissue. This value indicates that the animal was acquiring tritium either from the vegetation or from water sources in the area. It should be noted that no water had flowed in Cambric Ditch prior to the time of sampling since 1992 or during the sampling.

Table 10.1 Radionuclide Activities in NTS Biota Samples in 1999

Location	GPS Coordinates (UTM 1983, Zone 11, meters) Easting	Northing	Common Name	Scientific Name[a] Genus	Species	% H_2O (%)	Conc., x 10^{-9} μCi/mL Tritium[b]	Concentration, pCi/g ^{40}K	^{137}Cs	^{238}Pu[b]	$^{239,240}Pu$[b]	^{90}Sr[b]
PLANT SAMPLES												
Cambric Ditch												
Out of ditch near well head	592,059	4,075,671	saltcedar	Tamarix	ramosissima	59.5	103,000 ± 1,600	4.25 ± 4.0C	No Nucl Det	-0.0000917 ± 0.00018C	0.0000184 ± 0.00058C	0.0102 ± 0.0099C
0.3 miles down stream	592,572	4,075,334	saltcedar	Tamarix	ramosissima	61.9	122,000 ± 1,700	No Nucl Det	No Nucl Det	-0.0000982 ± 0.0002C	-0.0000982 ± 0.0002C	-0.00342 ± 0.0094C
0.7 miles down stream	592,950	4,075,037	saltcedar	Tamarix	ramosissima	61.2	134,000 ± 1,800	No Nucl Det	No Nucl Det	0.000172 ± 0.00054C	0.000687 ± 0.00092	0.00286 ± 0.0080C
1.0 miles down stream	593,375	4,074,660	saltcedar	Tamarix	ramosissima	59.5	415,000 ± 3,100	No Nucl Det	No Nucl Det	-0.0000865 ± 0.00017C	0.000173 ± 0.00055C	0.00261 ± 0.011C
Cane Spring												
Near dry pond	580,775	4,072,800	saltcedar	Tamarix	ramosissima	57.7	11.7 ± 440^{C}	1.23 ± 0.39	No Nucl Det	-0.0000869 ± 0.00017^{C}	-0.0000869 ± 0.00017^{C}	0.00328 ± 0.0095^{C}
East of dry pond	580,835	4,072,800	sandbar willow	Salix	exigua	62.9	-123 ± 430^{C}	1.65 ± 0.165	No Nucl Det	-0.0000868 ± 0.00017^{C}	-0.0000868 ± 0.00017^{C}	0.00101 ± 0.0067^{C}
East of spring (fenced area)	580,775	4,072,800	Goodding's willow	Salix	gooddingii	65.3	468 ± 450^{C}	2.08 ± 0.53	0.0385 ± 0.024^{C}	-0.0000786 ± 0.00016^{C}	-0.0000786 ± 0.00016^{C}	0.00176 ± 0.0090^{C}
E-Tunnel Ponds												
Pond 4 (lower pond)	571,832	4,116,049	rubber rabbitbrush	Ericameria	nauseosa	55.0	605,000 ± 3,900	12.1 ± 6.2	No Nucl Det	0.000248 ± 0.00086^{C}	0.000248 ± 0.00086^{C}	0.0126 ± 0.017^{C}
Pond 4 (lower pond)	571,832	4,116,049	fourwing saltbush	Atriplex	canescens	39.6	17,300 ± 800	17.9 ± 7.8	No Nucl Det	0^{C}	0.00025 ± 0.00087^{C}	0.0300 ± 0.044^{C}
Pond 3 (middle pond)	571,778	4,116,049	rubber rabbitbrush	Ericameria	nauseosa	45.8	-36.9 ± 460^{C}	No Nucl Det	No Nucl Det	-0.000289 ± 0.00058^{C}	0.000289 ± 0.001^{C}	0.0665 ± 0.018
Pond 3 (middle pond)	571,778	4,116,049	fourwing saltbush	Atriplex	canescens	58.6	659,000 ± 4,100	22.3 ± 7.6	No Nucl Det	-0.000814 ± 0.0012^{C}	0.000543 ± 0.0011^{C}	0.0222 ± 0.11^{L}
Pond 3 (middle pond)	571,778	4,116,049	saltcedar	Tamarix	ramosissima	57.4	12,500 ± 720	No Nucl Det	No Nucl Det	0.000567 ± 0.0011^{C}	0^{C}	0.0671 ± 0.037
Pond 2 (dry upper pond)	571,743	4,116,058	saltcedar	Tamarix	ramosissima	48.7	237,000 ± 2,500	No Nucl Det	No Nucl Det	0^{C}	0.0014 ± 0.0013^{C}	0.0525 ± 0.024
Camp 17 Pond												
East end of pond near water	565,421	4,113,305	rubber rabbitbrush	Ericameria	nauseosa	55.7	-172 ± 450^{C}	14.0 ± 4.8	No Nucl Det	0.000234 ± 0.00081^{C}	0^{C}	0.0207 ± 0.022^{C}
East end of pond--upland	565,431	4,113,306	rubber rabbitbrush	Ericameria	nauseosa	49.7	2,360 ± 520	12.9 ± 4.5	No Nucl Det	0.000456 ± 0.00091^{C}	0.000228 ± 0.00079^{C}	0.0207 ± 0.025^{C}
East end of pond near water	565,421	4,113,305	big sagebrush	Artemisia	tridentata	57.0	246 ± 470^{C}	17.1 ± 5.6	No Nucl Det	-0.000327 ± 0.00066^{C}	0.000655 ± 0.0013^{C}	-0.00224 ± 0.015^{C}
East end of pond--upland	565,431	4,113,306	big sagebrush	Artemisia	tridentata	46.7	-55.4 ± 460^{C}	13.8 ± 5.4	No Nucl Det	0^{C}	0.000896 ± 0.0011^{C}	0.0447 ± 0.032^{C}
East end of pond near water	565,421	4,113,305	sandbar willow	Salix	exigua	58.4	252 ± 470^{C}	No Nucl Det	No Nucl Det	0^{C}	0.000589 ± 0.0012^{C}	0.0736 ± 0.023
West end of pond near water	565,359	4,113,223	Chinese elm	Ulmnus	parvifolia	51.8	-73.8 ± 460^{C}	No Nucl Det	No Nucl Det	0^{C}	0.000225 ± 0.00078^{C}	0.0704 + 0.032
ANIMAL SAMPLES												
Cambric Ditch												
Out of ditch near well head	592,059	4,075,671	Desert cottontail	Sylvilagus	audubonii	76.1	34,400 ± 990					

± Error is the 2.0 Sigma Error, % H_2O is the percent water of sample on a dry weight basis, ^{L} = Low Recovery for Sample, No Nucl Det = No Nuclide Detected, ^{40}K is a naturally occurring radiosotope

[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

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