5.0 RADIOLOGICAL ENVIRONMENTAL PROGRAMS

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

5.1 AIR SURVEILLANCE ACTIVITIES

The air surveillance network on and around the NTS monitors for radionulcides to demonstrate compliance with the Clean Air Act (for a complete description, see Chapter 4.0). Air monitoring was conducted for radioactive particulates and tritiated water (HTO) vapor at 33 locations. The onsite air sampling locations and the ambient gamma radiation monitoring locations relative to the sites with potential for airborne radioactive emissions are shown in Figure 5.1. An insert in this figure also shows the locations of the offsite air sampling locations.

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

AIR PARTICULATE SAMPLING

Air particulate samplers are operated at 33 locations on the NTS. A constant volume of air is drawn through a 9-cm (3.5 in) diameter Whatman GF/A glass-fiber filter at approximately 85 L/min (3 cfm) to trap particulates from the air. The particulate filter are mounted in a filter holder that faced downward at a height of 1.5 m (5 ft) above ground. A run-time clock measured the operating time. The run time, multiplied by 85 L/min yields the volume of air sampled, which is about 860 m^3 (30,000 ft^3) during a typical seven-day sampling period. In CY 2000, flow and subsequent volume were calibrated to standard temperature and Pressure in order to make results directly comparable over the various elevations data collected on the NTS. Historically, ambient air calibrations were done at the elevation where data were collected.

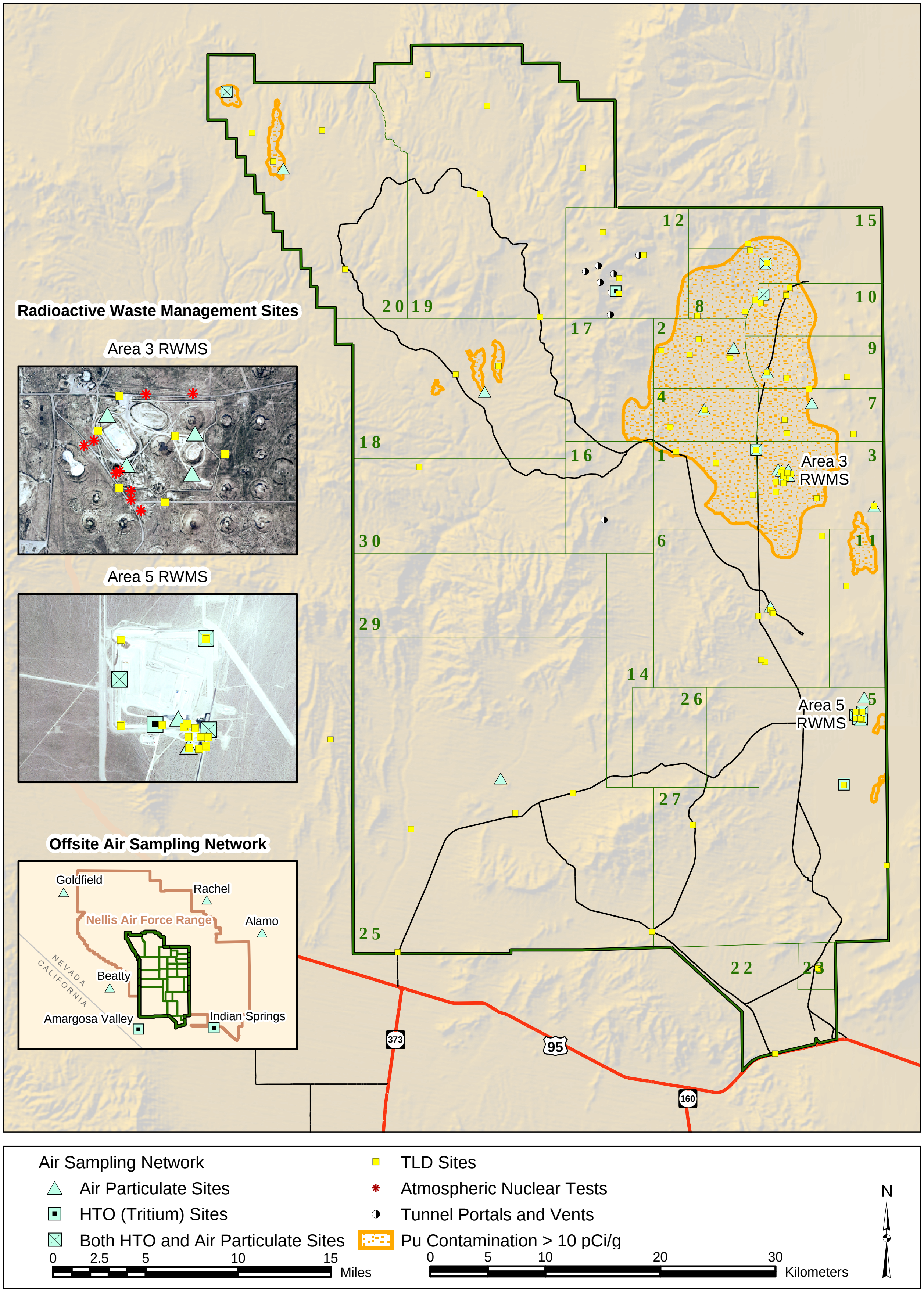

Figure 5.1 Air Sampling Network on or near the Nevada Test Site - 2000

The 9-cm diameter filters are 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. Beginning in March, the monthly composited filter samples were also analyzed for ^{241}Am.

Large volume air samplers were operated offsite at six locations drawing air at a constant rate of 68 m^3/hr through a (type FPAE-810) 20 x 25 cm (8 x 10 inch) glass-fiber filter. The filter is positioned upward and is covered to protect it from the wind and rain. The total volume (approximately 11,400 m^3 (400,000 ft^3) over a seven-day sampling period) and the elapsed time is summed by a microprocessor, which also maintains the constant flow rate. Increasing the volume of air sampled by a factor of 10 allowed greater sensitivity (i.e. lower detection limits) in looking for radionuclides of interest and greater sensitivity as required to confirm the concentrations predicted by modeling efforts. The operation of the high-volume air samplers were terminated during the first week of October 2000 after confirming the conceptual model and to focus resources on source term monitoring on the NTS. The Community Environmental Monitoring Program (CEMP) continues to collect offsite data as oversite verification of the results of source term monitoring.

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 (also for americium beginning in March).

Gross Alpha and Beta Results

The measurement of gross alpha and gross beta radioactivity in airborne particulates, after the decay of radon progeny, is used as a weekly screening and trending of long-lived radionuclides in air. During 2000, a total of 1,028 air filters were collected weekly and analyzed for alpha and beta radioactivity, before monthly composite analysis. Descriptive statistics for the gross alpha and beta results, in units of µCi per mL of air, are given in Tables 5.1 and 5.2, respectively. The variation in the gross alpha and gross beta radiation measurements during the year is shown in time series plots in Figures 5.2 and 5.3, respectively. As shown in Figure 5.2, the gross alpha concentrations in air were relatively constant. The exceptions were results from Bunker 9-300, a source term that has been recognized previously.

A step increase in all the gross alpha results were realized from the contractor laboratory which were a factor of 3-5 higher than the Bechtel Nevada (BN) results. Possible contributors to the factor of 3-5 difference is due to either equipment background differences or the variations in the configuration of equipment. Since there is no DCG for gross alpha radioactivity, these data are used for weekly screening and trending so investigating the exact cause of this difference is not warranted, but is suspected of being laboratory differences.

In Figure 5.3, the gross beta results from both laboratories are shown in a time series plot. Except for the one sample in August (this sample was also analyzed by BN and found to have a concentration which was consistent with those for the other locations), the results for all locations varied in a similar pattern, suggesting a systematic difference in the laboratory process, sampling equipment variability, or natural variability.

Plutonium Results

Descriptive statistics for ^{238}Pu are given in Table 5.3, which shows that ^{238}Pu was detected above the minimum detectable concentration (MDC) in 50 percent or less of the samples. The highest annual mean concentration onsite was 9.5 x 10^{-18} µCi/mL (350 nBq/m^3) at Bunker T-4,

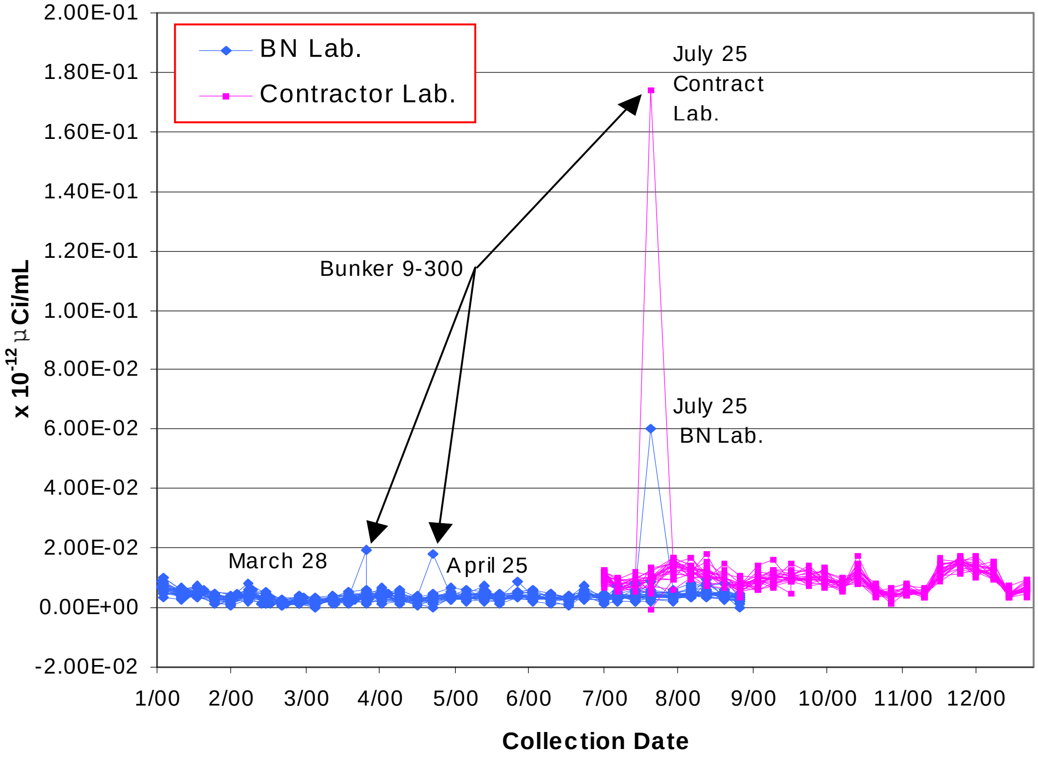

Figure 5.2 Time Series Plot of Alpha for ASL and GEL - 2000

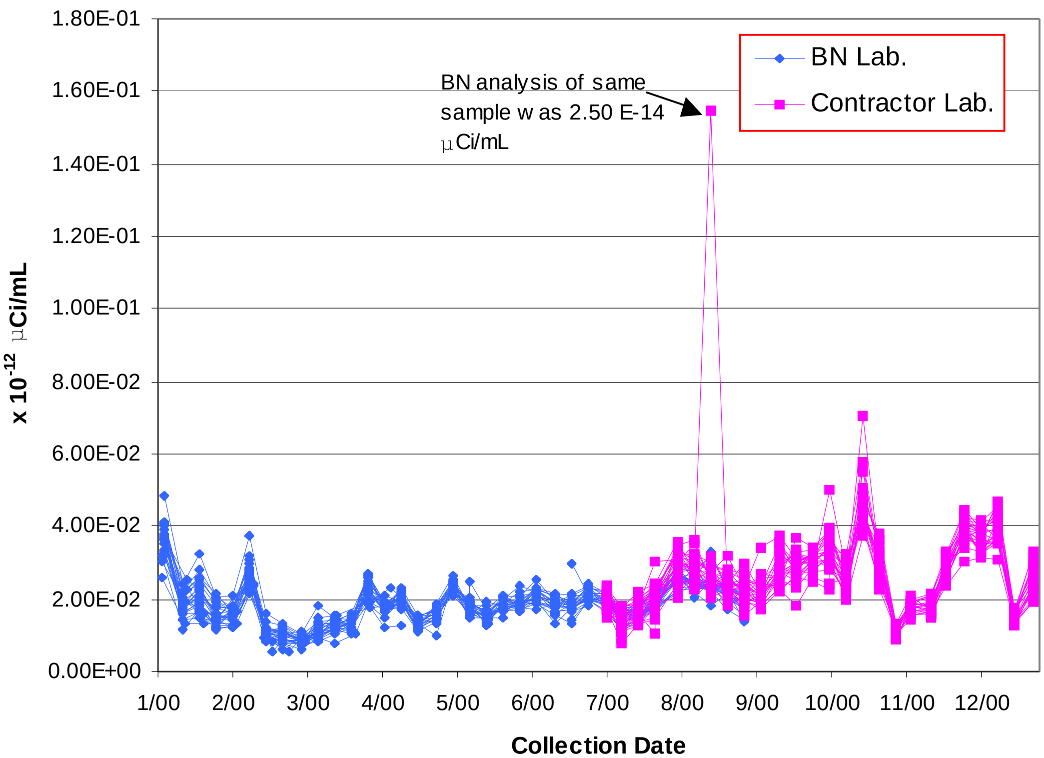

Figure 5.3 Times Series Plot of Beta - 2000

which is surrounded by areas with known deposits of radioactive fallout from past nuclear tests. The maximum onsite mean concentration was 47 x 10^{-18} mCi/mL (1.7 nBq/m^3) at Bunker 9-300. The highest average concentration offsite was 1.2 x 10^{-18} µCi/mL (44 µBq/m^3) at Rachel, Nevada, which is 0.04 percent of the DCG for the public.

Airborne concentrations of $^{239+240}$Pu, shown in Table 5.4, were consistently above the MDCs for samples collected from Bunker 3-300, U-3AH/AT N, U-AH/AT S, Bunker T-4, Bunker 9-300, and CLEAN SLATE II, where 90 percent or more of the samples had concentrations greater than the MDC. The highest onsite annual mean concentration, 4.3 x 10^{-16} µCi/mL (16 µBq/m^3), occurred at Bunker 9-300. This concentration is 22 percent of the DCG. The highest offsite mean concentration was 2.5 x 10^{-17} µCi/mL (0.93 µBq/m^3) at Amargosa Valley which is only 1.2 percent of the DCG.

The variation in concentrations for all locations during the year is shown by the time series plot in Figure 5.4, which shows Bunker 9-300 and Bunker 3-300 with the highest maximums. When the $^{239+240}$Pu concentrations at Bunker 9-300 are plotted with the gross alpha concentrations at all locations, as shown in Figure 5.5, the peaks in plutonium concentrations are found to occur on the same dates as the high gross alpha concentrations.

Figure 5.6 shows the trend in the highest annual averages of $^{239+240}$Pu from 1991 to 2000 onsite and offsite and compares them to the DCG. Except for the year 1992, when extensive ground disturbing activity occurred at the Area 3 Radioactive Waste Management Site (RWMS-3), the variation in highest average concentration offsite seemed to follow the variation in the onsite highest average concentration.

Figure 5.7 is a historical time series plot of the annual mean concentrations of $^{239+240}$Pu in air particulates for the years 1970 to 2000 at several locations on Yucca Flat and Frenchman Flat, where many nuclear tests have been conducted in the past. The blue line represents the decreasing trend in $^{239+240}$Pu concentrations over the 30-year period. The decrease is attributed to the termination of nuclear testing and the general reduction of field activities that can cause a resuspension of the plutonium in the surface soil. The red regression line is only for the last ten years, showing how air concentrations have leveled off, probably due to the reduced vehicular traffic on dirt roads and other field activities.

Americium Results

Air filter samples were analyzed for ^{241}Am beginning with the March filter composites. The descriptive statistics of the results are given in Table 5.5. As shown in this table, 90 and 100 percent of the samples collected from Bunker 3-300 and Bunker 9-300, respectively, had concentrations above the MDC. Offsite locations at Alamo and Amargosa had the highest percentage of samples with concentrations above the MDC, 28 and 33 percent respectively. The highest onsite annual mean concentration was 9.7 x 10^{-17} µCi/mL (3.6 µBq/m^3) at Bunker 9-300, which is 5 percent of the DCG for the public. The highest offsite concentration average was 2.1 x 10^{-18} µCi/mL (78 nBq/m^3) at Amargosa Valley, which is about 1 percent of the DCG.

A time series plot of all of the results for 2000 (see Figure 5.8), shows a trend similar to that for the $^{239+240}$Pu results; a peak on July 25 at Bunker 9-300 and low concentrations at the offsite locations.

Gamma-Emitting Radionuclides

^{137}Cs was the only man-made radionuclide detected in the air particulate samples by gamma spectroscopy. The descriptive statistics for those samples are given in Table 5.6. The only locations at which concentrations were above the MDCs of the measurements were at the

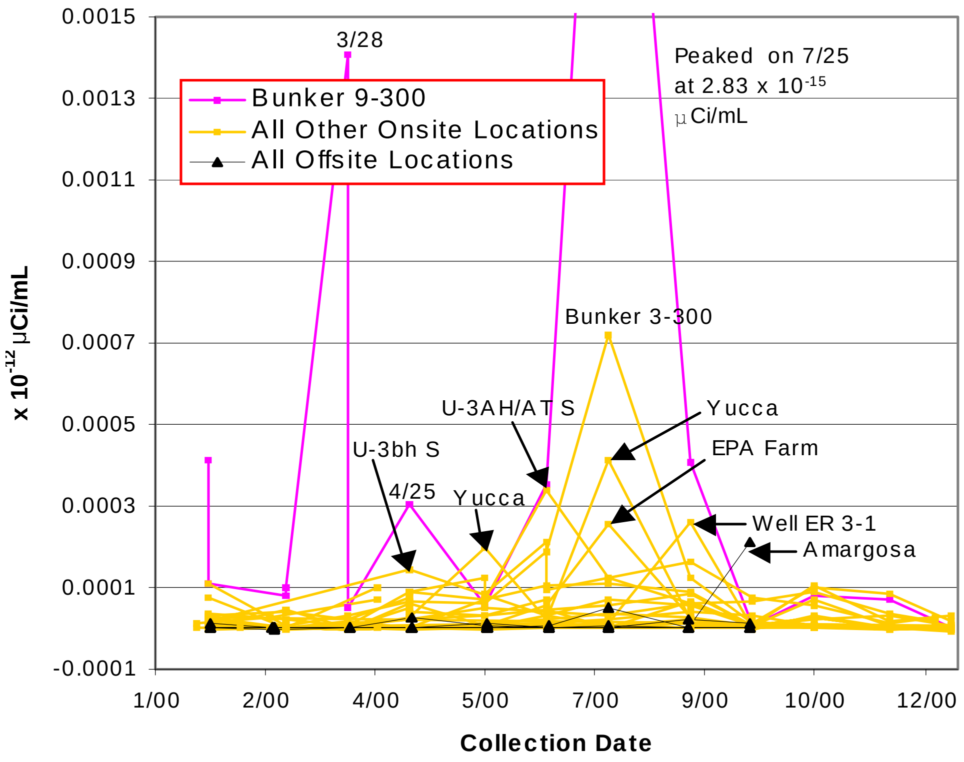

Figure 5.4 Time Series Plot of Plutonium in Air - 2000

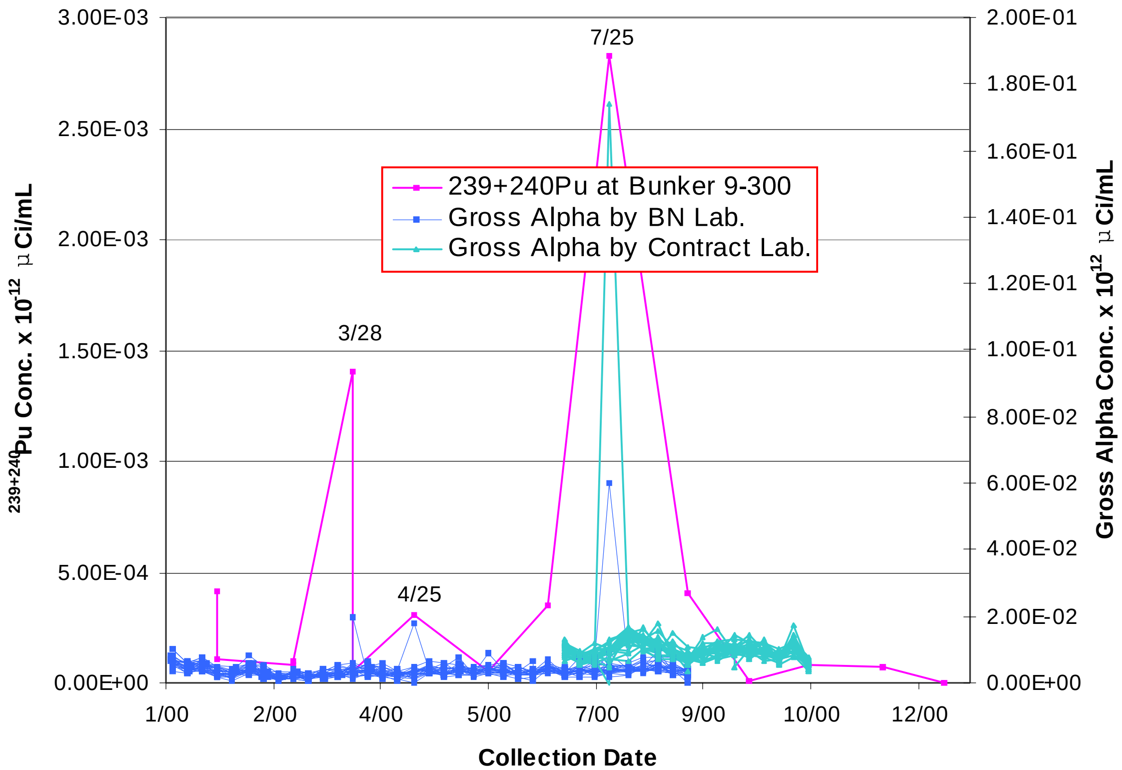

Figure 5.5 Time Series Plot of Plutonium vs Alpha - 2000

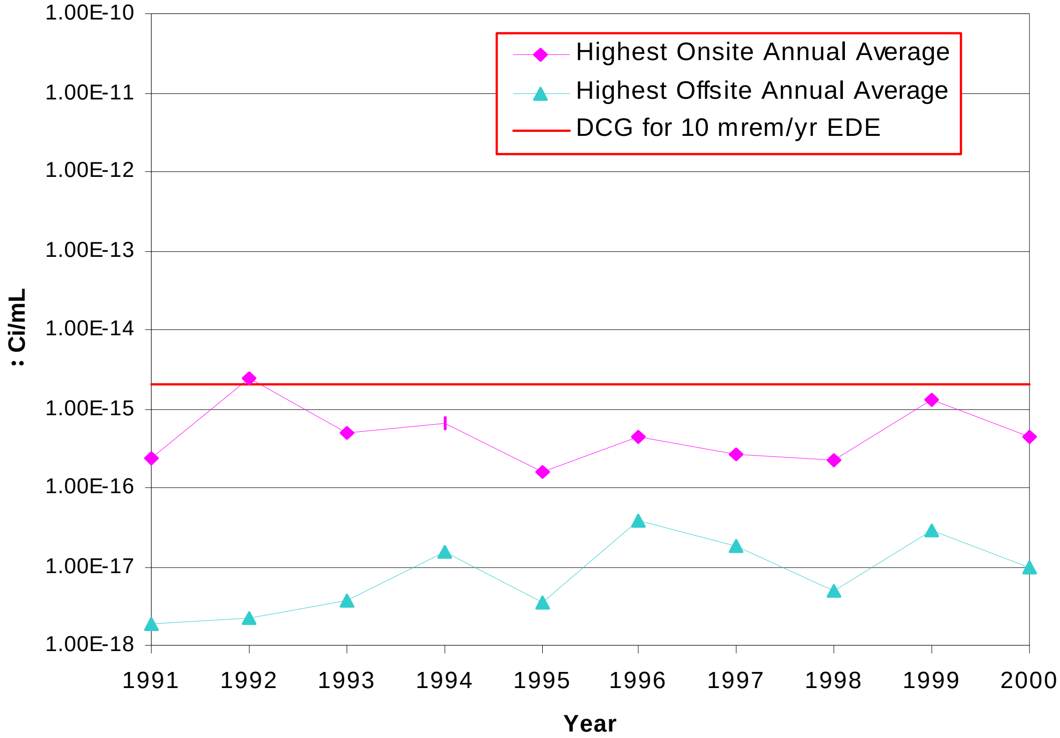

Figure 5.6 Trend in Annual Averages for $^{239+240}Pu$ Concentrations

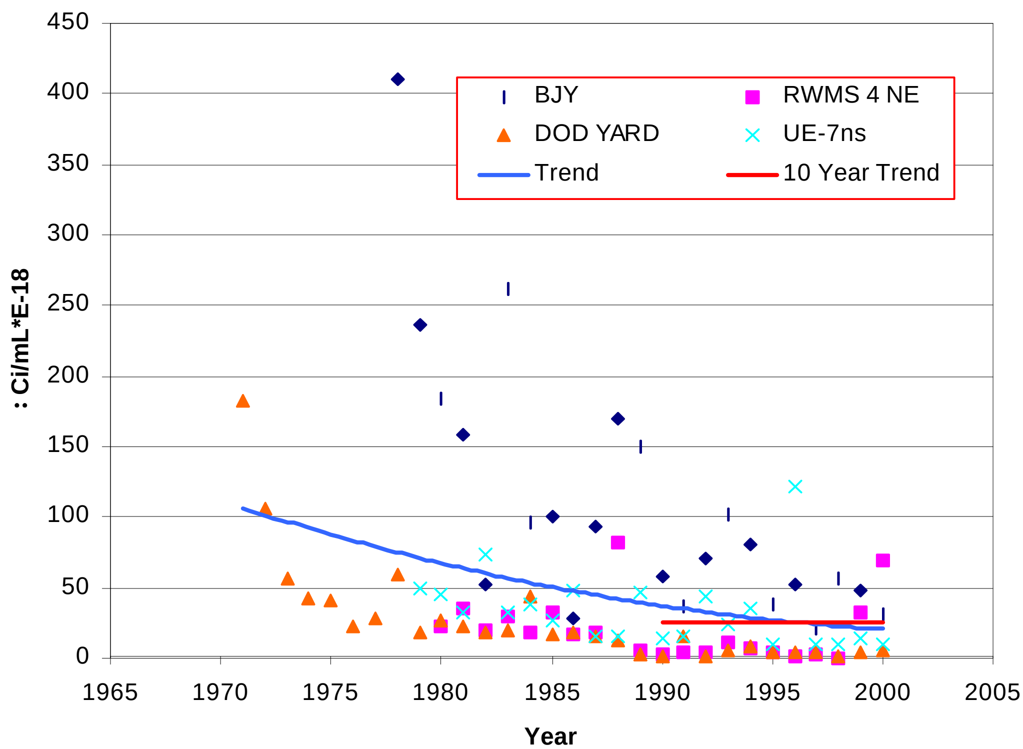

Figure 5.7 Time Series Plot for $^{239+240}Pu$ Annual Averages

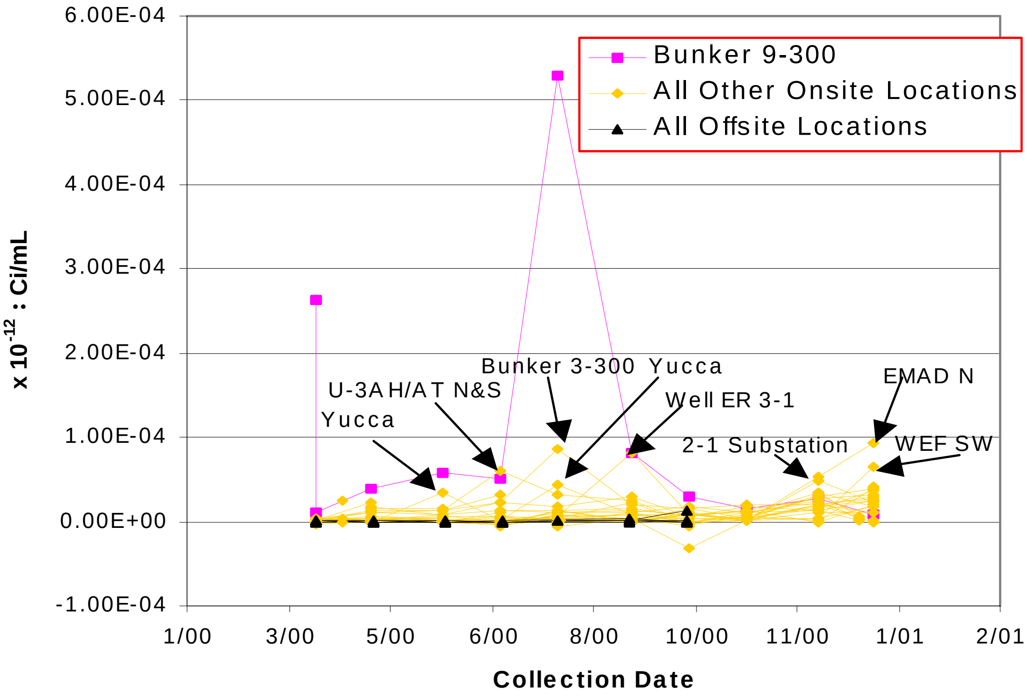

Figure 5.8 Time Series Plot of ^{241}Am in Air All Locations - 2000

The gamma spectroscopy analyses also detect naturally occurring radionuclides in addition to those from nuclear testing. The descriptive statistics for the concentrations of these radionuclides are given in Table 5.7. As the naturally occurring radioactivities from the progeny of radon and thoron (^{208}Tl, ^{214}Pb, ^{226}Ra, ^{228}Ac, and ^{228}Th) are not in equilibrium at the time of counting, they are not reported. The concentrations of ^{7}Be and ^{238}U reported in Table 5.7 are slightly lower than those reported last year. ^{235}U was not detected above the MDC.

TRITIUM IN AIR

Tritiated water vapor in the form ^{3}H^{3}HO or ^{3}HHO (HTO) was monitored at 10 onsite locations and two offsite locations. The samplers were operated at a constant flow rate of 0.6 L/min (1.25 ft^{3}/hr) by microprocessors, which summed the elapsed time and the total volume sampled (about 11 m^{3} over a two-week sampling period). At E Tunnel Pond 2 where grid electrical power was not available, a sampler without constant flow capability that summed the air volume sampled with a dry-gas meter had to be used because of the limited power provided by a solar photovoltaic system.

With either sampler, the HTO vapor was removed from the air stream by two molecular sieve columns connected in series (one for routine collection and a second one to indicate if breakthrough occurred during collection). These columns were exchanged biweekly. An aliquot of the total moisture collected was extracted from the columns and analyzed for tritium by liquid scintillation counting.

Tritium in Air Results

A total of 281 samples of atmospheric moisture were collected and analyzed for tritium. Samples were collected at each location throughout the year, except for incidental power outages, equipment malfunctions, and the termination of sampling at the offsite locations (Amargosa and Indian Springs) on October 4, 2000.

RWMS-3 (U-3bh North), Area 5 RWMS (RWMS-5) (Transuranic [TRU] Building and Waste Examination Facility [WEF] Northeast), and Bunker 9-300. The highest annual average concentrations were 2.4 x 10^{-16} µCi/mL (8.9 µBq/m ^{3}) inside the TRU Building and 1 x 10^{-16} µCi/mL (3.7 µBq/m^3) at the environmental location WEF Northeast. Both concentrations were less than 0.01 percent of the DCG

The descriptive statistics of the results, in units of 10^{-6} pCi/mL of air, are shown in Table 5.8. As in the past, the highest annual average HTO concentration, 3.3 x 10^{-4} pCi/mL (12 Bq/m^3), was measured in samples collected at a distance of 0.27 km (0.17 mi) from the cratering test SCHOONER. This concentration is 3.3 percent of the DCG for the general public. Those locations at which tritium was detected in the majority of samples (>50 percent) were SCHOONER (Area 20), SEDAN (Area 10), E Tunnel Pond #2 (Area 12), and RWMS 4 Northeast (Area 5 Waste Operations). SCHOONER was the only location at which 100 percent of the samples had HTO concentrations above the MDC of the measurement, which was most likely due to the sampler being close to the site of the test.

The variations in HTO concentrations at all locations are shown in Figure 5.9. As shown in this figure, the concentrations at all locations rose in the April/May and decreased in November. In Figure 5.10, air temperature appears to be the environmental parameter which affects the release of tritium from the soil and vegetation into the air. The peaking of the airborne tritium at SCHOONER follows the increase of air temperature in the spring and its decrease in the fall.

Precipitation in Area 20 is light (8.27 inches in 2000). However, a plot of precipitation with the tritium in air concentrations (Figure 5.11), indicates that heavy rainfall probably influences the variations of airborne tritium. An accurate correlation of rainfall and temperature with airborne tritium concentrations was not possible due to the meteorologic measurements being separate by considerable distances.

The historical trend for HTO concentrations, shown in Figure 5.11, illustrates how changes in sampling locations and equipment effects the average concentrations with time and provides a comparison of highest onsite and offsite average concentrations. The highest annual average concentrations onsite and the annual network averages showed little variation between the years 1991 and 1997, even when samplers were installed near the E Tunnel ponds and the SEDAN crater. However, there was a significant increase in the highest and average network concentrations for the year 1998 when an air sampler was installed near the SCHOONER crater. During 1999, the change to a more efficient desiccant (molecular sieve) contributed to the additional increase observed for that year. The slight increase in the highest onsite average concentration and the network average in 2000 is attributed to the use of molecular sieve for a full year, whereas in 1999 it was used only for half of the year, and to a change in the calibration procedure which corrected the sample volumes for changes in elevation. The single point plotted for the offsite locations in 2000 actually represents data for the years 1999 and 2000. It is included in Figure 5.12 for comparison with the highest onsite averages. Since the two offsite tritium samplers were only operated the last two months in 1999 and the first nine months in 2000, a time-weighted average of the highest offsite averages for the two years was used.

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 5.13 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. A linear regression on these data points show an approximately decreasing trend with a half-life of four years which is faster than its radioactive half-live of 12 years. This is expected due to its dispersion within the atmosphere.

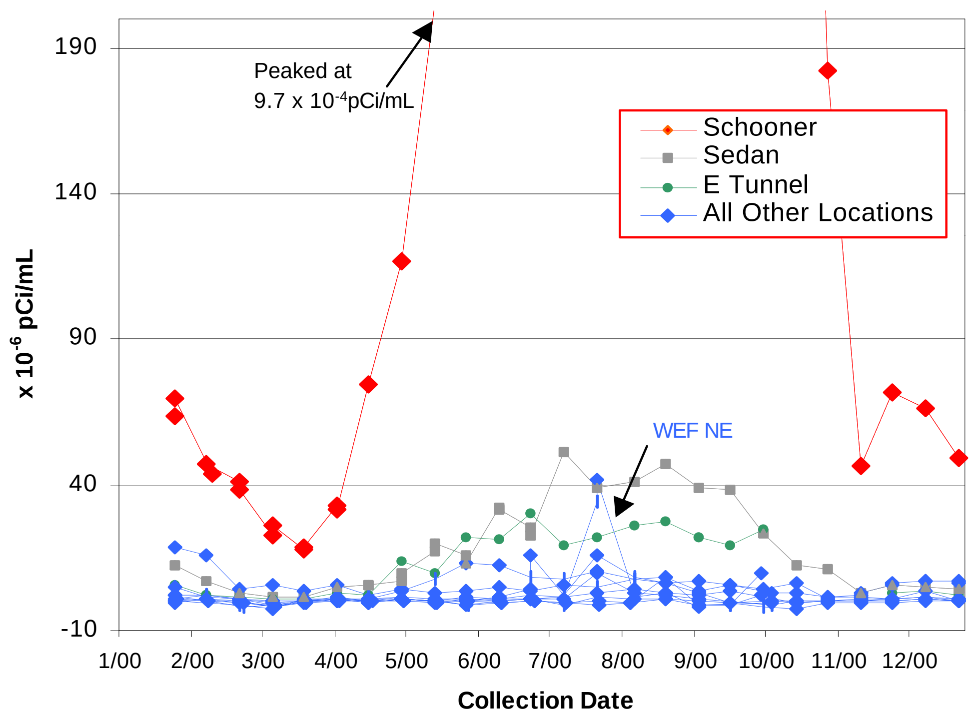

Figure 5.9 Time Series Plot of Tritium in Air - 2000

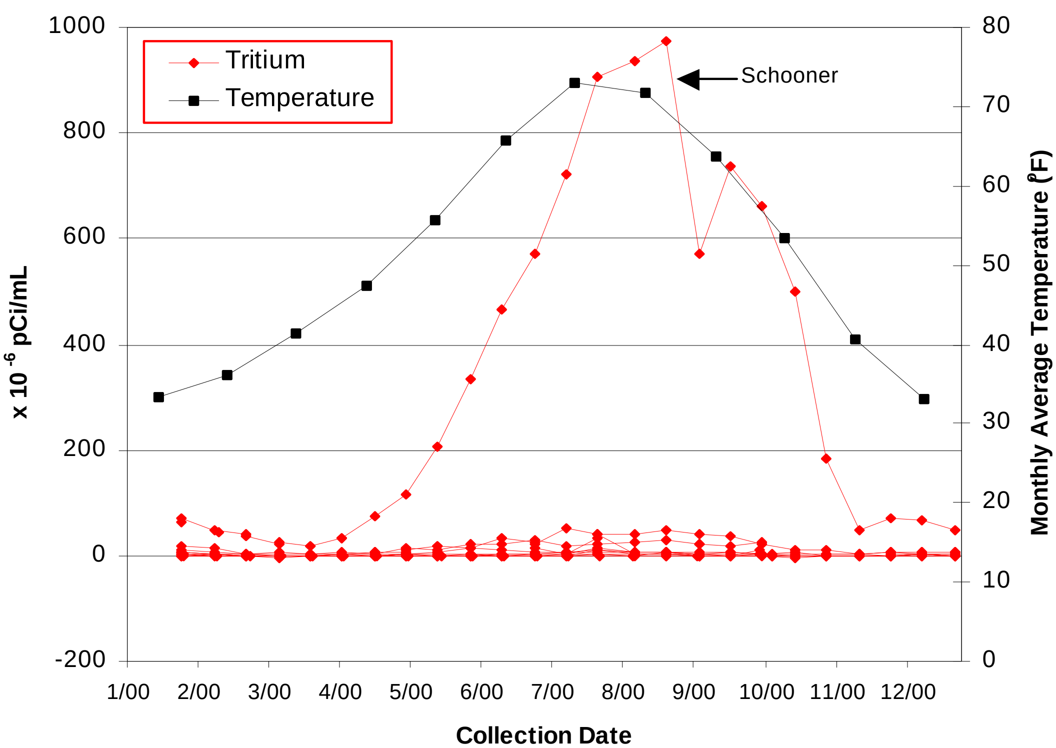

Figure 5.10 Time Series Plot of HTO vs Temperature

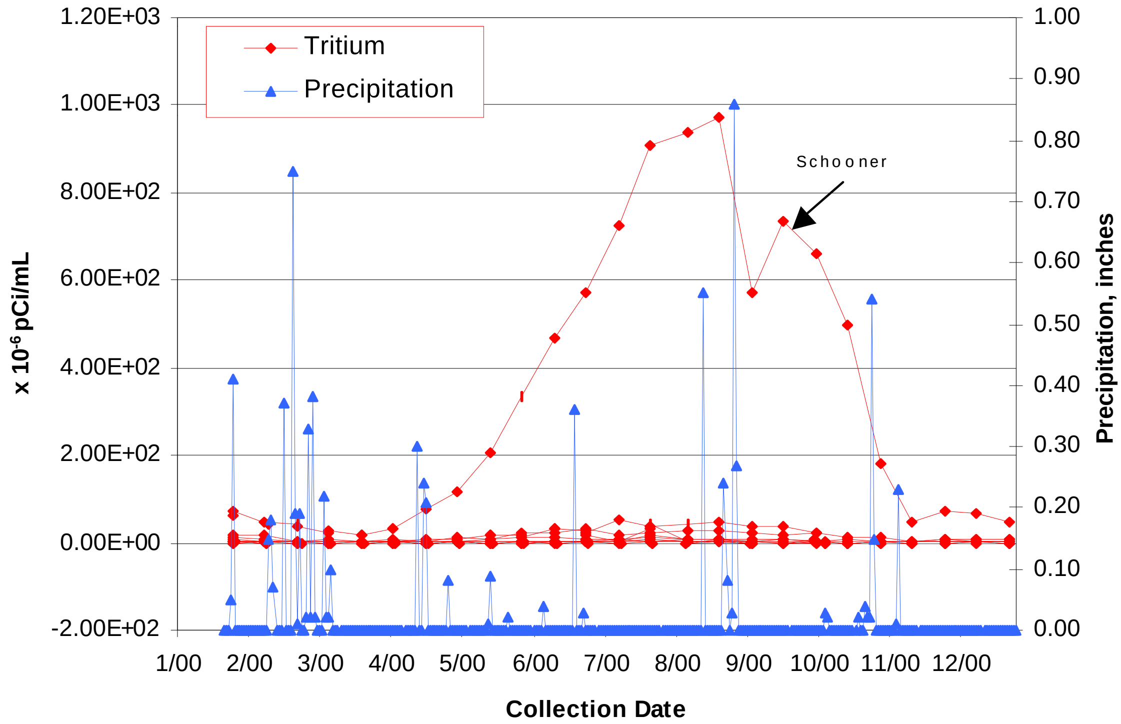

Figure 5.11 Time Series Plot of HTO vs Precipitation

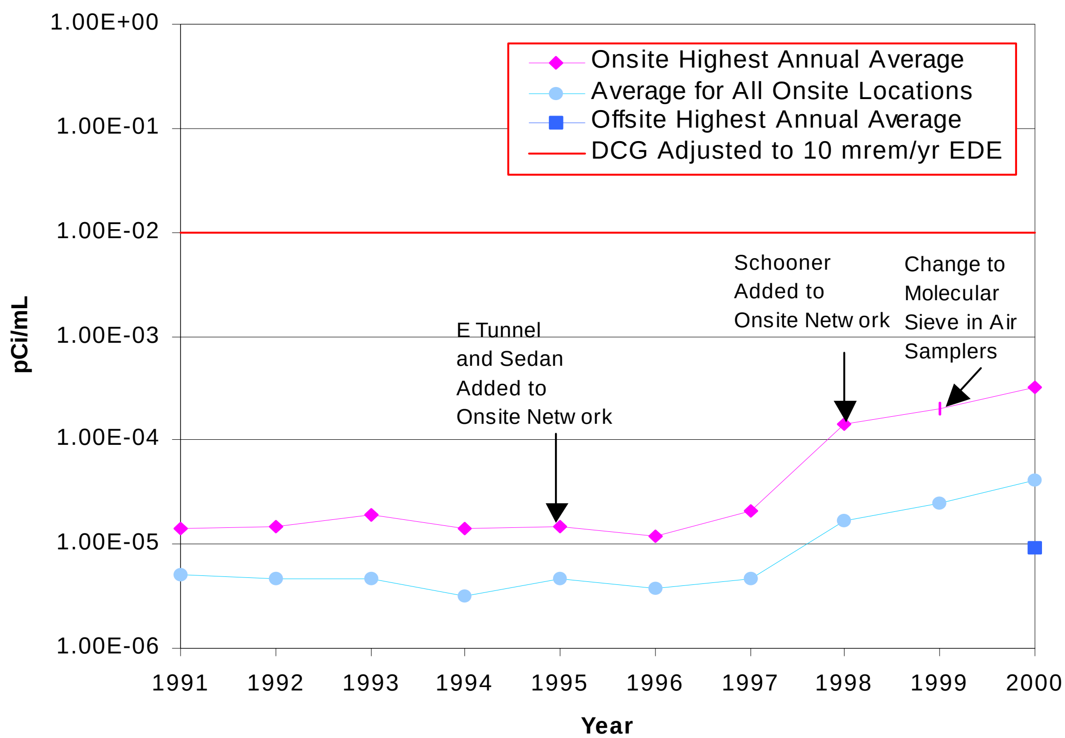

Figure 5.12 Trend in Annual Averages for HTO Concentrations Onsite

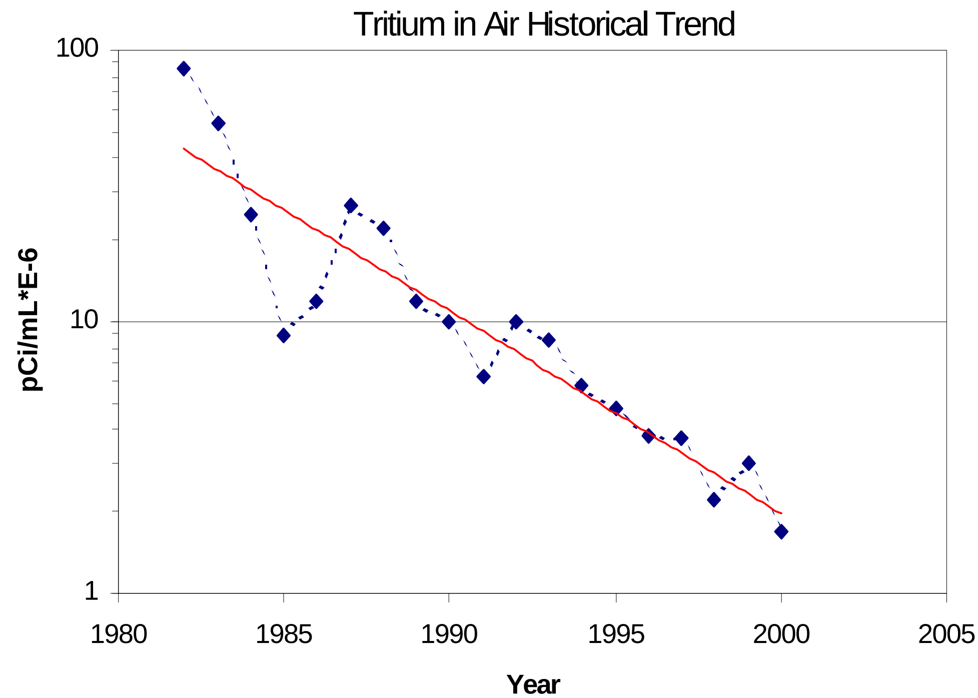

Figure 5.13 Time Series Plot for Tritium in Air on the NTS

5.2 ENVIRONMENTAL DOSIMETRY

AMBIENT GAMMA MONITORING

Film badges were used during early activities on the NTS for ambient gamma exposure monitoring. Thermoluminescent dosimeters (TLDs) replaced the film 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 2000, there were a total of 86 active TLD locations. The TLD used was the Panasonic UD-814AS consisting of four elements housed in an air-tight, water-tight ultraviolet-light-protected case. A lithium borate element was slightly shielded in order to measure low-energy radiation. Three calcium sulfate elements were shielded by 1,000 mg/cm^2 of plastic and lead and were used to monitor penetrating gamma radiation. TLDs were deployed in two holders placed about one meter above the ground and exchanged quarterly. Locations were chosen at the site boundary, at locations where historical monitoring has occurred, or where operations or ground contamination have occurred.

THERMOLUMINESCENT DOSIMETER MONITORING DATA

Table 5.9 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 2000 was 92 days. The range of TLD exposures was from 84 to 113 days.

TLD locations are divided into four classes or sample types, as shown in Table 5.9. Background locations are close to the perimeter of the NTS and in locations known to be relatively free of man-made radionuclide inventory. Operational locations are adjacent to stored radioactive materials in Areas 3 and 5 RWMS and the inactive Decontamination Facility locations. The remaining TLDs are in the environmental monitoring class with a small subset referred to as historical because of the long location history.

A statistical analysis of the data indicate that a log transformation is appropriate for the TLD data. A two-way analysis of variance (ANOVA) found highly statistically significant differences among quarters and among locations, with the location-to-location differences being somewhat more prominent than the temporal differences. Three locations, Stake A-9 (Area 4, E), Stake N-8 (Area 2, E), and RWMS South (Area 3, W), are identified as being distinctly higher than the remaining locations. An additional four locations, SEDAN West (Area 10, E), Bunker 7-300 (Area 7, E), T Tunnel #2 Pond (Area 12, E), and U-3CO North (Area 3, E), were somewhat higher than the remaining locations. These seven locations were also reported with atypical values in the annual report for 1999 (DOE 2000). There remain statistically significant differences among the other locations, although there were no particular clusters, just a continuous distribution involving all the remaining locations. The seven data values that were judged to be atypical are listed in Table 5.10 and are compared with the “Area Mean” for that general NTS area with the atypical values deleted. The locations in Table 5.10 are mostly in Yucca Flat, in places known to be contaminated by early atmospheric nuclear testing, the tunnel ponds containing products from nuclear testing performed within the tunnels, and operations at the Area 3 RWMS.

There are highly statistically significant differences among location Classes on the log scale: the historical location mean, 104 mR/hr, is significantly lower than both the environmental and waste operation means, 173 mR/yr and 159 mR/yr, respectively. The latter two are nearly the same, and the background class mean, 132 mR/yr, is between and not statistically significantly different from the others. Similarly, there are highly statistically significant differences among Areas, with no clustering except that the Area 23 mean is significantly lower than nearly all other Areas.

To evaluate the quarter-to-quarter pattern, a one-way ANOVA was performed on log observations adjusted for location-to-location differences. The result is that the third quarter mean values are systematically around 10-11 percent higher than the mean values for other quarters; the remaining quarters are nearly the same, with the first quarter slightly but not statistically significantly lower.

A nested ANOVA was performed as a follow-up to the location Class and Area analyses. In each case, the conclusion is that there are statistically significant differences among Classes or Areas beyond that due to the differences among locations, but that the additional variation is relatively minor compared with the location-to-location variation. All of the ANOVA conclusions remain qualitatively unchanged when the three or seven locations with highest mean values are omitted.

Comparing the 2000 TLD data with that for previous years, it was found that the median has increased slightly over 1999, from 119 mR/yr to 132 mR/yr, and the low and high values are lower and higher. These analyses are based on the environmental, background, and historical locations combined, omitting the atypical values identified previously. Based upon data from an aerial radiological survey of the NTS by the BN Remote Sensing Laboratory (Hendricks 1999), the median exposure rate of 132 mR/yr is actually lower than the average exposure rate of 165 mR/yr surveyed in the southwestern quarter of the NTS where little fallout from nuclear tests on the NTS has occurred.

The trend in exposure rates during the years 1994 to the present time is shown in Figure 5.14, which is a boxplot of the data by years for the environmental, background, and historical areas. Boxplots consist of a box, whiskers, and outliers. The bottom of the box is at the first quartile, the center line is the median, and the top of the box is the third quartile. The whiskers are lines

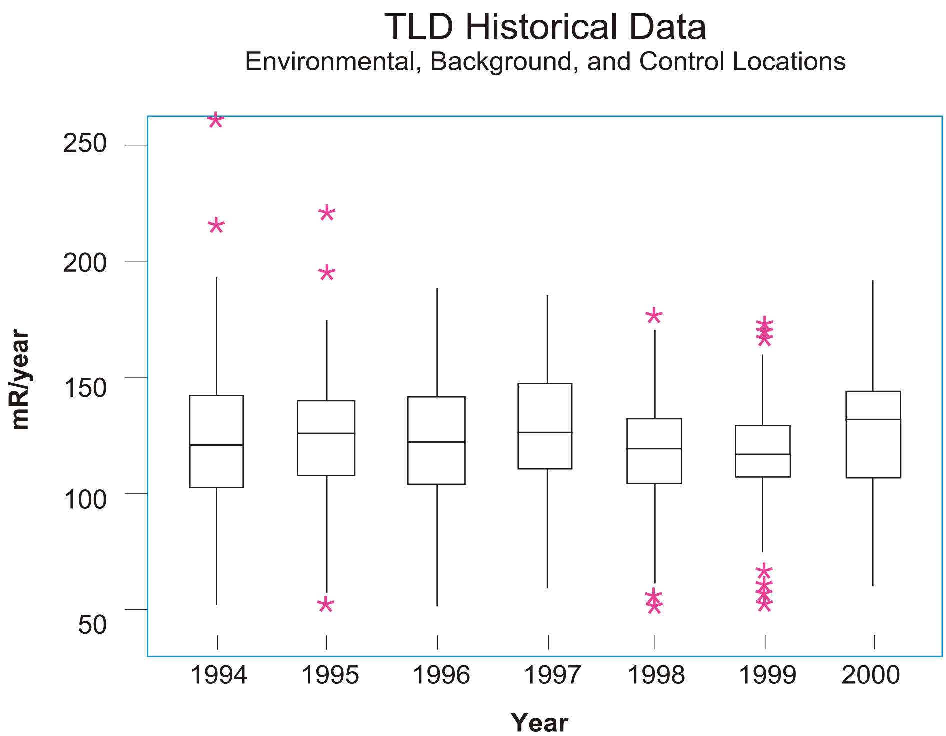

Figure 5.14 Historical Time Series of Boxplots of TLD Exposures

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. As shown by this boxplot, the median exposure rates were about the same in the years 1994 through 1997, decreased slightly in 1998 and 1999, and increased in 2000 to a level which is slightly higher than that for 1997.

5.3 WATER SURVEILLANCE ACTIVITIES

The surface waters that exist on the NTS are natural springs, containment ponds, and sewage lagoons. Water samples were collected only from the containment ponds and sewage lagoons. The onsite springs were not sampled because they are fed by locally derived groundwater that is not hydrologically connected to any of the aquifers that may be impacted by underground nuclear tests. Figure 5.15 shows the locations of all the containment ponds and sewage lagoons. No samples were collected from the Area 12 Sewage Lagoon or from the Engine Test Stand Sewage Lagoon due to a lack of water.

CONTAINMENT PONDS

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

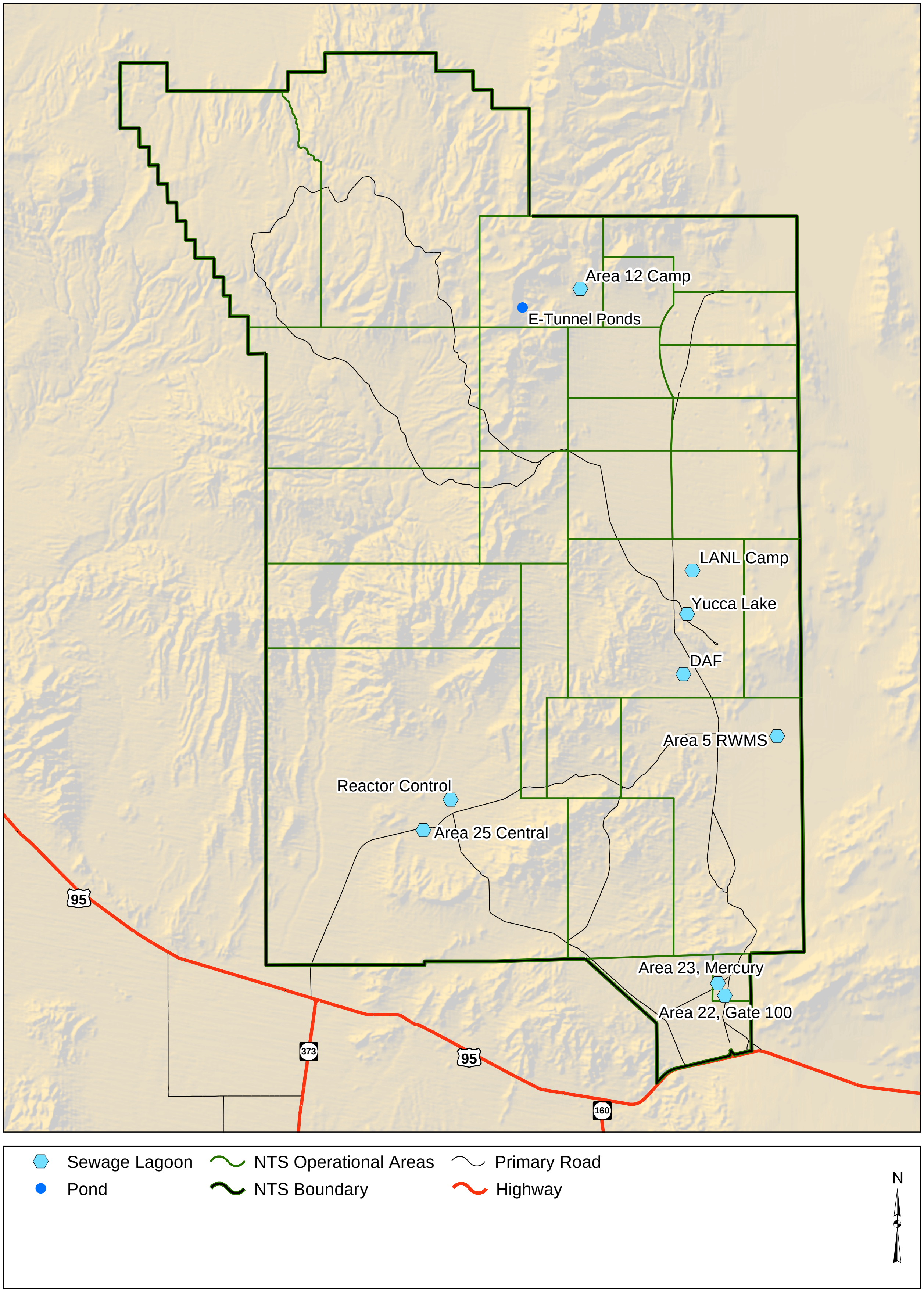

Figure 5.15 Surface Water Sampling Locations on the Nevada Test Site - 2000

SEWAGE LAGOONS

Each of the sewage lagoons are part of a closed system used for the evaporative treatment of sanitary sewage. The descriptive statistics of the gross beta radioactivity is given in Table 5.12. The annual average gross beta concentration was 28 x 10^{-9} mCi/mL (1.0 Bq/L) which is lower than last year's average of 67 x 10-9 mCi/mL (2.3 Bq/L). No test-related radioactivity was detected by gamma spectroscopy in any of the samples. No radioactivity was detected above the MDC for all ^{3}H, ^{90}Sr, ^{238}Pu, $^{239+240}$Pu, and ^{241}Am analyses.

5.4 BIOTA SURVEILLANCE ACTIVITIES

Biota sampling was implemented during 1999 and is described fully in the RREMP. 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 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 FY 2000 was conducted at two contaminated locations, E Tunnel Ponds, and SEDAN, and a control site, Whiterock Spring (Figure 5.16). E Tunnel Ponds (1,829 meters elevation, 6,000 feet elevation), located in Area 12 in the northern part of the NTS was selected for monitoring because of its historically high levels of contaminated water and soils (DOE 1998a). Vegetation at SEDAN was sampled for radionuclide components that could possibly be ingested by animals and enter the food chain. Whiterock Spring (1,539 meters elevation, 5,049 feet elevation), a naturally occurring spring in Area 12, was selected as an area control site for SEDAN. Vegetation at the Whiterock Spring was described by Hansen et al., (1997).

Collection of samples for the routine radiological monitoring of biota at the NTS commenced on September 21, 2000 and continued through October 16, 2000. 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 et al., 1998).

Extensive effort was made to trap rabbits, doves, or chukar from July to October at numerous sites (June/July coincide with abundant species and September/October coincide with migrants moving south, leaving only resident species). Despite an extensive effort, only a single bird was collected and rabbit trapping was unsuccessful during FY 2000, a normal rainfall year. Other sampling protocols are being investigated.

VEGETATION SAMPLING

Woody vegetation was primarily selected for sampling because of a more extensive root system and additionally serves as a major source of browse for wildlife game animals that might eat such vegetation and migrate off site. Grasses and forbs were sampled where species of woody plants were limited.

About 300 to 500 grams (10.6 to 17.6 ounces) of fresh-weight, green-leaf plant material was collected from the current year's growth. All plant samples consist of a composite of material from many plants in the area sampled. Plastic gloves were used by samplers and changed between each sample collected. Green-leaf plant materials from shrubs and forbs were hand-plucked and stored in ziploc-type 3.79 liter (1-gallon) plastic bags. Grasses were sampled by

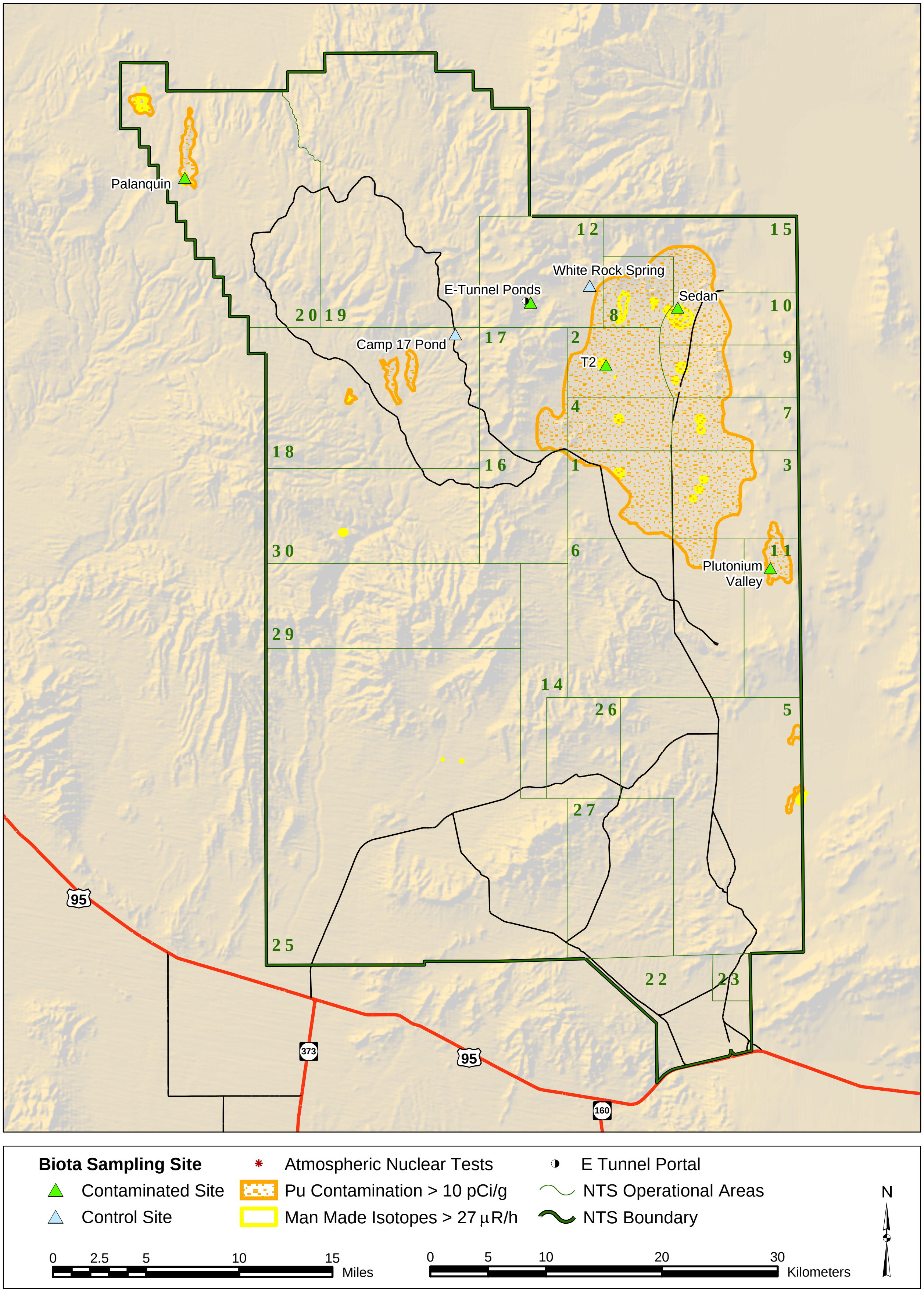

Figure 5.16 Nevada Test Site Onsite Surface Biota Radiological Monitoring Sites - 2000

cutting off plant material with a clean utility knife blade. Samples were labeled with permanent labels on the outside of the bag and stored in an ice chest until delivered to the laboratory (within two hours of collection). Plant samples were delivered to the laboratory under standard chain of custody procedures and frozen until analyzed (DOE 1998a).

Plant samples were taken from the SEDAN site (Figures 5.17 and 5.18) from within 100 meters (109 yards) of the western lip of the crater. Samples taken included representatives of the dominant annuals, grasses, and shrubs at SEDAN. Samples included one grass, desert needlegrass (*Achnatherum speciosa*), one annual, prickley Russian thistle (*Salsola kali*), and two woody shrubs, rubber rabbitbrush (*Ericameria nauseosa*), and fourwing saltbush (*Atriplex canescens*). No trees are present at SEDAN and no tree was sampled. Approximate location of plant samples at SEDAN was: UTM Zone 11, Easting 584480, Northing 4114980. These plants are now existing on soil that was throw out underburden from the initial SEDAN test in 1962.

Plant samples were taken of dominant shrubs at the Whterock Spring control site. These samples included Baltic rush (*Juncus balticus*), Stansbury cliffrose (*Purshia stansburiana*), rubber rabbitbrush *(Ericameria nauseosa*), fourwing saltbush (*Atriplex canescens*), and sandbar willow (*Salix exigua*). One dominant forb, the Louisiana sagewort (*Artemisia ludoviciana*) was sampled at the site. Approximate location of plant samples taken at Whiterock Spring was: UTM Zone 11, Easting 577060, Northing 4117350.

ANIMAL SAMPLING

State and Federal permits were secured to take quail and chukar in addition to doves during FY 2000. Animal trapping in FY 2000 consisted of about 30 trapping days. Trapping effort was directed to mourning doves (*Zenaida macroura*), chukar (*Alectoris chukar*), cottontail rabbits (*Sylvilagus audubonii*) and jackrabbits (*Lepus californicus*). Mourning doves are one of the few game animals that forage on the NTS and migrate offsite, thereby providing a possible pathway of radionuclides in food to man. The ecology of mourning doves is described in detail in (Baskett et al., 1993).

Field observations indicate doves arrive on the NTS during April and numbers increase until about mid August, after which numbers begin to decline. Few doves can be observed on the NTS in October indicating that migration off site is complete. It is reported that a majority of mourning doves in Nevada migrate out of state and end up in south central Arizona (Baskett et al., 1993). Chukars and quail are considered permanent residents of the NTS region. It is not likely that chukars or quail migrate off the NTS. Researchers (TRW 1999) studying quail movements near Yucca Mountain found that one female quail moved a maximum distance of 6.8 km (4.2 mi) from initial point of capture during 59 weeks of monitoring. Resident species such as quail or chukar might accumulate higher levels of activity than migratory species due to their longer residence time on the NTS.

Traps were placed at several sites in FY 2000 to catch birds and rabbits. These included Well 5B Pond, Camp 17 Pond, SEDAN, Whiterock Spring, and E Tunnel Ponds. At each site a minimum of two traps were set to different openings to allow rabbits or birds such as chukar, dove or quail to enter the traps. Trap locations were prebaited for 3-5 days prior to setting traps, to attract animals to each site. Prebaiting consists of applying a large quantity of bait in the area outside of traps to allow animals to consume bait and become adjusted to the presence of traps. Dead shrubs and trees were also used to camouflage and cover the traps to provide shade.

Traps were baited with several types of bird seed, including commercial song-bird seed mixtures with millet, sorghum, sunflower seeds, chopped corn, and commercial rabbit rations. Bait was sprinkled on the ground when applied. No water was provided as part of the bait environment.

Figure 5.17 View of the SEDAN Sampling Site about 100 m West of the Lip of the Crater where Plants were Sampled during October 2000

Figure 5.18 Closeup View of Vegetation (Rubber Rabbitbrush) Sampled at SEDAN about 100 m West of the Crater Edge during October 2000

Traps were baited about 3:00 pm and checked the following morning by about 10:00 am. Because predation of bait by unwanted species was unavoidable, a large quantity of bait was always applied each night to ensure enough bait was present at all times.

Doves were moderately abundant at NTS sites during June-July FY 2000 on both Frenchmann and Yucca Flats, when they were reproducing. Doves were observed to congregate around prebaited traps at Well 5B during late June through early July and several doves were caught and released after 6 days. Sites on northern Yucca Flat, Whiterock Spring, SEDAN, Camp 17 Pond, and E Tunnel Ponds were prebaited later in the year (August -October). An abundance of chukar were attracted to the prebaiting at E Tunnel Pond but a late August rainfall dispersed the birds before they could be caught. Overall only one dove was caught from this effort at E Tunnel Ponds after 10 days of trapping. The approximate location of the dove sample at E Tunnel ponds was: UTM Zone 11, Easting 571740, Northing 4116080. At Camp 17 pond, dove abundance was observed to be low in September and October and none were caught after six days of trapping. At SEDAN and Whiterock Spring no rabbits or doves were caught in approximately eight days at each site, although jackrabbits were observed on several occasions at SEDAN. Natural water is unavailable at SEDAN and no gamebirds were observed on any visit during this time.

Trapping efforts in FY 2000 indicate that birds may be captured easily at sites that are prebaited early in the year (June-July) when birds are abundant. Late season trapping of birds (September -October) when they are dispersed from water or are not abundant on NTS has proved to be very difficult. Shooting doves during September when fewer birds are present would be the preferred method for late season sampling. Rabbits cannot be regularly captured by trapping with bait on NTS. Shooting of rabbits is recommended to successfully obtain samples.

RESULTS

Radionuclide activities in NTS Biota Samples in FY 2000 are shown in Table 5.13. For most samples taken, above background levels of activity were detected for ^{40}K, a naturally occurring radioisotope, at both sites. Three samples tested above MDC for vegetation analyzed for ^{90}Sr at SEDAN. The highest activity detected for ^{90}Sr at SEDAN was (Russian thistle) 4.55 pCi/g (0.17 Bq/g) with detection limits of 0.548 pCi/g. Cesium levels were very low at both sites, with only one sample (desert needlegrass) that was above detection limits for ^{137}Cs at SEDAN with an activity of 0.383 pCi/g (MDC of 0.122 pCi/g).

Four vegetation samples at SEDAN were above MDC for ^{238}Pu and five samples tested above MDC for $^{239+240}$Pu (Table 5.13). All activites for ^{238}Pu and $^{239+240}$Pu were very low at SEDAN. The highest measured value for ^{238}Pu was 0.00902 pCi/g (MDC of 0.00457 pCi/g), and for $^{239+240}$Pu the highest activity was 0.0174 pCi/g with a MDC of 0.00925 pCi/g.

Tritium was detectable in all vegetation samples at SEDAN with highest levels in rubber rabbitbrush with an activity of 3,250,000 x 10^{-9} µCi/mL. Fourwing saltbush had a tritium activity range from a high of 510,000 x 10^{-9} µCi/mL to a low of 306,000 x 10^{-9} µCi/mL. Desert needlegrass had the lowest tritium activity of all shrubs sampled at SEDAN (Table 5.13). This may be due to the shallower rooting depth of grasses as compared to shrubs. Tritium concentrations from water in plants sampled by Hunter et al., (1998) from SEDAN in 1996 varied from about 1.73 to 5.02 x10^{-2} µCi/mL. The levels of tritium in plants during 1996 were roughly 5-15 times higher than the values reported here for FY 2000 and most liklely attibutable to natural variation due to rainfall spurring root growth and draughts causing the plant leaves to wilt.

At Whiterock Spring, eight plant samples tested above MDC for ^{238}Pu and five plant samples had small but detectable quantities of ^{239,240}Pu (Table 5.13). In addition, two plant samples (Baltic rush and Stansbury cliffrose) at Whiterock Spring had detectable amounts of ^{238}U. All activites of radionuclides detected were very low at Whiterock Spring. The highest value for ^{238}Pu in vegetation was for rabbitbrush at Whiterock Spring with an activity of 0.0306 pCi/g (MDC of 0.0112 pCi/g). Similarly, the highest activity for ^{239,240}Pu was found in the Louisiana sagewort with a measured activity of 0.0516 pCi/g (MDC of 0.0105 pCi/g). It is possible that these activities are the result of dust on the outside of the vegetation as uptake of plutonium ^{239}Pu from soil through the roots of plants to leaves is known to be very limited (Romney et al., 1970). These authors also noted that higher levels of ^{239}Pu were found to be in native vegetation from fallout areas on NTS which was assumed to be from external surface contamination. In only one plant sample was tritium detected above MDC at Whiterock Spring. This sample was from fourwing saltbush and was barely above detection limits (257 x 10^{-9} µCi/mL) with an activity of 404 $\pm$ 163 x 10^{-9} µCi/mL. Based on the levels of radionuclides detected in plants at Whiterock Spring, this site will not be adequate as a future control site for sampling biota on NTS but may be investigated further to confirm the questionable results.

The dove sampled at E Tunnel Pond during September had a tritium concentration of 391,400 $\pm$ 7450 x 10^{-9} µCi/mL of tissue moisture. The dove also had low but detectable activities of ^{238}Pu and ^{239,240}Pu. These activities were 0.0299 pCi/g ^{238}Pu and 0.0222 pCi/g ^{239,240}Pu (Table 5.13), with MDC's of 0.0134 and 0.0133 pCi/g, respectively.

For comparison to the tritium concentration measured in the dove sample from FY 2000, the average concentration of tritium in water in E Tunnel Pond # 4 sampled on July 13, 2000, was approximately 879,500 x 10^{-9} µCi/mL. Given that the quantity of tritium found in the dove is a factor of two or more times lower than the pond water, it is reasonabe to assume that doves were drinking from E Tunnel Pond water during late summer. In addition, the average concentrations of ^{238}Pu found in the E Tunnel ponds effluent water sampled on July 13, 2000, was roughly 0.198 x 10^{-9} µCi/mL. Similarly, for comparison to the dove sample, the average concentration of $^{239=240}$Pu in water at E Tunnel Pond #4 was approximately 0.603 x 10^{-9} µCi/mL for this date.

5.5 RADIOLOGICAL DOSE ASSESSMENT

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

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

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

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

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

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

RADIOACTIVE EMISSIONS

Known and potential sources of airborne emissions and liquid effluents containing radioactivity are identified and listed in Table 5.14. All sources are on the NTS or NAFR except for Building A-1, which is in North Las Vegas. A brief description of the methods used for estimating the emissions is given below. More details about the sources and methods used is reported separately (Grossman 2001).

Laboratory Sources

The emissions for the laboratory sources are actually the total quantities found on inventory and are assumed released into the air although they were not. Radiological analyses conducted in these laboratories require the use of radiation sources that can be volatilized. Since radioactivity can potentially be released from the handling of radioactive sources and samples in laboratory hoods, all the sources are conservatively assumed to be released.

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

Area Sources

The area sources in Table 5.14 are a summation of the estimated radionuclide emissions from the individual areas on the NTS and from several contaminated sites on the NAFR (near offsite). The major sources of tritium as HTO are attributed to the events SCHOONER (Area 20) and SEDAN (Area 12), the E Tunnel ponds (Area 12), a low-level waste burial pit in Area 5 RWMS, and water pumped from RNM-2s into the CAMBRIC ditch in Area 5.

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

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

OFFSITE RADIOLOGICAL DOSE ESTIMATES

Dose from Airborne Emissions

The radiation doses to offsite residents from airborne emissions were estimated with CAP88-PC software (Version 2.0), in accordance with Title 10 CFR, Part 61. The estimate is described in detail in a report (Grossman 2001) to the Environmental Protection Agency. The software required the following input:

- The annual emission rates calculated for each point/grouped source (Table 5.14)
- The annual emission rates for each of the NTS areas with surface contamination (Areas 1-11, 12, 13, 15, 16, 17, 18, 19, 20, 30, and 52 [NLVF]) (for brevity, total emissions are summed for all areas in Table 5.14).
- Wind files that were constructed for Mercury, Area 12, Area 20, Yucca Flat, and Area 5 from wind rose and stability array data collected over a 10-year period.
- Location of populated areas within 80 km of the NTS sources of emissions.

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

Dose from Consumption of Wild Game

Although hunting is prohibited on the NTS, there is the remote possibility that animals drinking water and feeding on the NTS could migrate offsite where hunters could harvest them. As described in Section 5.3 only tritium, ^{238}Pu, $^{239+240}$Pu were detected above the MDCs of the measurements in a dove. From the hunting bag limits required by the state of Nevada (10 doves per day with no more than 20 doves in a hunter's possession at any one time) an estimate of the EDE to a hunter consuming 20 doves per year was made. From the assumptions that the weight of the sampled dove breast tissue (32.7 g) was representative for each of the 20 doves and the moisture content of the tissue was 76.1 percent, the EDE was calculated using a dose conversion factor (DOE 1988) for each of the detected radionuclides. The sum of the estimated EDE for each radionuclide was 0.16 mrem/yr, (1.6×10^{-3} mSv/yr).

Total Offsite Dose to Maximally Exposed Individual (MEI)

A summary of the NTS radiological doses for calendar year 2000 can be found in Chapter 1.0, Table 1.2. Based upon the estimated airborne emissions of radioactivity from the NTS for all possible sources, the maximally exposed individual (MEI) was calculated to be at Springdale, Nevada, 58 km (36 mi) west-northwest of CP-1. The EDE to a hypothetical receptor at this location was calculated to be 0.17 mrem/yr (1.7 x 10^{-3} mSv/yr), which is 0.17 percent of the 10 mrem/yr limit required by NESHAPs (CFR 1989). If the receptor at Springdale was the hunter harvesting and ingesting the doves mentioned in the previous section, the person would have received an additional 0.16 mrem/yr for a total EDE of 0.33 mrem/yr, which is 0.33 percent of the dose limit (DOE 1990b) to the general public.

This calculated dose at Springdale is conservative when compared to the EDE calculated from the average concentrations of $^{239+240}$Pu and ^{241}Am (shown in Tables 5.4 and 5.5, respectively) measured at Beatty, which is about eight miles south of Springdale. The EDE calculated from the Beatty air sampling results was 0.0076 mrem/yr. The Springdale dose is also small compared to the gamma radiation background (152 mR/yr, Table 5.21) measured with a pressurized ion chamber at Beatty by the offsite Community Environmental Monitoring Program (section 5.6).

Onsite Biota Doses

The interim DOE Technical Standard, "A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota" (DOE 2000a) has been applied to the NTS to determine whether DOE sponsored activities are meeting the dose limits to aquatic and terrestrial biota recommended by the DOE Biota Dose Assessment Committee (BDAC). This technical standard was derived to assist all DOE activities in complying with the dose limit to aquatic organisms specified by Order DOE 5400.5, "Radiation Protection of the Public and the Environment" and the internationally-recommended dose limits for terrestrial biota. The application of this technical standard will demonstrate whether:

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

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

In 1999, the screening phase was completed for terrestrial biota on the NTS (DOE 2000) showing that the location with the highest radionuclide concentrations, Area 10, had a ratio of only 0.325, based primarily upon the soil concentrations of ^{90}Sr and ^{137}Cs. Since this ratio was less than one, the dose to terrestrial biota is less than 1 rad/day (10mGy/day). This evaluation was based upon past surveys of NTS surface contamination by in situ gamma spectroscopy measurements and soil sampling and analysis (DOE 1991d).

No natural rivers or streams exist on the NTS, but there is a set of tunnel drainage ponds at the Area 12 E Tunnel that have existed for many years and may support some aquatic organisms. The screening phase to evaluate the dose to aquatic biota there was postponed in 1999 until the radionuclide content of the E Tunnel ponds could be characterized. Sediment sampling of the ponds was delayed until December and due to cold temperatures, the ponds were frozen, making sediment sampling impossible. Therefore, the screening phase was conducted using the maximum radionuclide concentrations of the E Tunnel pond water given in Table 5.11 for ^{3}H, ^{90}Sr, ^{137}Cs, ^{238}Pu, $^{239+240}Pu$, and ^{241}Am and using the default concentration values for sediment estimated by the RAD-BCG Calculator for the inputted radionuclide concentrations in the pond water.

The results of the screening phase showed that the sum of the concentration ratios was 6.1, indicating that a more detailed analysis is required to assure that the dose to aquatic and terrestrial biota is less than limits prescribed above. The concentration of ^{137}Cs was the major contributor to the concentration to BCG ratio that caused the ratio of one to be exceeded.

Since the ponds are man-made, the existence of aquatic animals is unlikely. However, there are birds and other animals that find access to the fenced ponds to drink the water. Plants also grow around the ponds. The dove that was trapped in 2000 had concentrations of ^{3}H, ^{238}Pu, and $^{239+240}Pu$ in its breast tissue that were above the MDCs of the measurement (see Table 5.13 and Section 5.4). Plants around the ponds were also found to have detectable concentrations of ^{3}H, ^{137}Cs and ^{90}Sr. From the measured concentrations in the biota tissue (dove and vegetation) and the internal dose conversion factors recommended by the BDAC, the internal dose to the biota was estimated. Table 5.15, which summarizes the results, shows that the doses to the dove and vegetation were, respectively, 0.065 mrad/day (6.5×10^{-5} mGy/day) and 0.045 mrad/day (4.5×10^{-5} mGy/day), which are below the dose limits specified by the technical dose standards for biota.

5.6 COMMUNITY ENVIRONMENTAL MONITORING PROGRAM

The CEMP provides communities surrounding the NTS with radiological and weather data, and is operated by the DRI of the University and Community College System of Nevada. During calendar year 2000, there were 20 CEMP stations managed by DRI (Figure 5.19). An additional four stations (Stone Cabin, Twin Springs, Nyala, and Garden Valley) were administered by EPA, but are expected to come under the purview of the CEMP in the latter portion of 2001.

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

DRI has upgraded stations to enhance their technical capability as well as improve their service to the public. The stations (Figure 5.20) are now equipped with a full suite of meteorological equipment to measure air temperature, humidity, wind speed and direction, incident solar radiation, barometric pressure, and precipitation.

DATA COLLECTION AND DISSEMINATION

All data collected by electronic sensors at the CEMP stations are stored in a datalogger. Current data readings are displayed on-site and are updated every six seconds. Data are transmitted by telephone landline, cellular phone, or GOES satellite when the preceding options are not

Figure 5.19 CEMP, MET, PIC and Air Sampling Sites on or near the Nevada Test Site - 2000

Figure 5.20 The CEMP Station at Beatty, Nevada

feasible. Data storage is designed to allow for 20 days of storage on the datalogger in the event of communication loss. Collected data are transmitted once every three hours to the Western Regional Climate Center (WRCC). The data from the stations are posted on a publicly accessible WRCC web site at http://www.wrcc.dri.edu/cemp.

COMMUNITY ENVIRONMENTAL MONITORS (CEMs)

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

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

CEMP AIR SURVEILLANCE NETWORK (ASN)

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

During calendar year 2000, the CEMP ASN consisted of 19 continuously operating low-volume air sampling locations. Three additional locations at ranch sites were administered by EPA, but these are expected to come under the purview of the CEMP beginning in September 2001. Duplicate air samples are collected from two routine ASN stations each week. The duplicate samplers are operated at randomly selected stations for three months and moved to new locations.

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

CEMP THERMOLUMINESCENT DOSIMETRY (TLD) NETWORK

External dosimetry is another of the essential components of environmental radiological assessments. This is used to determine both individual and population exposure to ambient radiation from natural or artificial sources. In calendar year 2000, the TLD program consisted of 20 fixed environmental monitoring stations. The primary purpose of the CEMP offsite environmental dosimetry program is to establish dose estimates to populations living in the areas surrounding the NTS. For quality assurance purposes, duplicate TLDs are deployed at two randomly selected environmental stations. An average daily exposure rate was calculated for each quarterly environmental exposure period, and the average of the four values was multiplied by 365.25 to obtain the total annual exposure for each station.

CEMP PRESSURIZED ION CHAMBER (PIC) NETWORK

The PIC measures gamma radiation exposure rates, and because of its sensitivity may detect low-level exposures that go undetected by other monitoring methods. PICs are in place at all 20 stations in the CEMP network. The primary function of the PIC network is to detect changes in ambient gamma radiation due to human activities. In the absence of such activities, ambient gamma radiation rates differ naturally among locations, as they may change with altitude (cosmic radiation), radioactivity in the soil (terrestrial radiation), and may vary slightly within a location due to weather patterns. Since the addition of a full suite of meteorological instrumentation at the CEMP stations, variations in PIC readings caused by weather events such as precipitation or changes in barometric pressure have become much more readily apparent. These variations can be easily viewed by selecting the Time Series link from the CEMP home page http://www.wrcc.dri.edu/cemp after selecting a desired station, and then selecting the desired variables.

ANALYTICAL RESULTS

Procedures and Quality Assurance

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

Standard Operating Procedures

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

Field Quality Assurance Samples

The collection of duplicate samples in the field is an important part of quality assurance procedures. Two duplicate air samplers for the CEMP program are kept in the field at all times, and are rotated among 18 stations on a quarterly basis. This results in the collection of up to 13 duplicate air filter samples for each station. The results of these sample analyses are used to measure the repeatability of the collection and analytical technique. A summary of the results is shown in Table 5.17. The average %RSD (Relative Standard Deviation) is a measure of the precision of the analysis. This is calculated by dividing the standard deviation of the duplicate pair by the analytical mean then multiplying by 100 to obtain a percent.

Overall, the %RSD for all duplicate analyses falls well within data quality objectives, only slightly higher than the %RSD for the laboratory duplicate results. Gross alpha results from the field duplicates individually show the most variation with about 10 percent of the duplicates exceeding or showing borderline results in terms of data quality objectives. Given the fact that equipment and field conditions are by far the most variable parameters in air sample collection, these results are acceptable. The %RSD for all gross beta and gamma spectroscopy analyses falls within data quality objectives.

Laboratory Quality Assurance Samples

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

AIR SAMPLING RESULTS

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

Gross Alpha

Gross alpha analysis was performed on all low-volume network samples. The annual average gross alpha activity was $2.7 \pm 1.3 \times 10^{-15}$ Ci/mL (101 ± 48 Bq/m^3). A summary of the results is shown in Table 5.18. As in previous years, the results exceeded the analytical MDC and overall showed similar values.

Gross Beta

Gross beta analysis was also performed on all low-volume network samples. As in previous years, these results also exceeded the analytical MDC. The annual average gross beta activity was $2.4 \pm 0.8 \times 10^{-14}$ Ci/mL ($9.0 \pm 3.0 \times 10^{-4}$ Bq/m^3). A summary of the results is shown in Table 5.19. The results overall showed similar values to previous years' data.

Gamma Spectroscopy

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

TLD RESULTS

There were 20 offsite environmental stations monitored with TLDs in 2000. The total exposure for 2000 ranged from 45 mR (0.45 mSv) per year at Pahrump, Nevada, to 112 mR (1.12mSv) at Milford, Utah, with a mean annual exposure of 79 mR (0.79 mSv) per year for all operating locations. All results are shown in Table 5.20 and are consistent with recent years' results.

PRESSURIZED ION CHAMBER (PIC) RESULTS

The PIC data presented in this section are based on daily averages of gamma exposure rates from each station. Table 5.21 contains the maximum, minimum, and standard deviation of daily averages for the periods during 2000 when telemetry data were available. It also shows the average gamma exposure rate for each station during the year, as well as the total mR/yr. The mean ranged from 68 to 152 R/yr. Background levels of environmental gamma exposure rates in the United States (from the combined effects of terrestrial and cosmic sources) vary between 49 and 247 mR/yr (BEIR III 1980). Averages for selected regions of the United States have been compiled by the U.S. Environmental Protection Agency (EPA), and are shown in Table 5.22. The annual exposure levels observed at the CEMP stations are well within these United States background levels.

Table 5.1 Descriptive Statistics for Gross Alpha in Air (x 10^{-15} μCi/L) - 2000

Area	Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	%> MDC
1	BJY	52	5.812	4.561	3.48	1.108	15.255	85.6
2	2-1 Substation	51	5.578	4.598	3.53	0.061	13.730	75.5
3	Bunker 3-300	52	5.919	4.742	3.53	0.879	15.948	86.5
3	U-3ah/at N	51	5.926	5.441	2.99	0.757	15.073	93.1
3	U-3ah/at S	51	6.223	4.915	3.65	0.884	15.336	89.2
3	U-3bh N	51	5.904	5.145	3.07	0.378	12.526	90.2
3	U-3bh South	35	7.306	6.307	3.75	2.152	14.746	85.7
3	Well Er 3-1	52	5.804	4.384	3.79	0.744	15.176	82.7
4	Bunker T-4	50	5.818	4.870	3.35	0.880	15.027	93.0
5	DOD	52	5.586	4.544	3.54	1.241	15.832	89.4
5	RWMS TRU Building	34	5.229	4.827	2.18	1.991	10.764	91.2
5	RWMS 4 Northeast	52	6.114	4.983	3.81	1.519	16.380	88.5
5	RWMS 7 West	52	6.485	5.959	3.08	1.260	15.475	94.2
5	WEF Northeast	52	5.757	4.905	3.52	0.502	16.743	83.6
5	WEF Southwest	52	5.942	5.050	3.24	1.372	16.734	94.2
6	Yucca	52	6.497	5.695	3.69	1.247	16.637	90.4
7	UE7nS	52	5.518	4.491	3.48	0.572	15.990	83.6
9	Bunker 9-300	52	9.217	6.071	15.76	1.184	116.958	87.5
10	SEDAN North	51	6.186	5.493	3.54	1.146	15.243	92.2
15	EPA Farm	52	5.471	4.843	3.16	0.748	14.687	79.8
18	LITTLE FELLER 2 N	34	7.002	6.337	3.48	2.550	17.389	97.1
20	CABRIOLET	52	5.394	4.477	3.20	1.119	14.387	81.7
20	SCHOONER	51	5.775	4.705	3.60	1.140	17.707	87.2
25	E-MAD N	52	5.947	4.849	3.68	0.962	15.458	81.7
All Onsite Locations		**1187**	**6.084**	**5.059**	**4.73**	**0.061**	**116.958**	**87.5**
NAFR Locations								
13	Project 57	15	3.296	3.136	1.42	1.481	6.513	73.3
52	CLEAN SLATE II	13	3.839	3.546	1.66	1.581	7.391	76.9
52	CLEAN SLATE III	13	4.012	3.231	1.97	1.313	8.678	61.5
All Near Offsite Locations		**41**	**3.695**	**3.379**	**1.67**	**1.313**	**8.678**	**70.7**
All Measurements		**1228**	**6.004**	**4.970**	**4.68**	**0.061**	**116.958**	**86.9**

Table 5.2 Descriptive Statistics for Gross Beta in Air (x 10^{-14} µCi/L) - 2000

Area	Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	%> MDC
1	BJY	52	2.185	2.012	0.846	0.808	5.075	100.0
2	2-1 Substation	51	2.160	1.892	0.961	0.710	5.487	100.0
3	Bunker 3-300	52	2.229	2.061	0.859	0.943	4.642	100.0
3	U-3ah/at N	51	2.048	1.855	0.766	0.938	4.117	100.0
3	U-3ah/at S	51	2.203	2.006	0.884	0.811	5.049	100.0
3	U-3bh N	51	2.320	1.999	1.243	0.970	8.979	100.0
3	U-3bh South	35	2.340	2.201	0.853	0.891	4.649	100.0
3	Well ER 3-1	52	2.202	1.927	0.890	0.763	4.268	100.0
4	Bunker T-4	50	2.136	1.892	0.856	0.794	4.765	100.0
5	DOD	52	2.185	2.042	0.874	0.868	4.531	100.0
5	RWMS TRU Building	34	2.174	2.058	0.754	1.052	4.864	100.0
5	RWMS 4 Northeast	52	2.239	1.991	0.930	0.809	4.450	100.0
5	RWMS 7 West	52	2.292	2.042	0.903	0.940	4.570	100.0
5	WEF Northeast	52	2.142	1.943	0.871	0.778	4.484	100.0
5	WEF Southwest	52	2.176	1.998	0.865	0.815	4.709	100.0
6	Yucca	52	2.382	2.154	0.914	0.876	4.697	100.0
7	UE7nS	52	2.110	2.037	0.797	0.854	4.013	100.0
9	Bunker 9-300	52	2.272	2.251	0.913	0.841	5.673	100.0
10	SEDAN North	51	2.295	2.161	0.916	0.776	5.769	100.0
15	EPA Farm	52	2.076	1.943	0.780	0.893	4.705	100.0
18	LITTLE FELLER 2 N	34	2.343	2.246	1.083	0.884	7.022	100.0
20	CABRIOLET	52	1.979	1.843	0.762	0.859	4.008	100.0
20	SCHOONER	51	2.141	2.021	0.879	0.606	4.257	100.0
25	E-MAD N	52	2.237	2.150	0.948	0.628	4.794	100.0
All Onsite Locations		**1187**	**2.199**	**2.005**	**0.891**	**0.606**	**8.979**	**100.0**
	NAFR Locations							
13	Project 57	15	1.363	1.192	0.668	0.574	3.171	100.0
52	CLEAN SLATE II	13	1.483	1.391	0.571	0.537	2.570	100.0
52	CLEAN SLATE III	13	1.772	1.635	0.609	0.807	3.037	100.0
All Near Offsite Locations		**41**	**1.531**	**1.391**	**0.629**	**0.537**	**3.171**	**100.0**
All Measurements		**1228**	**2.177**	**1.982**	**0.891**	**0.537**	**8.979**	**100.0**

Table 5.3 Descriptive Statistics for ^{238}Pu in Air (x 10^{-18} µCi/mL) - 2000

Area	Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	%> MDC
1	BJY	12	3.012	1.520	3.349	0.000	9.890	33.3
2	2-1 Substation	12	1.718	1.130	2.969	-1.100	9.650	16.7
3	Bunker 3-300	12	3.247	1.265	4.690	0.000	13.450	16.7
3	U-3ah/at North	12	2.393	1.120	3.261	-0.600	9.480	25.0
3	U-3ah/at South	12	1.759	0.245	3.129	-0.700	9.130	8.3
3	U-3bh North	12	1.357	0.000	3.453	-1.300	10.620	8.3
3	U-3bh South	9	1.882	1.330	2.750	-1.300	7.430	0.0
3	Well ER 3-1	12	0.990	0.365	2.010	-0.900	6.310	8.3
4	Bunker T-4	12	9.492	8.385	8.287	0.930	29.120	41.7
5	DOD	12	1.734	1.902	3.216	-5.600	7.035	16.7
5	RWMS TRU Building	7	0.921	0.740	2.027	-0.600	5.180	0.0
5	RWMS 4 Northeast	12	1.157	0.000	2.503	-1.300	6.480	8.3
5	RWMS 7 West	12	1.222	0.900	2.128	-0.800	6.930	8.3
5	WEF Northeast	12	1.763	0.088	5.230	-0.600	18.160	8.3
5	WEF Southwest	12	1.327	0.585	2.794	-3.400	7.040	8.3
6	Yucca	12	2.308	0.915	3.319	-0.600	9.050	8.3
7	UE7nS	12	1.191	0.102	1.890	-0.700	5.410	8.3
9	Bunker 9-300	12	8.529	4.018	12.813	0.840	46.690	29.2
10	SEDAN North	12	5.264	5.305	4.334	-1.000	12.660	50.0
15	EPA Farm	12	1.428	0.690	2.155	-1.100	5.640	8.3
18	LITTLE FELLER 2 North	8	2.478	2.015	2.431	0.000	6.620	12.5
20	CABRIOLET	12	1.513	1.420	1.734	-0.700	5.340	5.6
20	SCHOONER	12	2.577	2.080	2.299	0.000	5.980	25.0
25	E-MAD North	11	2.018	0.680	3.748	-0.700	10.890	4.5
All Onsite Locations		**275**	**2.593**	**1.060**	**4.734**	**-5.600**	**46.690**	**15.5**
	NAFR Locations							
13	PROJECT 57	3	-1.110	-0.500	3.228	-4.600	1.770	0.0
52	CLEAN SLATE II	3	0.000	0.000	0.900	-0.900	0.900	0.0
52	CLEAN SLATE III	3	0.060	0.000	0.692	-0.600	0.780	0.0
All Near Offsite Locations		9	-0.350	0.000	1.804	-4.600	1.770	0.0
	Offsite Locations							
95	Alamo	9	0.942	0.220	1.676	0.000	5.030	22.2
95	Amargosa Valley	9	0.554	0.000	0.837	0.000	2.250	11.1
95	Beatty	9	0.630	0.070	0.934	-0.100	2.380	22.2
95	Goldfield	9	0.820	0.090	1.286	0.000	3.650	22.2
95	Indian Springs	9	0.137	0.000	0.229	-0.100	0.590	11.1
95	Rachel	9	1.239	1.050	1.360	-0.100	4.040	33.3
All Offsite Locations		**54**	**0.720**	**0.105**	**1.148**	**-0.100**	**5.030**	**20.4**

Table 5.4 Descriptive Statistics for $^{239+240}$Pu in Air (x 10^{-18} µCi/mL) - 2000

Area	Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	%> MDC
1	BJY	12	30.49	26.84	26.16	3.70	84.81	66.7
2	2-1 Substation	12	12.39	6.26	13.64	-0.40	43.32	58.3
3	Bunker 3-300	12	126.77	75.65	193.52	8.31	718.00	100.0
3	U-3ah/at North	12	69.53	63.66	42.90	17.80	154.52	100.0
3	U-3ah/at South	12	85.19	64.05	92.13	8.23	337.71	100.0
3	U-3BH North	12	21.12	16.98	19.89	2.01	66.78	66.7
3	U-3BH South	9	38.74	25.56	45.77	1.00	143.42	77.8
3	Well ER 3-1	12	26.38	5.72	74.58	0.00	262.91	50.0
4	Bunker T-4	12	33.49	27.83	27.99	3.74	102.81	91.7
5	DOD	12	5.30	2.35	10.36	-5.60	33.22	29.2
5	RWMS TRU Building	7	13.46	3.76	18.31	0.00	46.61	57.1
5	RWMS 4 Northeast	12	3.07	2.28	3.64	-0.90	10.40	16.7
5	RWMS 7 West	12	2.40	1.96	2.30	-1.10	6.68	16.7
5	WEF Northeast	12	2.70	1.10	4.67	-1.65	14.72	8.3
5	WEF Southwest	12	2.19	1.74	3.52	-3.40	11.34	16.7
6	Yucca	12	58.51	6.37	123.88	0.00	411.78	50.0
7	UE7nS	12	10.58	5.00	11.80	0.00	34.15	45.8
9	Bunker 9-300	12	432.16	175.33	783.18	2.06	2825.30	91.7
10	SEDAN North	12	41.77	15.61	43.32	0.49	108.59	75.0
15	EPA Farm	12	37.76	7.17	72.71	-0.70	258.30	58.3
18	LITTLE FELLER 2 North	8	4.85	3.99	3.59	1.06	10.21	25.0
20	CABRIOLET	12	2.24	1.57	2.51	-0.85	7.44	0.0
20	SCHOONER	12	2.03	2.10	2.19	-0.90	5.70	16.7
25	E-MAD North	11	3.65	2.58	3.53	0.00	11.48	31.8
All Onsite Locations		**275**	**45.80**	**6.31**	**188.78**	**-5.60**	**2825.30**	**52.2**
Near Offsite Locations								
13	PROJECT 57	3	57.89	74.90	51.06	0.50	98.27	66.7
52	CLEAN SLATE II	3	34.91	25.04	30.70	10.35	69.33	100.0
52	CLEAN SLATE III	3	0.74	0.78	0.73	0.00	1.45	0.0
All Near Offsite Locations		**9**	**31.18**	**10.35**	**38.83**	**0.00**	**98.27**	**55.6**
Offsite Locations								
95	Alamo	9	7.49	1.36	16.39	0.32	50.94	77.8
95	Amargosa Valley	9	24.78	1.05	70.66	0.00	213.17	77.8
95	Beatty	9	2.00	1.77	1.27	0.00	4.13	77.8
95	Goldfield	9	1.05	0.95	0.69	0.25	2.09	55.6
95	Indian Springs	9	2.82	0.98	4.14	0.16	11.96	66.7
95	Rachel	9	9.90	7.76	8.60	0.96	25.27	77.8
All Offsite Locations		**54**	**8.01**	**1.50**	**29.59**	**0.00**	**213.17**	**72.2**

Table 5.5 Descriptive Statistics for ^{241}Am in Air (x 10^{-18} µCi/mL) - 2000

Area	Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	%> MDC
1	BJY	10	11.375	4.892	13.706	-3.600	38.040	45.0
2	2-1 Substation	10	9.775	3.660	15.444	-0.600	49.210	40.0
3	Bunker 3-300	10	23.827	19.535	22.750	1.840	85.510	90.0
3	U-3ah/at North	10	12.863	11.815	7.428	1.930	24.250	65.0
3	U-3ah/at South	10	19.049	12.510	18.877	0.000	59.970	80.0
3	U-3bh North	10	6.068	5.730	7.373	-1.400	23.540	30.0
3	U-3bh South	8	10.320	12.000	7.333	-1.900	17.960	62.5
3	Well ER 3-1	10	14.268	5.355	25.013	-0.700	81.300	50.0
4	Bunker T-4	10	11.519	13.310	7.498	0.650	24.550	60.0
5	DOD	10	8.122	2.535	12.113	-1.800	32.150	35.0
5	RWMS TRU Building	5	2.824	3.260	4.137	-3.500	8.090	0.0
5	RWMS 4 Northeast	10	6.599	2.270	10.373	-3.200	31.680	30.0
5	RWMS 7 West	10	2.577	0.955	6.817	-2.800	20.950	20.0
5	WEF Northeast	10	4.727	2.100	8.565	-3.000	27.393	25.0
5	WEF Southwest	10	8.326	1.415	19.786	0.000	64.080	20.0
6	Yucca	10	15.037	6.710	16.529	-0.600	42.630	40.0
7	UE7nS	10	5.606	2.870	7.979	0.000	26.170	10.0
9	Bunker 9-300	10	97.506	45.105	155.926	8.470	528.280	100.0
10	SEDAN North	10	13.536	12.270	9.129	0.000	30.250	70.0
15	EPA Farm	10	7.244	4.655	11.157	0.000	37.930	20.0
18	LITTLE FELLER 2 North	7	3.066	0.320	6.486	-5.400	10.920	42.9
20	CABRIOLET	10	6.877	1.725	15.294	-10.900	36.753	20.0
20	SCHOONER	10	7.118	3.115	10.724	-3.600	29.670	40.0
25	E-MAD North	10	15.886	1.340	31.966	-3.100	93.380	20.0
All Onsite Locations		**230**	**13.90**	**4.85**	**38.62**	**-10.90**	**528.28**	**43.0**
	Offsite Locations							
95	Alamo	5	0.206	0.210	0.347	-0.300	0.620	0.0
95	Amargosa Valley	7	2.121	0.220	4.903	-0.100	13.210	28.6
95	Beatty	6	0.467	0.260	0.444	0.000	1.060	33.3
95	Goldfield	6	0.163	0.000	0.499	-0.300	1.110	0.0
95	Indian Springs	7	0.239	0.000	0.358	-0.100	0.770	14.3
95	Rachel	6	0.565	0.070	1.640	-0.600	3.820	16.7
All Offsite Locations		**37**	**0.67**	**0.22**	**2.24**	**-0.60**	**13.21**	**16.2**

Table 5.6 Descriptive Statistics for ^{137}Cs in Air (x 10^{-16} µCi/mL) - 2000

Area	Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	%> MDC
1	BJY	9	-0.103	0.000	1.528	-3.178	2.079	0.0
2	2-1 Substation	9	0.321	0.000	1.704	-2.723	2.915	0.0
3	Bunker 3-300	9	0.890	0.238	1.283	-0.664	3.297	0.0
3	U-3ah/at North	9	0.029	0.000	1.412	-1.893	2.209	0.0
3	U-3ah/at South	9	1.821	0.735	3.274	-0.728	9.753	0.0
3	U-3bh North	9	1.009	0.000	1.536	-0.235	4.402	11.1
3	U-3bh South	8	0.681	0.314	1.475	-1.313	2.917	0.0
3	Well ER 3-1	9	-0.576	0.000	1.314	-3.001	1.521	0.0
4	Bunker T-4	9	0.320	0.000	1.070	-0.995	2.937	0.0
5	DOD	9	1.102	0.468	1.953	-0.851	5.237	0.0
5	RWMS TRU Building	5	2.404	0.000	5.757	-0.669	12.690	20.0
5	RWMS 4 Northeast	10	1.020	0.000	2.805	-0.955	8.659	0.0
5	RWMS 7 West	9	-0.410	0.000	0.770	-1.723	0.762	0.0
5	WEF Northeast	9	1.109	0.146	2.213	-0.394	6.726	11.1
5	WEF Southwest	9	-0.013	0.000	0.790	-1.385	1.050	0.0
6	Yucca	9	0.460	0.000	1.478	-1.148	4.021	0.0
7	UE7nS	9	-0.120	0.000	1.392	-2.520	1.771	0.0
9	Bunker 9-300	10	0.926	0.000	4.055	-3.058	11.684	10.0
10	SEDAN North	9	0.910	0.000	2.266	-2.348	4.466	0.0
15	EPA Farm	9	0.678	0.078	1.872	-2.163	4.875	0.0
18	LITTLE FELLER 2 North	7	-0.251	0.000	1.533	-3.256	1.502	0.0
20	CABRIOLET	9	0.258	0.000	0.941	-0.411	2.688	0.0
20	SCHOONER	9	0.523	0.064	0.721	-0.351	1.616	0.0
25	E-MAD North	9	0.806	0.000	1.871	-1.145	3.943	0.0
All Onsite Locations		**211**	**0.551**	**0.000**	**2.053**	**-3.256**	**12.690**	**1.9**
	Offsite Locations							
95	Alamo	22	0.908	0.542	1.137	-0.496	3.261	9.1
95	Amargosa Valley	22	0.766	0.034	1.499	-0.614	5.887	2.3
95	Beatty	22	0.578	0.022	1.343	-0.250	6.053	6.8
95	Goldfield	23	0.588	0.094	1.095	-0.915	3.710	8.7
95	Indian Springs	20	0.914	0.000	2.083	-0.110	8.549	12.5
95	Rachel	22	0.910	0.250	1.486	-0.736	4.179	20.5
All Offsite Locations		**131**	**0.774**	**0.067**	**1.442**	**-0.915**	**8.549**	**9.9**

Table 5.7 Descriptive Statistics for Radionuclides Detected in Air Samples by Gamma Spectroscopy (x 10^{-13} µCi/mL) - 2000

Radionuclide	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	%> MDC
Onsite							
^{7}Be	275	1.451	1.416	0.438	0.010	2.338	99.6
^{40}K	114	0.1515	0.1590	0.0437	0.0665	0.3812	83.8
^{238}U	141	0.1073	0.0804	0.1014	0.00	0.5492	0.60
NAFR							
^{7}Be	9	1.471	1.322	0.376	1.034	2.023	100.0
^{40}K	7	0.1263	0.1215	0.0579	0.0691	0.2423	71.4
Offsite							
^{7}Be	234	1.515	1.349	2.719	0.144	42.395	100.0
^{40}K	146	0.0457	0.0428	0.0178	0.0196	0.1318	67.1
^{238}U	90	0.0733	0.0023	0.1447	0.00	0.6396	0.89
All Locations							
^{7}Be	518	1.480	1.368	1.854	0.010	42.395	99.8
^{40}K	267	0.0930	0.0676	0.0615	0.0196	0.3812	74.3
^{238}U	231	0.0940	0.0490	0.1210	0.00	0.6396	0.71

Table 5.8 Descriptive Statistics for Airborne Tritium Concentrations - 2000

^{3}H Concentration (x 10^{-6} pCi/mL)								
Area	**Location**	**Number of Sample**	**Mean**	**Median**	**Standard Deviation**	**Minimum**	**Maximum**	**%> MDC**
Onsite Locations								
1	BJY	25	1.02	0.68	1.35	-1.12	4.12	16.0
5	RWMS 4 Northeast	25	4.38	3.19	3.98	0.21	13.46	62.0
5	RWMS 7 West	24	2.37	0.87	3.87	-1.26	15.57	35.4
5	RWMS 9 South	24	1.21	0.81	2.01	-1.30	9.70	27.1
5	WEF Northeast	23	2.08	0.30	7.92	-1.72	38.10	8.7
5	Well 5B	24	-0.20	-0.02	1.08	-2.63	1.39	0.0
10	SEDAN North	25	18.18	12.23	16.17	1.30	51.41	88.0
12	E Tunnel Pond No. 2	22	12.95	11.79	10.54	0.58	30.42	86.4
15	EPA Farm	25	5.90	5.55	3.81	1.33	18.66	92.0
20	SCHOONER	26	325.48	149.57	331.11	18.45	972.99	100.0
All Onsite Locations		**243**	**42.21**	**1.66**	**152.56**	**-2.63**	**972.99**	**48.6**
Offsite Locations								
95	Amargosa Valley	19	0.06	0.06	0.93	-1.66	2.60	5.3
95	Indian Springs	18	0.60	-0.36	3.16	-1.95	9.75	11.1
All Offsite Locations		**37**	**0.32**	**0.05**	**2.28**	**-1.95**	**9.75**	**8.1**

Table 5.9 Descriptive Statistics for TLD Annual Exposures, (mR/yr) - 2000

Area	Location	Sample Type	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum
1	BJY	(a)	4	109	110	11	96	119
1	Bunker 1-300	(a)	4	131	130	5	127	139
1	Sandbag Storage Hut	(a)	4	120	119	3	118	124
1	Stake C-2	(a)	4	129	128	11	118	144
2	Stake L-9	(a)	4	192	187	12	183	209
2	Stake M-140	(a)	4	141	140	9	132	152
2	Stake N-8	(a)	4	748	745	43	704	798
2	Stake TH-58	(a)	4	101	101	4	97	104
3	A3 RWMS Center	(d)	4	173	174	12	158	187
3	LANL Trailers	(a)	4	122	121	7	116	131
3	RWMS East	(d)	4	156	156	5	150	161
3	RWMS North	(d)	4	131	129	9	121	143
3	RWMS South	(d)	3	481	465	34	458	519
3	RWMS West	(d)	4	132	132	9	121	142
3	Stake A-6.5	(a)	4	156	157	10	142	168
3	Stake OB-11.5	(a)	4	136	134	6	132	146
3	Stake OB-20	(a)	4	93	92	5	87	98
3	U-3Co North	(a)	4	235	232	22	214	264
3	U-3Co South	(a)	4	171	167	12	162	187
3	Well ER 3-1	(a)	4	134	135	8	123	140
4	Stake A-9	(a)	4	895	893	47	840	953
4	Stake TH-41	(a)	4	117	115	5	113	124
4	Stake TH-48	(a)	4	127	124	5	123	134
5	3.3 Miles SE of Aggregate Pit	(b)	4	67	66	4	62	72
5	Building 5-31	(a)	4	121	121	7	111	129
5	RWMS East Gate	(d)	4	160	162	9	148	168
5	RWMS Northeast Corner	(d)	4	124	123	7	117	134
5	RWMS Northwest Corner	(d)	4	137	137	7	128	144
5	RWMS South Gate	(d)	4	121	119	9	112	133
5	RWMS Southwest Corner	(d)	4	128	127	7	121	138
5	Water Well 5b	(c)	4	120	118	8	114	131
5	WEF East	(d)	4	130	129	6	125	138
5	WEF North	(d)	4	126	126	5	120	132
5	WEF South	(d)	4	132	131	6	127	141
5	WEF West	(d)	4	145	146	12	131	157
6	CP-6	(c)	4	77	77	2	74	79
6	DAF East	(a)	4	98	97	5	93	104
6	DAF West	(a)	4	93	91	6	86	101

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

Table 5.9 (Descriptive Statistics for TLD Annual Exposures, [mR/yr] - 2000, cont.)

Area Location	Sample Type	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum
6 Decon Facility Northwest	(a)	4	134	128	16	121	157
6 Decon Facility Southeast	(a)	4	136	136	4	131	141
6 Yucca Oil /Storage	(a)	4	104	105	3	101	107
7 Bunker 7-300	(a)	4	286	288	11	271	296
7 Reitmann Seep	(a)	4	133	133	6	127	138
7 Stake H-8	(a)	4	135	137	7	126	141
8 Road 8-02	(a)	4	135	134	7	128	144
8 Stake K-25	(a)	4	110	109	4	106	115
8 Stake M-152	(a)	4	178	177	9	170	189
9 Bunker 9-300	(a)	4	129	129	5	124	136
9 Papoose Lake Road	(c)	4	84	83	4	81	89
9 U-9CW South	(a)	4	107	104	6	104	117
9 V & G Road Junction	(a)	4	125	125	7	117	133
10 Circle & L Roads	(a)	4	124	123	6	118	132
10 Gate 700 South	(c)	4	137	134	8	132	149
10 SEDAN East Visitor Box	(a)	4	142	141	8	134	153
10 SEDAN West	(a)	4	295	293	15	281	313
11 Stake A-21	(a)	4	136	135	5	132	144
12 Gold Meadows Spring	(b)	1	159	159	.	159	159
12 T-Tunnel No.2 Pond	(a)	4	258	258	19	241	274
12 Upper Haines Lake	(a)	4	123	124	7	114	131
12 Upper N. Pond	(a)	4	135	134	4	131	140
15 EPA Farm	(a)	4	117	114	7	113	127
15 U-15E Substation	(b)	4	100	99	5	96	107
18 Stake A-83	(a)	4	148	148	7	140	158
18 Stake F-11	(a)	4	150	149	9	140	161
19 Gate 19-3P	(b)	2	105	105	105	31	179
19 Stake C-27	(b)	3	163	168	19	142	180
19 Stake P-41	(a)	4	169	167	9	161	180
19 Stake P-77	(a)	3	173	177	21	151	192
19 Stake R-26	(b)	3	169	167	14	156	184
20 Stake A-118	(b)	4	158	155	10	149	170
20 Stake J-31	(a)	4	193	190	14	179	211
20 Stake J-41	(a)	4	145	145	8	138	154
20 Stake LC-4	(b)	3	175	172	15	162	192
22 Army #1 Water Well	(b)	4	86	85	4	84	92

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

Table 5.9 (Descriptive Statistics for TLD Annual Exposures, [mR/yr] - 2000, cont.)

Area	Location	Sample Type	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum
23	Building 650 Dosimetry	(c)	4	64	65	3	61	67
23	Building 650 Roof	(c)	4	58	58	2	57	61
23	Mercury Fitness Track	(a)	3	75	85	20	51	87
23	Post Office	(c)	4	84	77	16	74	107
25	Gate 25-4-P	(b)	4	141	139	7	136	151
25	Guard Station 510	(b)	4	136	134	7	130	145
25	HENRE	(c)	4	133	130	7	129	143
25	Jackass Flats & A-27	(b)	4	87	86	5	82	94
25	NRDS Warehouse	(c)	4	133	130	9	127	146
25	Yucca Mountain	(b)	4	145	143	7	141	155
27	Cafeteria	(c)	4	145	141	10	137	158
30	Junction Cat Can Buggy Rd	(b)	4	188	186	12	176	205
	Summary by Sample Type							
	Environmental	(a)	190	173	133	145	51	953
	Background	(b)	48	132	141	42	31	205
	Historical	(c)	40	104	110	33	57	159
	Waste Operations	(d)	51	159	134	83	112	519
	All Locations		**346**	**151**	**132**	**118**	**27**	**953**

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

Table 5.10 Listing of Atypical TLD Data Values - 2000

Area	Location	Location Mean	Mean for Other Locations in Area
4	Stake A-9 [a]	895	122
2	Stake N-8 [a]	748	144
3	RWMS South [d]	481	139
10	SEDAN West [a]	295	134
7	Bunker 7-300 [a]	286	134
12	T-Tunnel No. 2 Pond [a]	258	132
3	U-3Co North [a]	235	139

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

Table 5.11 Descriptive Statistics for Radioactivity in E Tunnel Effluent and Ponds ($x\ 10^{-9}$ µCi/mL) - 2000

Radionuclide	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	%> MDC
Gross Beta	12	67.38	67.85	4.89	56.00	73.70	100
^{3}H	16	850000.00	881000.00	79345.00	714000.00	943000.00	100
^{90}Sr	4	0.96	0.76	0.46	0.66	1.65	50
^{137}Cs	16	170.00	195.00	195.00	57.40	258.00	100
^{238}Pu	16	0.35	0.34	0.22	0.07	1.02	100
$^{239+240}Pu$	16	2.80	2.66	1.66	0.57	7.55	100
^{241}Am	4	0.29	0.29	0.05	0.24	0.35	100

Table 5.12 Descriptive Statistics for Gross Beta Radioactivity in Sewage Lagoons - 2000

Area	Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum	%> MDC
5	RWMS Sewage Pond	3	32.18	38.30	11.38	19.05	39.20	100.0
6	DAF Sewage Pond	3	27.97	24.90	14.05	15.70	43.30	100.0
6	LANL Sewage Pond	3	44.97	51.30	11.49	31.70	51.90	100.0
6	Yucca Sewage Pond	3	20.50	21.80	2.97	17.10	22.60	100.0
22	Sewage Pond	2	42.25	42.25	12.52	33.40	51.10	100.0
23	Sewage Pond	2	17.08	17.08	0.25	16.90	17.25	100.0
25	Central SP	1	9.34	9.34	-	9.34	9.34	100.0
25	Reactor Control SP	2	16.50	16.50	4.52	13.30	19.70	100.0
All Locations		**19**	**28.31**	**22.60**	**13.85**	**9.34**	**51.90**	**100.0**

Table 5.13 Radionuclide Activities in NTS Biota Samples - 2000

Location	Common Name	Scientific Name[(a)] Genus	Scientific Name[(a)] Species	$\%H_20$ (%)	Concentration x 10^{-9} µCi/mL Tritium[(b)]	^{40}K	^{137}Cs	^{90}Sr[(b)]
PLANT SAMPLES								
Sedan Crater								
100m west of crater	desert needlegrass	*Achnatherum*	*speciosa*	12.6	61,800 ± 1,850	3.16 ± 2.02	0.383 ± 0.157	0.377 ± 0.226c
100m west of crater	desert needlegrass	*Achnatherum*	*speciosa*	15.6	63,900 ± 1,660	2.58 ± 2.48(c)	0 ± 0.275(c)	0.424 ± 0.275(c)
100m west of crater	fourwing saltbush	*Atriplex*	*canescens*	25.6	306,000 ± 5760	48.2 ± 7.96	0.124 ± 0.212(c)	0.392 ± 0.332(c)
100m west of crater	fourwing saltbush	*Atriplex*	*canescens*	30.3	510,000 ± 9,320	59.9 ± 10.3	0.0723 ± 0.181(c)	0.0624 ± 0.279(c)
100m west of crater	rubber rabbitbrush	*Ericameria*	*nauseosa*	26.1	3,250,000 ± 57,300	19.1 ± 8.23	0.136 ± 0.239(c)	0.164 ± 0.13(c)
100m west of crater	rubber rabbitbrush	*Ericameria*	*nauseosa*	20.2	2,780,000 ± 49,100	17.2 ± 8.66	0.104 ± 0.263(c)	0.449 ± 0.22
100m west of crater	prickly russian thistle	*Salsola*	*kali*	44.7	325,000 ± 6,030	55.7 ± 11.8	0.04 ± 0.359(c)	4.55 ± 1.42
100m west of crater	prickly russian thistle	*Salsola*	*kali*	32.1	72,200 ± 1,580	72.8 ± 11.1	0.122 ± 0.156(c)	0.715 ± 0.402
Whiterock Spring								
50m south of spring	Louisiana sagewort	*Artemisia*	*ludoviciana*	52.4	3.5 ± 152(c)	15.6 ± 8.29	0.298 ± 0.377(c)	0.0266 ± 0.142(c)
50m south of spring	Louisiana sagewort	*Artemisia*	*ludoviciana*	39.2	-12.5 ± 156(c)	17.9 ± 7.8	0.175 ± 0.318(c)	-0.035 ± 0.133(c)
50m south of spring	fourwing saltbush	*Atriplex*	*canescens*	23.4	404 ± 163	52 ± 5.94	0.0549 ± 0.12(c)	0.0339 ± 0.212(c)
50m south of spring	fourwing saltbush	*Atriplex*	*canescens*	36.4	-40.1 ± 151(c)	70.3 ± 6.97	-0.0386 ± 0.13(c)	0.227 ± 0.255(c)
50m south of spring	rubber rabbitbrush	*Ericameria*	*nauseosa*	32.3	0 ± 152(c)	11.7 ± 7.69	0.0697 ± 0.498(c)	0.0045 ± 0.13(c)
50m south of spring	rubber rabbitbrush	*Ericameria*	*nauseosa*	27.6	-86.3 ± 147(c)	16.4 ± 10.2	0.209 ± 0.818(c)	0.0000686 ± 0.104(c)
50m south of spring	Baltic rush	*Juncus*	*balticus*	28.2	-117 ± 141(c)	13.8 ± 5	-0.112 ± 0.177(c)	0.222 ± 0.204(c)
50m south of spring	Baltic rush	*Juncus*	*balticus*	45.3	-97.6 ± 151(c)	11.3 ± 5.33	-0.0546 ± 0.198(c)	0.142 ± 0.145(c)
50m south of spring	Stansbury cliffrose	*Purshia*	*stansburiana*	26.4	-5.1 ± 147(c)	5.72 ± 4.05	-0.121 ± 0.176(c)	0.0173 ± 0.0776(c)
50m south of spring	Stansbury cliffrose	*Purshia*	*stansburiana*	20.5	-117 ± 147(c)	8.35 ± 3.35	-0.0234 ± 0.153(c)	0.036 ± 0.0878(c)
50m south of spring	sandbar willow	*Salix*	*exigua*	27.9	-101 ± 149(c)	10 ± 4.38	0.162 ± 0.208(c)	0.022 ± 0.164(c)
50m south of spring	sandbar willow	*Salix*	*exigua*	31.5	-74.5 ± 221(c)	10.6 ± 5.32	-0.000212 ± 0.177(c)	0.0809 ± 0.198(c)
ANIMAL SAMPLES								
E Tunnel Ponds								
50m north of ponds	Mourning dove	*Zenaida*	*macroura*	54.7	391,400 ± 7,450	No data	0.373 ± 0.255(c)	0.269 ± 0.446(c)

± Error is the 2.0 Sigma Error, % H20 is the approximate percent water of sample on a dry weight basis, 40K 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.

Table 5.13 (Radionuclide Activities in NTS Biota Samples - 2000, cont.)

Location	Common Name	Scientific Name[a] Genus	Species	$\%H_20$ (%)	^{238}Pu[b]	$^{239+240}Pu$[b]	^{241}Am[b]	^{235}U	^{238}U
PLANT SAMPLES									
Sedan Crater									
100m west of crater	desert needlegrass	*Achnatherum*	*speciosa*	12.6	0.00386 ± 0.00604(c)	0.00616 ± 0.0096(c)	0.211 ± 0.384(c)	0 (c)	0 (c)
100m west of crater	desert needlegrass	*Achnatherum*	*speciosa*	15.6	0.00836 ± 0.00697	0.0142 ± 0.00811	0.442 ± 0.648(c)	0.737 ± 0.795(c)	0 (c)
100m west of crater	fourwing saltbush	*Atriplex*	*canescens*	25.6	0.00437 ± 0.0063	0.0101 ± 0.0094(c)	0.184 ± 0.717(c)	0.702 ± 1.01(c)	0.747 ± 4.9(c)
100m west of crater	fourwing saltbush	*Atriplex*	*canescens*	30.3	0.00902 ± 0.00846	0.00912 ± 0.00734	-0.491 ± 0.494(c)	0.232 ± 0.679(c)	3.15 ± 4.09(c)
100m west of crater	rubber rabbitbrush	*Ericameria*	*nauseosa*	26.1	0.00191 ± 0.00536(c)	0.0174 ± 0.00904	0.726 ± 1.03(c)	0.0836 ± 1.6(c)	0.639 ± 9.01(c)
100m west of crater	rubber rabbitbrush	*Ericameria*	*nauseosa*	20.2	0.00538 ± 0.00499	0.0143 ± 0.00757	-0.362 ± 1.3(c)	0.377 ± 1.14(c)	0.452 ± 15.7(c)
100m west of crater	prickly russian thistle	*Salsola*	*kali*	44.7	0.00881 ± 0.00904(c)	3.46E-10 ± 0.00698(c)	0.356 ± 1.35(c)	0.177 ± 0.86(c)	0.955 ± 11.5(c)
100m west of crater	prickly russian thistle	*Salsola*	*kali*	32.1	0.00345 ± 0.00556(c)	0.00507 ± 0.00499	0.553 ± 1.04(c)	0 (c)	2.09 ± 7.38(c)
Whiterock Spring									
50m south of spring	Louisiana sagewort	*Artemisia*	*ludoviciana*	52.4	0.0117 ± 0.00731	0.0168 ± 0.00857	-0.348 ± 1.56(c)	0.395 ± 1.49(c)	9.65 ± 11.3(c)
50m south of spring	Louisiana sagewort	*Artemisia*	*ludoviciana*	39.2	0.0196 ± 0.0102	0.0516 ± 0.016	-0.189 ± 1.11(c)	0.76 ± 1.68(c)	10.4 ± 9.64(c)
50m south of spring	fourwing saltbush	*Atriplex*	*canescens*	23.4	0.0291 ± 0.00564(c)	0.00288 ± 0.00565(c)	0.285 ± 0.348(c)	0.201 ± 0.909(c)	4.24 ± 3.02(c)
50m south of spring	fourwing saltbush	*Atriplex*	*canescens*	36.4	-0.00278 ± 0.0106(c)	0.00135 ± 0.00591(c)	-0.147 ± 0.674(c)	-0.234 ± 0.539(c)	2.73 ± 7.69(c)
50m south of spring	rubber rabbitbrush	*Ericameria*	*nauseosa*	32.3	0 (c)	0.00373 ± 0.00367	-0.485 ± 0.478(c)	0 (c)	0 (c)
50m south of spring	rubber rabbitbrush	*Ericameria*	*nauseosa*	27.6	0.0306 ± 0.0126	0.00202 ± 0.00281(c)	1.84 ± 2.14(c)	2.2 ± 1.81(c)	14 ± 28.3(c)
50m south of spring	Baltic rush	*Juncus*	*balticus*	28.2	0.0115 ± 0.00719	0.00176 ± 0.00423(c)	0.643 ± 1.24(c)	0.448 ± 1.88(c)	7.17 ± 7.27(c)
50m south of spring	Baltic rush	*Juncus*	*balticus*	45.3	0.00485 ± 0.0044	0.00158 ± 0.00311(c)	0.27 ± 0.557(c)	0.033 ± 1.34(c)	11.2 ± 11.2
50m south of spring	Stansbury cliffrose	*Purshia*	*stansburiana*	26.4	0.0144 ± 0.00889	0.0036 ± 0.00409	0.146 ± 0.864(c)	0.438 ± 0.982(c)	13.2 ± 11.4
50m south of spring	Stansbury cliffrose	*Purshia*	*stansburiana*	20.5	0.00609 ± 0.00546	0.00392 ± 0.00473(c)	0.483 ± 0.36(c)	-0.199 ± 0.775(c)	0.238 ± 7.82(c)
50m south of spring	sandbar willow	*Salix*	*exigua*	27.9	0.0151 ± 0.00798	0.00663 ± 0.00495	0.292 ± 0.566(c)	0.315 ± 0.787(c)	5.15 ± 4.35(c)
50m south of spring	sandbar willow	*Salix*	*exigua*	31.5	0.00449 ± 0.0102(c)	0.000589 ± 0.0012(c)	0.368 ± 0.469(c)	0.522 ± 1.71(c)	4.27 ± 8.12(c)
ANIMAL SAMPLES									
E Tunnel Ponds									
50m north of ponds	Mourning dove	*Zenaida*	*macroura*	54.7	0.0299 ± 0.0248	0.0222 ± 0.0196	0.218 ± 1.05(c)	-0.433 ± 1.5(c)	0 (c)

Concentration, pCi/g applies to the ^{238}Pu through ^{238}U columns.

± Error is the 2.0 Sigma Error, % H20 is the approximate percent water of sample on a dry weight basis, 40K 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.

Table 5.14 Summary of Annual Radionuclide Emissions by Source [(a)] (Multiply Ci by 37 to obtain Gbq) - 2000

Location	Source Type	Radionuclide	Half-Life (years)	Quantity (Ci)
Area 6, CP-95A Laboratory	Point	^{3}H	12.35	4.6×10^{-5}
Area 6, DAF Laboratory	Point	^{3}H	12.35	5.6
Area 23, Building 650 Laboratory	Grouped	^{3}H	12.35	3.0×10^{-4}
Area 52, Building A-1, North Las Vegas	Point	^{3}H	12.35	0.37
Onsite	Area	^{3}H [(c)]	12.35	426
Total ^{3}H				**431**
Area 23, Building 650 Laboratory (12)[(b)]	Grouped	^{85}Kr	10.72	2.1×10^{-6}
		^{129}I	1.57×10^{7}	5.4×10^{-7}
Onsite	Area	$^{239+240}Pu$	24,065	2.9×10^{-1}
Near Offsite, NAFR	Area	$^{239+240}Pu$	24,065	3.2×10^{-2}
Total $^{239+240}Pu$				**3.2×10^{-1}**
Onsite	Area	^{241}Am	432.2	4.7×10^{-2}
Near Offsite, NAFR	Area	^{241}Am	432.2	2.0×10^{-3}
Total ^{241}Am				**4.9×10^{-2}**

(a) All locations on or near the NTS except Building A-1, which is in North Las Vegas.
(b) (x) is number of vents or stacks.
(c) Emissions based on environmental air sampling data at SCHOONER and SEDAN, tritiated water discharged from the E Tunnel and tritiated water pumped from Well RNM-2s into the CAMBRIC ditch.

Table 5.15 Internal Dose Estimates for E Tunnel Biota - 2000

Biota	**Radionuclide**	**Concentration (pCi/g wet)**	**Internal Dose Factor (rad/day per Bq/kg wet)**	**Internal Dose (rad/day)**
Dove Breast Tissue	^{3}H	391,000 (pCi/L)[(a)]	4.5×10^{-6}	0.0514
	^{238}Pu	0.0299	5.4×10^{-3}	0.000006
	$^{239+240}Pu$	0.0222	5.4×10^{-3}	0.000004
Total Internal Dose to Dove				**0.065**
Rubber Rabbitbrush	^{3}H	3,250,000 (pCi/L)[(a)]	2.9×10^{-7}	0.0349
Desert Needlegrass	^{137}Cs	0.383	4.3×10^{-5}	0.00061
Prickly Russian Thistle	^{90}Sr	4.55	5.8×10^{-5}	0.0098
Total Internal Dose to Vegetation				**0.045**

(a) Concentration of tritium in water removed from dove or vegetation tissue by vaccum distillation.

Table 5.16 Air Filter Analyses and Techniques

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

Table 5.17 Results of Field and Laboratory Quality Assurance Samples

Analyte	**Number of Field Duplicates**	**Average %RSD**	**Number of Laboratory Duplicates**	**Average %RSD**
Gross Alpha	96	15.3	103	13.3
Gross Beta	96	4.3	103	3.1
Gamma ^{7}Be	8	5.3	8	8.4
Gamma ^{210}Pb	8	7.2	8	6.1

Table 5.18 Gross Alpha Results for the Offsite Air Surveillance Network - 2000

Concentration (10^{-15} Ci/mL [37 Bq/m^3])					
Sampling Location	**Number**	**Maximum**	**Minimum**	**Mean**	**Standard Deviation**
Alamo	52	7.7	1.2	3.2	1.6
Amargosa Center	52	7.1	0.5	3.1	1.6
Beatty	52	8.2	0.9	2.8	1.3
Boulder City	52	10.2	1.1	3.6	1.7
Caliente	52	5.1	0.9	2.5	1.1
Cedar City	52	9.0	2.0	3.8	1.3
Delta	50	5.2	0.9	2.2	0.9
Goldfield	52	7.3	0.7	2.6	1.5
Henderson	51	8.2	0.7	2.7	1.4
Indian Springs	49	4.9	0.7	2.1	0.7
Las Vegas	52	5.4	1.0	2.8	1.4
Milford	52	5.4	0.8	2.3	1.0
Overton	50	6.6	1.1	2.9	1.3
Pahrump	52	5.5	0.5	2.2	1.0
Pioche	52	4.8	0.5	2.2	1.0
Rachel	48	8.0	0.9	2.9	1.5
St. George	52	6.6	0.5	2.6	1.3
Tonopah	52	5.5	0.9	2.3	1.0
Mean MDC = 5.6 x 10^{-16} Ci/mL		Standard Deviation of Mean MDC = 1.0 x 10^{-16} Ci/mL			

Table 5.19 Gross Beta Results for the Offsite Air Surveillance Network - 2000

Concentration (10^{-14} Ci/mL [0.37 Bq/m^3])					
Sampling Location	**Number**	**Maximum**	**Minimum**	**Mean**	**Standard Deviation**
Alamo	52	4.1	1.2	2.5	0.7
Amargosa Center	52	6.7	1.2	2.5	1
Beatty	52	5.6	1.4	2.4	0.8
Boulder City	51	6.6	1.2	2.7	1
Caliente	52	4.4	1.2	2.5	0.7
Cedar City	52	4.3	1.4	2.4	0.6
Delta	50	6.3	1.3	2.5	1
Goldfield	52	6.1	0.8	2.4	0.9
Henderson	51	5.2	1.2	2.4	0.8
Indian Springs	49	3.3	1	2.2	0.5
Las Vegas	52	4.7	1.3	2.5	0.7
Milford	52	6.5	1	2.4	1
Overton	50	5.5	1.2	2.6	1
Pahrump	52	4.9	1.1	2.3	0.8
Pioche	52	3.9	0.6	6.2	0.6
Rachel	48	5	1.3	2.5	0.8
St. George	52	5.6	1	2.5	1
Tonopah	52	6.8	1.1	2.4	0.9
Mean MDC = 1.12 x 10^{-15} Ci/mL			Standard Deviation of Mean MDC = 0.15 x 10^{-15} Ci/mL		

Table 5.20 TLD Monitoring Results for Offsite Stations - 2000

		Daily Exposure (mR)			
Sampling Location	**Days**	**Minimum**	**Maximum**	**Mean**	**Total (mR) Exposure**
Alamo	370	0.13	0.23	0.19	71
Amargosa Center	370	0.17	0.21	0.19	71
Beatty	370	0.27	0.34	0.30	111
Boulder City	370	0.16	0.23	0.20	73
Caliente	287	0.22	0.24	0.22	82
Cedar City	372	0.15	0.19	0.17	63
Delta	372	0.18	0.22	0.20	75
Goldfield	370	0.17	0.29	0.23	83
Henderson	370	0.18	0.27	0.22	82
Indian Springs	370	0.14	0.22	0.18	66
Las Vegas	371	0.13	0.17	0.15	55
Milford	371	0.29	0.34	0.31	112
Overton	370	0.11	0.19	0.17	60
Pahrump	279	0.10	0.14	0.12	45
Pioche	377	0.18	0.22	0.20	72
Rachel	369	0.20	0.32	0.28	98
St. George	281	0.12	0.16	0.14	51
Tonopah	278	0.23	0.32	0.28	102
Sarcobatus Flats	370	0.24	0.33	0.29	106
Medlins Ranch	369	0.27	0.30	0.28	103

Table 5.21 Summary of Gamma Exposure Rates (μR/hr) as Measured by PIC - 2000

Sampling Location	**Maximum**	**Minimum**	**Standard Deviation**	**Average**	**mR/Year**
Alamo	13.4	11.9	0.40	12.2	107
Amargosa Center	13.6	9.5	1.29	12.1	107
Beatty	18.7	15.7	0.62	17.4	152
Boulder City	14.2	10.9	1.05	11.4	100
Caliente	17.3	13.1	1.00	14.2	125
Cedar City	11.1	9.1	0.49	9.7	86
Delta	14.4	11.0	0.57	11.6	102
Henderson	15.5	11.4	1.09	12.4	109
Goldfield	16.2	14.4	0.43	15.2	133
Indian Springs	13.4	9.8	0.55	10.3	91
Las Vegas	11.6	8.9	0.71	9.3	82
Medlins Ranch	17.0	15.1	0.50	15.5	137
Milford	18.8	16.0	0.62	17.0	150
Overton	11.3	8.5	0.70	9.2	81
Pahrump	8.8	7.9	0.29	8.0	71
Pioche	13.2	11.1	0.44	11.8	104
Rachel	16.2	14.0	0.49	15.1	133
St. George	9.2	6.2	0.74	7.7	68
Sarcobatus Flats	17.1	15.5	0.37	16.1	142
Tonopah	18.2	15.8	0.38	17.1	150

Table 5.22 Average Natural Background Radiation for Selected U.S. Cities (Excluding Radon)

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

Note: From http://www.wrcc.dri.edu/cemp/Radiation.html.