

National Emission Standards for Hazardous Air Pollutants Submittal - 1997

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June 1998

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

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LIST OF ACRONYMS

ARL/SORD	Air Resources Laboratory Special Operations and Research Division
BN	Bechtel Nevada
CFR	Code of Federal Regulation
CY	Calendar Year
DOE/NV	U.S. Department of Energy Nevada Operations Office
DRA	Desert Rock Meteorological Observatory
EDE	Effective Dose Equivalent
EPA	U.S. Environmental Protection Agency
GCD	Greater Confinement Disposal
HTO	Tritiated Water
LANL	Los Alamos National Laboratory
LLW	Low-Level Radioactive Waste
MDC	Minimum Detectable Concentration
MEDA	Meteorological Data Acquisition System
MEI	Maximally Exposed Individual
MIDNET	Meteorological Data Network
NESHAP	National Emission Standard for Hazardous Air Pollutants
NOAA	National Oceanic and Atmospheric Administration
NTS	Nevada Test Site
RWMS	Radioactive Waste Management Site
RWMS-3	Area 3 Radioactive Waste Management Site
RWMS-5	Area 5 Radioactive Waste Management Site
STAR	Stability Array - Grouping of Meteorological Data
TRU	Transuranic - Nuclides with Atomic Numbers Greater than Uranium
UCC	Yucca Flat Meteorological Observatory

**U.S. Department of Energy
Air Emissions Annual Report
(under Subpart H, Title 40 Code of Federal
Regulation [CFR] 61.94) Calendar Year (CY) 1997**

Site Name: Nevada Test Site

Operations Office Information

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SECTION I FACILITY INFORMATION

SITE DESCRIPTION

The Nevada Test Site (NTS) is operated by the U.S. Department of Energy's Nevada Operations Office (DOE/NV) as the site for nuclear weapons testing, now limited to readiness activities and experiments in support of the nations Stockpile Stewardship Management Program. It is located in Nye County, Nevada, with the southeast corner about 90 km (56 mi) northwest of Las Vegas, Nevada. The NTS covers about 3,500 km² (1,350 mi²), an area larger than Rhode Island. Its size is about 46 to 56 km (28 to 35 mi) east to west and from 64 to 88 km (40 to 55 mi) north to south. The NTS is surrounded, except on the south side, by public exclusion areas (Nellis Air Force Range Complex) that provide another 24 to 104 km (15 to 65 mi) between the NTS and public lands (Figure 1.0). The NTS is characterized by desert valley and Great Basin mountain topography, with a climate, flora, and fauna typical of the southwest deserts. Population density within 150 km (93 mi) of the NTS is only about 0.5 persons per square km, excluding the Las Vegas area. Restricted access, low population density in the surrounding area, and extended wind transport times are advantageous factors for the activities conducted at the NTS. Surface waters are scarce on the NTS, and there is great depth to slow-moving groundwater.

SOURCE DESCRIPTION

The sources of radionuclides include current and previous activities conducted on the NTS. Figure 2.0 is a map of the NTS that shows the areas used for such activities. The NTS was the primary location for testing of nuclear explosives in the Continental U.S. between 1951 and 1992. Historical testing has included, (1) atmospheric testing in the 1950s and early 1960s, (2) earth-cratering experiments, and (3) open-air nuclear reactor and rocket engine testing. Since the mid 1960s, testing of nuclear devices has occurred underground in drilled vertical holes or in mined tunnels. No nuclear tests have been conducted since September 1992. Limited non-nuclear testing includes spills of hazardous materials at the Hazardous Materials Spill Center and aerospace and demilitarization activities. Processing of radioactive materials is limited to laboratory analyses, and handling is restricted to transport, storage, and assembly of nuclear explosive devices and operation of radioactive waste management sites (RWMSs) for low-level radioactive and mixed waste. Monitoring and evaluation of the various activities conducted onsite indicate that the potential sources of offsite radiation exposure in 1997 were releases from, (1) evaporation of tritiated water (HTO) from containment ponds that receive drainage water from E Tunnel in Area 12 and from wells used for site characterization studies, (2) onsite radioanalytical laboratories, (3) the Area 5 RWMS (RWMS-5) facility, and (4) diffuse sources of tritium and resuspension of plutonium. The following sections present a general description of the sources on the NTS.

At the North Las Vegas Facility, operated for DOE/NV by Bechtel Nevada (BN), there was an unusual occurrence in 1995 that led to a very small potential exposure to an offsite person. The incident involved the release of tritium as HTO. The HTO emission continued into 1997 in decreasing amounts and during cleanup activities in November and December 1997. A description of the incident and the method of calculating the effective dose equivalent (EDE) for offsite exposure are set forth in Appendix A.

Ground Seepage of Noble Gases

Ground seepage may be enhanced when changes in ambient pressure act like a pump to bring small amounts of noble gases up through the overburden and into the atmosphere from the cavity created by a nuclear test. This process, sometimes referred to as "atmospheric

pumping," creates a diffuse source of radiological effluents. These area sources are rare and therefore not routinely monitored. The phenomenon is usually restricted to events conducted in the Pahute Mesa region of the NTS. These seepages are from nuclear tests conducted prior to 1993.

⁸⁵Kr is generally detected on the NTS at air concentrations consistent with data previously collected at offsite areas by the U.S. Environmental Protection Agency's (EPA's) Radiation and Indoor Environments National Laboratory - Las Vegas. During 1996, ⁸⁵Kr was detected at the three environmental monitoring stations at an average level of 27 pCi/m³, consistent with previous years. In 1997, there were no differences between the sampling locations on Pahute Mesa and in Yucca Flat. Therefore, a source term for this emission is not calculated.

Tunnel Operations

Nuclear tests have been conducted within tunnel complexes mined into the Rainier Mesa region. No such tests were conducted in 1997. When tests were conducted, purging gases from the tunnel occasionally resulted in releases of radioactivity, and contaminated water drained from them (see below).

Containment Ponds

Water contaminated with radionuclides seeped from the tunnels in Area 12 and was collected in containment ponds where some evaporated and some seeped into the soil. A photograph of tunnel containment ponds is provided as Figure 3.0. The tunnels have been sealed, but water continues to seep from E Tunnel. The only radiological contaminant which produces a measurable air emission from evaporation of the water is ³H (as HTO). The seepage is expected to cease in the near future as remedial actions are implemented. Calculation of the source term for this emission is described in Appendix B.

To characterize the groundwater regime under the NTS, suitable wells are being drilled and existing wells recompleted in the vicinity of certain underground tests and at other locations on the NTS. During these drilling operations, contaminated water may be pumped from the wells. This water is diverted to lined containment ponds if the tritium level exceeds 2×10^5 pCi/L, as required by the state. The emission was smaller this year. Calculations for this activity are also described in Appendix B.

Drillbacks

Following underground nuclear tests, slant wells are drilled so core samples can be taken from the cavity formed by the nuclear detonation for analysis and diagnosis. This is referred to as core sampling and is accomplished by drilling into the area of interest and recovering samples using special drilling equipment. Radioactive material may be discharged into the atmosphere during these operations. No drillback activities occurred during 1997.

Laboratories

Radiological analyses are conducted by BN in a laboratory located in Building 650 and by Los Alamos National Laboratory (LANL) in Building 701, both in Mercury. Because these facilities primarily process environmental samples, very little radioactivity passes through them. However, there is potential for some radionuclides to be discharged into the atmosphere

through the hood ventilation system during sample processing, particularly of spiked samples, or from loss of radioactive standards. Figure 4.0 is a photograph of the Building 650 hood ventilation stacks, seen from above. The source term for Building 701 was limited to 500 μCi of tritium. The source term for Building 650 is described in Appendix B. In general, evaporation and spills from samples containing HTO, radioiodines, or noble gases are conservatively estimated by assuming all such materials are released. Radioactive standards contained most of the activity potentially releasable. Non-volatile materials are controlled by keeping their inventory below the possession limits set forth in Appendix E to Title 40 CFR 61, as shown in Appendix C.

Radioactive Waste Management Sites

The RWMSs, in Area 3 (RWMS-3) and RWMS-5, are used for the disposal of low-level radioactive waste (LLW). The RWMS-5 is used for accumulation of mixed waste, storage of transuranic (TRU) and mixed TRU wastes, and contains the Greater Confinement Disposal (GCD) Test Unit and 12 GCD boreholes (only a few have any waste). Disposal is accomplished by the use of pits and trenches. Concrete pads are used for temporary storage of certain wastes. At RWMS-5, only packaged wastes are accepted for disposal. The facility is considered a diffuse source of radiological effluents. The only radioactive effluent detected, by the various types of samplers surrounding the site, is HTO in atmospheric moisture. The calculation of the HTO source term is explained in Appendix D. The RWMS-3 LLW site is in a location where surface soil has been contaminated by deposited plutonium (see below), and resuspension of this soil by wind or vehicular activity results in above background levels of plutonium being detected in air samples collected nearby.

Plutonium Contaminated Surface Areas

Surface soils in certain areas on and off the NTS were contaminated with plutonium from either nuclear device safety, atmospheric, or cratering tests (the Plowshare Program), using nuclear explosives. Investigations of these areas during the Nevada Applied Ecology Group studies⁽¹⁾, as expanded by the Desert Research Institute⁽²⁾, developed the inventories of plutonium shown in Table 1.0. These areas could become sources of plutonium exposure if the contaminated soils were to be resuspended; e.g., during surface cleanup, construction, vehicular travel, or similar activities. Figure 5.0 is a map showing the approximate locations of the nuclear device safety tests on the NTS. There are air samplers at or near almost all of these onsite areas. Plutonium analyses of the glass-fiber filters from these samplers indicate that the majority of the results are less than the minimum detectable concentration (MDC), and most of those are even less than the two standard deviation (2s) counting error. The results that are higher than the MDC are from air samplers in areas where operational activities can cause contaminated surface soil to become resuspended. These areas are considered diffuse sources of radioactive effluents, although plutonium is the only detectable one. The calculation of the source term for these plutonium contaminated areas is explained in Appendix E.

⁽¹⁾ Friesen, H.N., 1992, "Summary of the Nevada Applied Ecology Group and Correlative Programs" Report DOE/NV-357, Nevada Operations Office, U.S. Department of Energy, Las Vegas, Nevada.

⁽²⁾ McArthur, R.D., 1991, "Radionuclides in Surface Soil at the Nevada Test Site" Report DOE/NV/10485-02, Nevada Operations Office, U.S. Department of Energy, Las Vegas, Nevada.

Table 1.0 Summary of Estimated Inventory of $^{239+240}\text{Pu}$ in Surface Soil (0 to 5 cm) at Studied Sites

Site (on NTS)	Area (km ²)	Number Samples	Est. Inventory (Curies)	95% Conf. Interval (Curies)	$^{239+240}\text{Pu}$ Air Conc. Annual Avg. (X ± 2s) in 10 ⁻¹⁸ μCi/mL Units
Project 56 (Area 11) ^(a)	4.83	205	36	28 - 44	23 ± 39
GMX (Area 5) ^(a)	0.125	111	1.5	1.1 - 1.9	5 ± 5
LITTLE FELLER II (Area 18) ^(c)	0.375	712	32 ^(c)	22 - 41	
PALANQUIN (Area 20) ^(b)	3.895	148	13 ^(c)	6 - 21	1.6 ± 1.2
SEDAN (Area 10) ^(b)	28.264		111.2		12 ± 13
T2 SERIES (Area 2) ^(d)	30.100		26.7		8 ± 16
Various Tests (Area 9)			89		245 ± 216
Area 13 ^(a)	4.02	169	46	28 - 64	
CLEAN SLATE II & III ^(a)	2.6	236	54		

(a) Safety tests of nuclear devices.

(b) Plowshare tests (PALANQUIN and CABRIOLET sites in Area 20 combined).

(c) Inventory consists of $^{239+240}\text{Pu}$ + ^{241}Am

(Gilbert, NVO-181 p. 425; NVO-272, pp. 381-429; McArthur, DOE/NV10162-20).

(d) Weapons effects tests.

SECTION II AIR EMISSIONS DATA

Each potential source of NTS emissions was characterized by one of the following methods: (1) monitoring methods and procedures previously developed at the NTS; (2) a yearly radionuclide inventory of the source, assuming that volatile radionuclides are released to the environment; (3) the measurement of tritiated water (as HTO or T₂O) concentration in liquid effluents discharged to containment ponds and assuming all the effluent evaporates over the course of the year to become an air emission; or (4) using a combination of environmental measurements and CAP88-PC to calculate emissions (generally confirmed by offsite air measurements). Appendices A through E describe the methods used to determine the emissions from the sources listed in Section I. In accordance with Title 40 CFR 61.93.(b).(4), no credit was taken for pollution control equipment in determining air emissions.

The emissions for National Emission Standards for Hazardous Air Pollutants (NESHAPs) reporting are listed in Table 2.0. They are very conservative (worst-case) and are used in Section III to calculate the EDE to the maximally exposed individual (MEI) offsite. Offsite environmental surveillance data, where available, are used to confirm that calculated emissions are, indeed, conservative.

Table 2.0 Summary of Annual Air Emissions Data by Source (Multiply Ci by 37 to Obtain GBq)

<u>Point Source</u>	<u>Type of Control</u>	<u>Efficiency</u>	<u>Distance to Nearest Receptor</u>	<u>Nuclide</u>	<u>Quantity (Ci)</u>
Building 701	None	0%	24 km	³ H	5.0 x 10 ⁻⁴
Building A-1 (Atlas)	None	0%	0.1 km	³ H	1.1 x 10 ⁻¹
<u>Grouped Sources</u>					
Building 650 Laboratory (12) ^(a)	None	0%	24 km	³ H ⁸⁵ Kr ¹²⁹ I	2.0 x 10 ⁻⁴ 1.9 x 10 ⁻² 1.5 x 10 ⁻⁶
Containment ^(b) Pond: Area 12 Area 20	None	0%	56 km 42 km	³ H ³ H	16 4.1
<u>Non-Point Sources</u>					
Yucca Flat ^(c) Area 3 Area 9	None	0%	54 km 53 km	²³⁹⁺²⁴⁰ Pu ²³⁹⁺²⁴⁰ Pu	1.2 x 10 ⁻² 2.4 x 10 ⁻²
RWMS-5 ^(c) Other Areas ^(d) SEDAN	None	0%	42 km 42 km 51 km	³ H ²³⁹⁺²⁴⁰ Pu ³ H	2.4 x 10 ⁻¹ 2.4 x 10 ⁻¹ 140

(a) (x) is number of vents or stacks.

(b) Evaporation of all HTO effluents is assumed.

(c) Emissions based on environmental surveillance data.

(d) Described in Appendix E.

A summary of the NTS total CY 1997 emissions for NESHAP's reporting, by radionuclide, is provided in Table 3.0.

Table 3.0 Total Emissions for CY 1997 (Multiply Ci by 37 to Obtain GBq)

<u>Radionuclide</u>	<u>Half-Life (days)</u>	<u>Annual Quantity (Ci)</u>
^3H	4510	160
^{129}I	5.7×10^9	1.5×10^{-6}
$^{239+240}\text{Pu}$	8.8×10^6	3.9×10^{-1}

Note: This table includes all worst-case point and diffuse source releases.

SECTION III DOSE ASSESSMENTS

SUMMARY OF INPUT PARAMETERS

CAP88-PC was used to calculate EDEs to offsite residents. The input parameters were the radionuclide releases listed in Section II above as determined from effluent monitoring performed by the contractor, from evaporation of HTO, and from calculations of diffuse source emissions that are based on environmental monitoring data. The latter includes measurable particulate emissions of $^{239+240}\text{Pu}$ originating in certain areas of the NTS and Nellis Air Force Range Complex, and HTO detected at the boundary of the RWMS.

To calculate the amount of HTO evaporated, measurements of HTO concentrations in the containment ponds for the first and fourth quarters of 1995 were compared. These concentrations were equal; i.e., within the measurement error, and the surface areas were approximately equal and thus the volume, so all the HTO influent to the ponds was assumed to have evaporated. This was a conservative estimate, as no allowance for infiltration into the soil column was made. This is assumed to be true for 1997 also. A description of the source term estimated for this emission is contained in Appendix B.

The source data listed above are used with five stability array (STAR) data files as input to CAP88-PC. The five STARs for the NTS include the files with names NTSYUCCA, AREA05, MEDA20, DESERTRK, and T TUNNEL. NTSYUCCA is used for sources on Yucca Flat (Areas 1, 2, 3, 4, 6, 7, and 9); AREA05 is used for sources on Frenchman Flat; DESERTRK is used for sources in Mercury; MEDA20 is used for sources in Areas 19 and 20; and T TUNNEL is used for the tunnel pond sources in Area 12. MEDA20, T TUNNEL, and AREA05 were developed by the Air Resources Laboratory, Special Operations and Research Division (ARL/SORD) using data obtained from the meteorological stations located near the boundary of Areas 19 and 20 on Pahute Mesa, near the tunnels in Area 12, and at Well 5B in Area 5. The other two files were provided by the National Climatic Data Center in North Carolina, based on data from meteorological stations in Yucca Flat and at the Desert Rock airstrip. The ARL/SORD assessment is attached as Appendix F. For each of these five STARs, there may be a different location for the MEI; but when the contributions of all the NTS sources to a given location are considered, only one location would receive the maximum exposure. In this case, the location was Springdale, Nevada, with a population of 20 persons. See Figure 1.0 for residences and communities around the NTS.

The EDE, in mrem to the MEI (a resident in Springdale, Nevada), was calculated using CAP88-PC for each of the listed sources in Section II. A summary of sources contributing to the EDE is shown in Table 4.0. Calculation of this EDE requires summing the contribution from all sources, as shown in Table 5.0. The sources listed as containment ponds in Area 12 and Laboratory Buildings 650 and 701 (Mercury) were added to the NESHAPs program in 1991 for 1990 emissions. Consideration of diffuse sources, such as soils contaminated by safety and other nuclear device tests (as detected by air sampling) were added in the 1992 report to complete the possible sources of emission of radioactivity on the NTS. Recently, a resuspension calculation has been used for source terms from contaminated areas. Appendices A through E contain estimates of radionuclides, which have or could have been released in 1997.

Descriptions and estimations of the errors involved in each step of the dose assessments process (measurement, monitoring, and calculation), estimations of potential releases, and worst-case scenarios are also included in Appendices A through E where possible. Evaporative and resuspension emissions are also compared to EPA suggested methods as a check on the relative values produced.

COMPLIANCE ASSESSMENT

Table 4.0 Summary of CY 1997 CAP88-PC Calculations of EDE to the MEI Offsite - Springdale, Nevada^(a)

<u>Source</u>	<u>Distance to Individual and Direction</u>	<u>Effective Dose Equivalent (mrem)^(b)</u>
Tunnel Pond (Area 12)	56 km WSW	$3.2 \times 10^{-4(c)}$
Laboratories (Area 23)	78 km WNW	1.9×10^{-8}
Yucca Flat (Area 3) (Area 9)	62 km W 64 km W	5.0×10^{-3} 9.5×10^{-3}
RWMS-3, 5	74 km WNW	7.9×10^{-6}
Area 10	65 km WSW	4.0×10^{-4}
Other Areas ^(d)	---	7.4×10^{-2}
TOTAL EDE		8.9×10^{-2} mrem

(a) Location of residences and communities around the NTS is shown in Figure 1.0.

(b) For mSv, multiply by 10^{-2} .

(c) Assumes evaporation of all HTO influents to ponds.

(d) Described in Appendix E.

COMPLIANCE ASSESSMENT

Table 5.0 EDE Tabulation by Location (Multiply mrem by 10^{-2} for Equivalent mSv Units) - 1997^(d)

Location	Pop. ^(c)	EDE (10^{-6} mrem/Year) Due to Releases from:						Total EDE 10^{-3} mrem	Collective EDE man-mrem
		Area 12 ^(a) Tritium	Other Areas ^(b)	YUCCA Flat Area 3 ^(a)	YUCCA Flat Area 9 ^(a)	Area 5+3 RWMS ^(a)	Area 10 Tritium		
Alamo	1000		7400			71	7.47	7.5	
Amargosa Valley	990	370	47100	3700	9500	290	61	61	
Ash Meadows	10	(see note ⁴)	10100	4000			14	0.14	
Ash Springs	70		1900				1.9	0.13	
Beatty	1570	290	62200	4900	9500	380	77.3	121	
Clark Station	2		12000				12	0.024	
Crystal	45	500	44000	3900	6500	210	55.1	2.5	
Death Valley Jct.	7						0.0043	3.0×10^{-5}	
Desert Game Range	4						0.0041	1.6×10^{-5}	
Goldfield	600		4100				4.1	2.5	
Hiko	103		1800				1.8	0.18	
Indian Springs	1210	680	15000	1500	4000	260	22	27	
Lathrop Wells	30	350	62900	6800	12000	340	82.4	2.5	
Lida Junction	8		14000				14	0.11	
Medlin's Ranch	2	350	27000	2400	5500	120	35.4	0.07	

- (a) Emissions calculated from surveillance data.
- (b) Emissions calculated from engineering data.
- (c) Estimated population at that location for 1997.
- (d) Blank spaces represent locations farther than 80 km from the source for the column.

Table 5.0 (EDE Tabulation by Location [Multiply mrem by 10^{-2} for Equivalent mSv Units - 1997^(d)], cont.)

Location	Pop. ^(c)	EDE (10^6 mrem/year) Due to Releases from:						Area 10 Tritium	Total EDE 10^3 mrem	Collective EDE man-mrem
		Area 12 ^(e) Tritium	Other Areas ^(b)	YUCCA Flat Area 3 ^(a)	YUCCA Flat Area 9 ^(a)	Area 5+3 ^(a) RWMS	Area 5+3 ^(a)			
Mt. Charleston	500					4.1		0.0041	2.0×10^{-3}	
Pahrump	18700					4.2		0.0042	0.084	
Penoyer Farm	16	350	33200	2000	4400	3.0	120	40	0.64	
Rachel	105	350	29000	1900	4300	2.9	120	36	3.8	
Sarcobatus Flats	40	470	27600	2300		2.8		30.4	1.2	
S NV Corr. Ctr	2000		1400	1100		4.3		2.5	5.0	
Springdale	20	320	74400	5000	9500	7.9	400	89.6	1.8	
Stateline & Area	70		11000	3200		7.6		14.2	1.0	
Stone Cabin Rn.	6		8900					8.9	0.053	
Tonopah	3400		4000		3800			7.8	27	
Twin Springs Rn.	6		2200					2.4	0.014	
U.S. Ecology	35	320	45000	4900	8500	8.2	280	59	2.1	

Total Population - 30,600 Maximally Exposed Individual: 0.09 mrem Location of Maximally Expose: Springdale, Nevada	Maximum Individual Dose Calculated for Each Release Point - 10^{-3}				Total Person-rem: 0.26
	Area 12	Other Areas	YUCCA Flat	Area 3+5	
	Area 10	Area 9	Area 5	Area 10	
	0.68	74.4	18.8	0.008	0.40

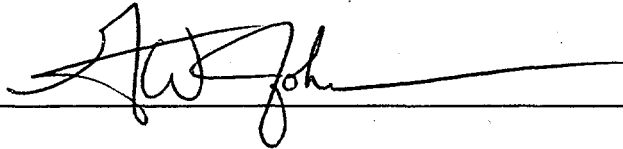
(a) Emissions calculated from surveillance data.
 (b) Emissions calculated from engineering data.
 (c) Estimated population at that location for 1997.
 (d) Blank spaces represent locations farther than 80 km from the source for the column.

Certification

I certify under penalty of law that I have personally examined and am familiar with the information submitted herein and based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information including the possibility of fine and imprisonment. See 18 U.S.C. 1001.

Name: G. W. Johnson, Manager, Nevada Operations Office

Signature:

A handwritten signature in black ink, appearing to read 'G. W. Johnson', written over a horizontal line.

Date:

6/4/98

SECTION IV ADDITIONAL INFORMATION

NEW CONSTRUCTION/MODIFICATION ACTIVITIES AT THE NTS

A Waste Examination Facility was constructed in Area 5, adjacent to the RWMS. One use of this facility is for repackaging TRU waste prior to shipment to the Waste Isolation Pilot Plant in New Mexico. Assuming no controls, and that the container with the highest content of TRU waste would release all of it, the maximum EDE offsite, as calculated with CAP88PC, would have been only 0.004 mrem.

UNPLANNED RELEASES DURING CY 1997

All releases on the NTS during CY 1997 were operational. There was a detectable release at the Atlas Facility located in North Las Vegas that was a continuance of a 1995 incident (see Appendix A for a description).

SOURCES OF DIFFUSE OR FUGITIVE EMISSIONS

These sources included evaporation from containment ponds that receive liquid effluents from E Tunnel in Area 12 and from groundwater characterization wells in Area 3; resuspension of $^{239+240}\text{Pu}$ from soil deposits on the NTS in Areas 3, and 9, other atmospheric test areas, and safety test areas; and seepage of tritium from the SEDAN crater and from packages buried at the RWMS-5 (see Appendix G).

The EDE to the MEI was principally due to the diffuse sources. The EDE from point sources was negligible. The methods used to determine the emissions from these diffuse sources are described in the appendices.

FIGURES

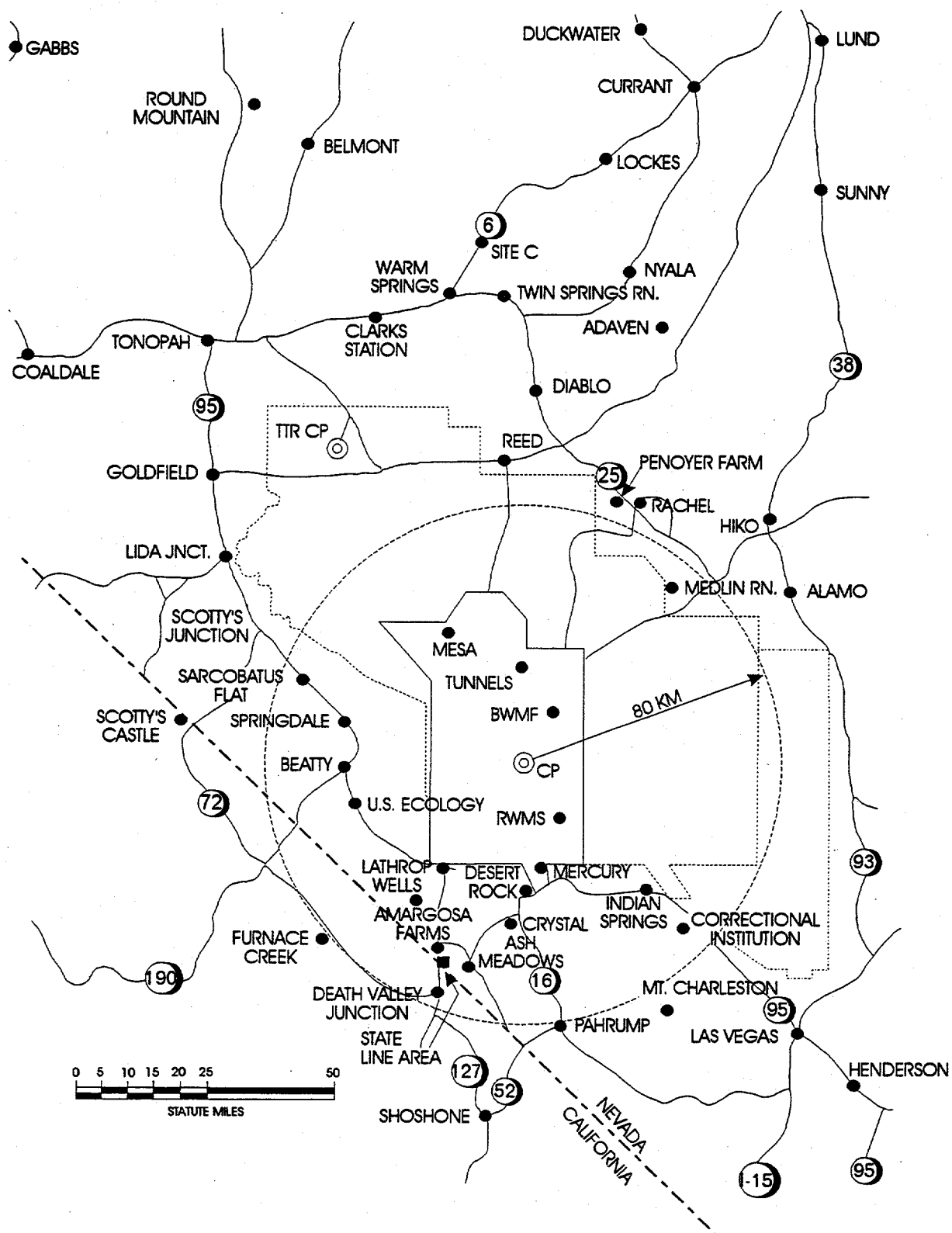


Figure 1.0 Map of the NTS and Surrounding Area

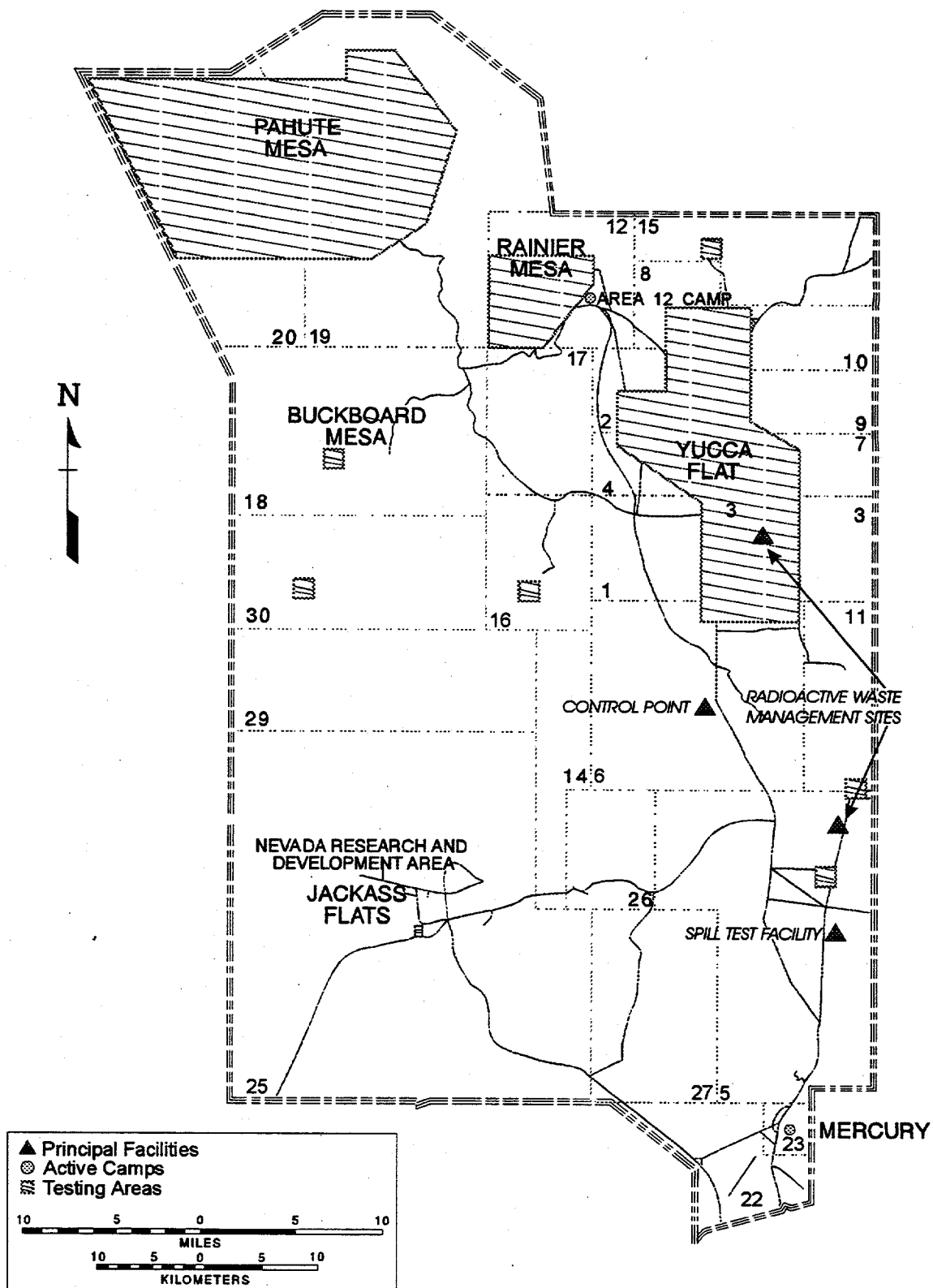


Figure 2.0 Nuclear Testing Areas on the NTS

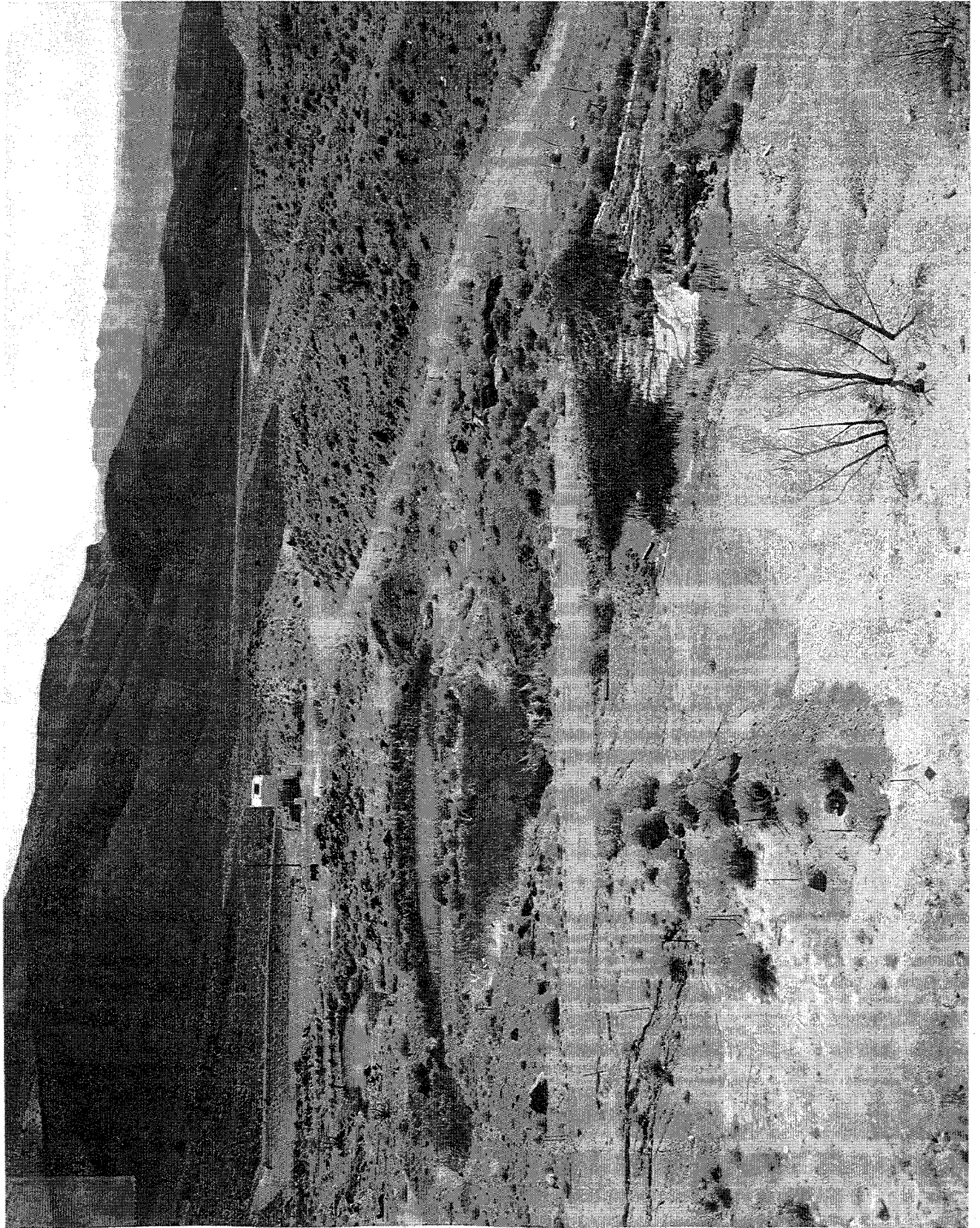


Figure 3.0 Photograph of Tunnel Containment Ponds

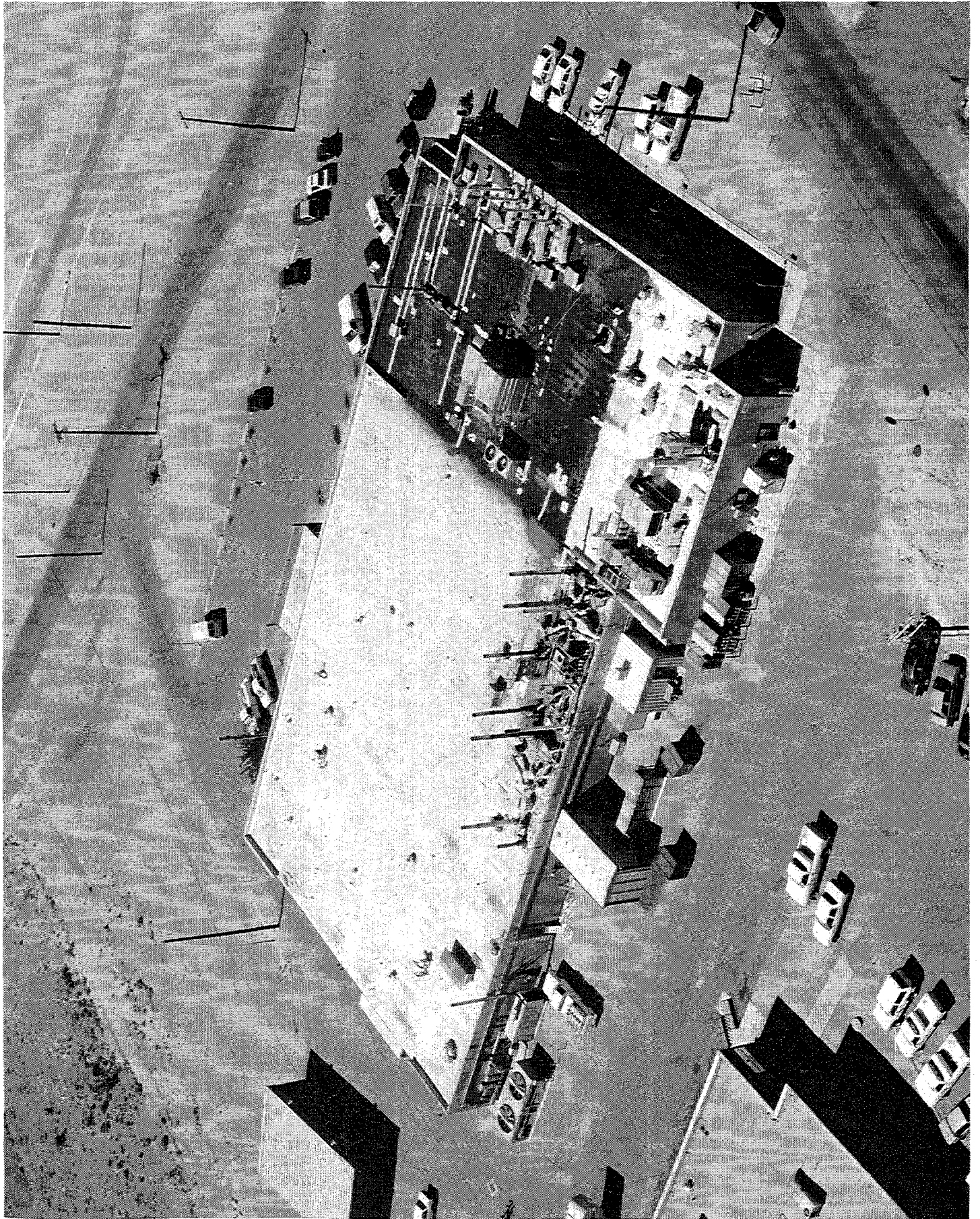


Figure 4.0 Photograph of the Building 650 Hood Ventilation Stacks Seen from Above

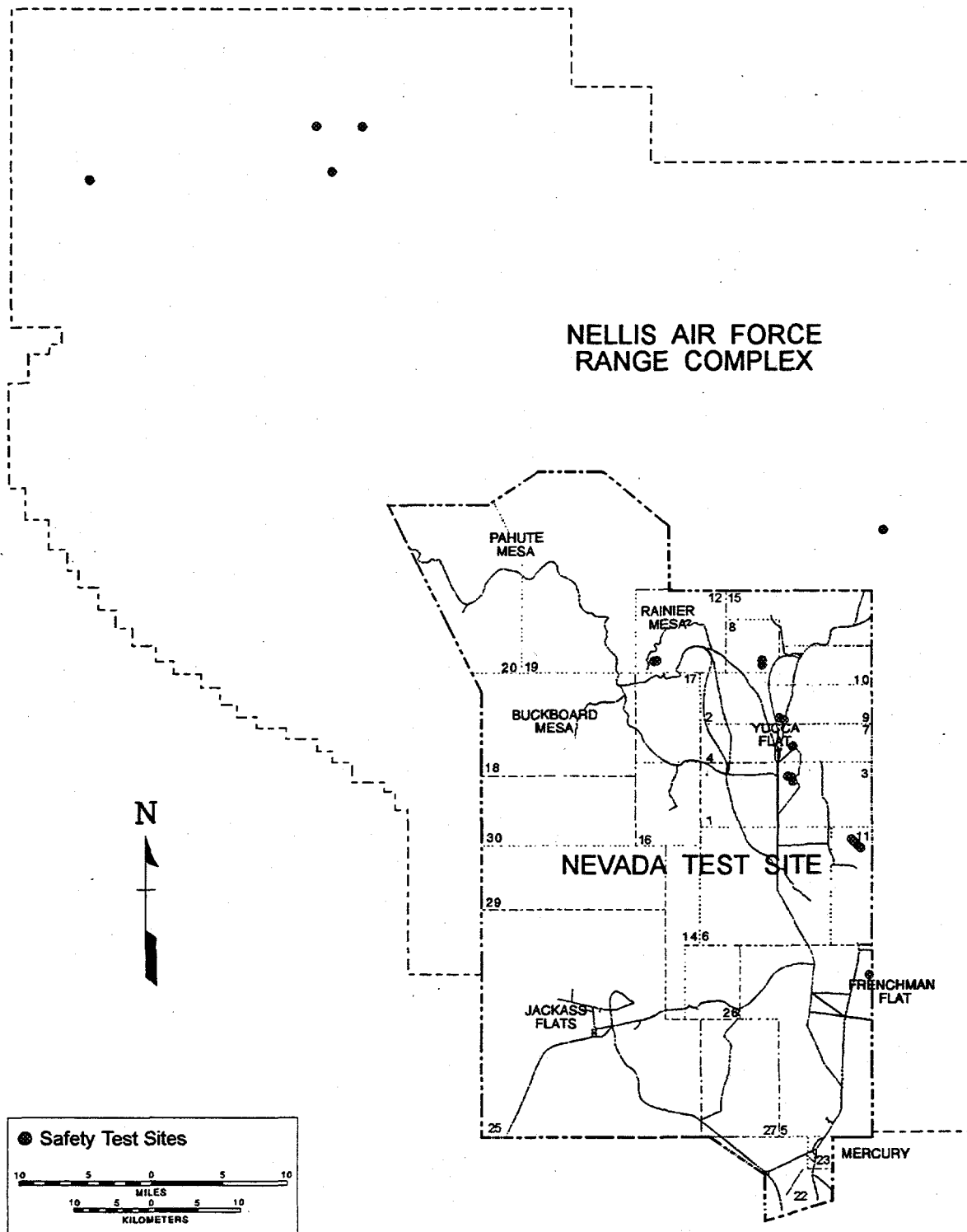


Figure 5.0 Location of Nuclear Device Safety Test (•) on the NTS

APPENDICES

**APPENDIX A
PUBLIC DOSE CALCULATIONS FOR THE ATLAS TRITIUM INCIDENT**

ENVIRONMENTAL SURVEILLANCE

As reported in the 1995 NESHAP report, a container of tritium foils was opened in the Atlas Facility at the North Las Vegas Operations area that emitted about a Ci of ^3H into a basement area used as a fixed radiation source range. Environmental surveillance efforts began with notification on Friday, July 14, 1995, that the tritium leak had occurred. Environmental HTO samplers were installed at three locations outside the facility. Later, an HTO sampler was installed in the basement so that progress on cleanup of the spill could be monitored. After cleanup began, the environmental samplers were removed but the basement air sampler continued operation.

Basement sampling continued through 1997. The 1996 results and offsite EDE were reported in the 1996 NESHAP report. The data accumulated for 1997 are shown in Table A-1 and indicate continued emission of HTO into Building A-1. Another cleanup operation in November and December 1997 was attempted to further reduce the emission.

The EDE for offsite locations was obtained by using the air sampler results to calculate a total emission from the facility. The method is as follows:

- The annual average 5.2 pCi/m^3 effluent from A-11 is negligible (bottom part of Table A-1). The measurements in A-1 Basement are fairly consistent. The levels for the environmental sampler are background before and after cleanup (top part of table). Assume the environmental sampler average as the annual average and calculate the EDE for a person at that sampler location, but reduce the calculated emission to the actual sampling time.
- The dose conversion factor for tritium inhalation ($6.4 \times 10^{-8} \text{ mrem/pCi}$), multiplied by 1.5 to correct for skin absorption, by 39.3 pCi/m^3 measured, and by $8,400 \text{ m}^3/\text{yr}$ breathed by a normal adult gives an EDE for that sampler location.
- A 1 mCi release was used in CAP88PC D stability Las Vegas wind data, to obtain an EDE at the location of the air sampler ($4.8 \times 10^{-5} \text{ mrem}$).
- Divide the calculated EDE from monitoring data as in step two by the EDE/mCi from CAP88PC in step three to obtain an estimated release in mCi.

For example, use the calculated average data from Table A-1 for the environmental sampler (39.3 pCi/m^3):

$$\begin{aligned} \text{EDE} &= 39.3 \text{ pCi/m}^3 \times 1.5 \times 8400 \text{ m}^3/\text{yr} \times 6.4 \times 10^{-8} \text{ mrem/pCi} \\ &= 0.032 \text{ mrem.} \end{aligned}$$

A CAP88PC run with 1 mCi release yields $4.8 \times 10^{-5} \text{ mrem}$ at the sampler position.

$$\therefore \text{the estimated effluent would be: } \frac{0.032 \text{ mrem}}{4.8 \times 10^{-5} \text{ mrem/mCi}} = 666 \text{ mCi.}$$

However, the emission lasted two months (1/6 year), at most, so $666/6 \text{ mCi} = 110 \text{ mCi}$ is the estimated release. The CAP88PC run with a 1 mCi emission of tritium also yielded data for other locations around the site, such as the data for the nearest building of $4.8 \times 10^{-6} \text{ mrem/mCi}$. Assuming there is an individual at that location, that individual would be the MEI and the EDE would be $110 \text{ mCi} \times 4.8 \times 10^{-6} \text{ mrem/mCi} = 5.3 \times 10^{-4} \text{ mrem}$ or $0.53 \text{ } \mu\text{rem}$.

CONCLUSION: The best estimate of offsite EDE to the MEI was $0.53 \text{ } \mu\text{rem}$. For comparison, the NESHAPs: Radionuclides specifies a limit of 10 mrem to the MEI or about 19,000 times that calculated. Also, the calculated EDE assumes the person resides at the nearest building location year around. That building is not a residence, i.e., not occupied 24 hr/day, so the dose to any occupant would be much less.

Table A.1 HTO in Air Results in 1997 - pCi/m³

HTO in Air Results at Building A-1 During Cleanup

Date	Basement	Room 4520	Room 4540	Room 4540B	Environmental Sampler
11/10/97	4460	106.0	42.5		2.14
11/17/97	5250	197.0	55.8		
11/24/97	3900	156.0	59.6	40.2	
12/01/97	3760	106.0	46.1	88.4	
12/08/97	4420	98.8	143.0	111.0	93.5
12/15/97	3590	76.6	49.0	65.4	
12/22/97	3270	87.8	48.5	69.2	62.7
12/29/97	2460	69.2	46.6	66.6	
01/05/98	3970	120.0	76.6	102.0	-1.05
Average	3898	113	63.1	77.5	39.3

HTO in Air Results at the Atlas Facility

Date	Building A-11	Building A-1 Basement	No. Days	pCi/m ³	pCi/m ³	Building A-11 pCi-dy-m ⁻³	Building A-1 pCi-dy-m ⁻³
01/27/97	7.63 x 10 ⁻¹³	8.57 x 10 ⁻⁰⁹	12	0.763	8570	9.16	102840
02/18/97	1.74 x 10 ⁻¹⁴	1.31 x 10 ⁻⁰⁸	21	0.0174	13100	0.37	275100
02/24/97	1.72 x 10 ⁻¹²	4.57 x 10 ⁻⁰⁹	6	1.72	4570	10.32	27420
03/10/97	8.43 x 10 ⁻¹³	7.53 x 10 ⁻⁰⁹	14	0.843	7530	11.80	105420
03/25/97	6.08 x 10 ⁻¹¹	7.02 x 10 ⁻⁰⁹	15	60.8	7020	912.00	105300
04/11/97	7.73 x 10 ⁻¹³	8.53 x 10 ⁻⁰⁹	17	0.773	8530	13.14	145010
04/21/97	7.68 x 10 ⁻¹³	4.73 x 10 ⁻⁰⁹	10	0.768	4730	7.68	47300
05/24/97	2.07 x 10 ⁻¹²	5.41 x 10 ⁻⁰⁹	33	2.07	5410	68.31	178530
06/09/97	6.00 x 10 ⁻¹²	1.09 x 10 ⁻⁰⁸	15	6	10900	90.00	163500
06/18/97	3.55 x 10 ⁻¹²	8.60 x 10 ⁻⁰⁹	9	3.55	8600	31.95	77400
07/02/97	7.54 x 10 ⁻¹³	4.50 x 10 ⁻⁰⁹	14	0.754	4500	10.56	63000
07/14/97	4.13 x 10 ⁻¹³	4.94 x 10 ⁻⁰⁹	12	0.413	4940	4.96	59280
07/28/97	2.98 x 10 ⁻¹²		14	2.98	4095	41.72	57330
08/11/97	-1.13 x 10 ⁻¹²		14	-1.13	4095	-15.82	57330
08/25/97	-7.86 x 10 ⁻¹³		14	-0.786	4095	-11.00	57330
09/08/97	-6.95 x 10 ⁻¹³		14	-0.695	4095	-9.73	57330
09/22/97	5.87 x 10 ⁻¹³		14	0.587	4095	8.22	57330
10/06/97	1.36 x 10 ⁻¹²		14	1.36	4095	19.00	57330
10/20/97	4.40 x 10 ⁻¹¹	3.30 x 10 ⁻⁰⁹	14	44	3300	616.00	46200
11/03/97	1.38 x 10 ⁻¹³		14	0.138		1.93	0
11/10/97	7.03 x 10 ⁻¹³	4.46 x 10 ⁻⁰⁹	7	0.703	4460	4.92	31220
11/17/97		5.25 x 10 ⁻⁰⁹					
11/24/97	-1.24 x 10 ⁻¹³	3.90 x 10 ⁻⁰⁹	14	-0.124	6405	-1.74	89670
12/01/97		3.76 x 10 ⁻⁰⁹					
12/08/97	1.92 x 10 ⁻¹⁴	4.42 x 10 ⁻⁰⁹	14	0.0192	5726	0.27	80164
12/15/97		3.59 x 10 ⁻⁰⁹					
12/22/97	8.13 x 10 ⁻¹³	3.27 x 10 ⁻⁰⁹	14	0.813	4802	11.38	67228
12/29/97		2.46 x 10 ⁻⁰⁹					
01/05/98	1.54 x 10 ⁻¹³	3.97 x 10 ⁻⁰⁹	14	0.154	4501	2.16	63014
Sum			353			1838	2071576
Weighted Average pCi/m ³						5.2	5868

**APPENDIX B
EMISSIONS FROM CONTAINMENT PONDS**

EMISSION FROM TUNNELS, PONDS, ETC.

Effluent water from the Area 12 E Tunnel and the containment ponds that receive that water were sampled monthly. These water samples are analyzed for radionuclides by gamma spectroscopy, for gross beta, and for tritium (as HTO). Less frequently, other samples are collected for analysis of plutonium and strontium. The flow rate of water discharged from the tunnels was measured weekly. The total amount of radioactive liquid effluent from the tunnels is calculated from the concentration of radionuclides in the water and the total volume of water discharged during the year is based on the weekly measurements.

In order to calculate doses using CAP88-PC, an airborne source term must be known. By assuming that the total amount of tritium (as HTO) measured in the liquid effluent during the year evaporates and becomes airborne, a conservative estimate of the airborne source term is obtained. It is unlikely that this is a true source term for the containment pond, but it is an upper limit of the effluents which could be released. The fact that the concentration of tritium in the ponds at the beginning and end of the year has been relatively constant⁽³⁾ (1995 data) lends credence to this calculation. The tunnels have been sealed so E Tunnel is now the only source of HTO to tunnel ponds. The curies of HTO discharged are shown in Table B-1.

In 1997, two wells in Area 3 were recompleted. To purge these wells, HTO was pumped from them into lined containment ponds. At one well, the concentration of HTO ranged from MDC to 3,200 pCi/L. The data were plotted and the area under the curve measured to determine that 0.55 Ci was discharged to the pond. The purging of the other well yielded water ranging from 12 µCi/L to 13.7 µCi/L with an average value of 13 µCi/L. The total discharge in this case was 3.7 Ci as shown in Table B-1.

Table B-1 Tritium in Water Effluents in 1997

<u>Location</u>	<u>Area (m²)</u>	<u>Total ³H Discharged (Ci)</u>
Area 12 E Tunnel	336	16
Area 3 Well U-3cn PS No. 2	--	3.7
Area 3 Well U-3cn 5	--	0.55
Total Effluent		20.2

The MEI for the Area 12 emission resides in Indian Springs, Nevada and would receive an EDE of 0.68 µrem (6.8×10^{-6} mSv).

⁽³⁾ For example: E Tunnel Pond	<u>Result (X)</u>	<u>Quarter</u>
	5.65×10^{-4}	1st
	4.91×10^{-4}	4th

The MEI for the Area 3 emission resides in Springdale, Nevada and would receive an EDE of 3.6×10^{-6} mrem (3.6×10^{-8} mSv).

A calculation was performed in the 1995 NESHAPs report to estimate tritium emission from the E Tunnel pond during 1994 using the methods for estimating diffuse emissions as suggested in the EPA report dated July 1994 for comparison with the above method. It was concluded that the EPA method seriously underestimated the effluent source term so the calculation was not repeated herein. For reference, the equation used for that calculation is repeated below. Use of the equation resulted in a source term of 2.4 Ci for 1995, when total evaporation would yield a more conservative source term estimate of 260 Ci.

EVAPORATION OF WATER - EPA's RECOMMENDATION

The following is the formula on page 26 of the EPA report that is recommended for estimating water evaporation from a circular pool:

$$E = \frac{20.73 \times P_s \times A^{0.9} \times U^{0.8}}{T^{1.47}}$$

where

E = evaporation rate, g/s

A = surface area of pond, m²

U = wind speed, m/s

P_s = equilibrium water vapor pressure at ambient temperature, mm Hg

T = °K = °C + 273.2

APPENDIX C RADIONUCLIDE INVENTORY OF RADIOANALYTICAL LABORATORIES

Analytical Services Laboratory

The inventory of radionuclides in the Analytical Services Laboratory, located in Building 650, at the NTS, was estimated by inventorying the standards, check sources, and tracer solutions. The activity contained in these sources was orders of magnitude above that contained in samples (based on data collected in previous years), so they are listed in Table C.1 on the next page.

From the inventory, only three of the items are volatile and may become a source of air emissions. These items are ^3H (as HTO), ^{129}I , and ^{85}Kr and are listed in Table 2.0, above. All of the standards and solutions are compared to the possession limits set forth in Title 40 CFR 61, Appendix E, and all are less than 1 percent of those limits, as shown in the last column of Table C.1, so they present no problems.

LANL Laboratory

In previous years, this laboratory maintained standards of radioactivity containing ^{133}Xe , ^{131}I , and ^3H . Due to the test moratorium that began in 1992, the need for standards was reduced and the only standard of significance for airborne emission maintained in 1997 was 500 μCi of tritium (5×10^{-4} Ci). This quantity is assumed to evaporate over the course of the year and adds to the amount listed above for BN.

Table C.1 Building 650 Analytical Services Laboratory Inventory Compared to NESHP

<u>Radionuclide</u>	<u>Annual Inventory (μCi/Year)</u>	<u>Possession Limit (Ci/Year Liquid Form)</u>	<u>Ratio %</u>
H-3	202.000	15000.000	1.3×10^{-6}
C-14	5.100	290.000	1.8×10^{-6}
Fe-55	6.400	140.000	4.6×10^{-6}
Cr-51	0.000	63.000	0.0
Co-57	0.075	1.600	4.7×10^{-6}
Co-60	0.700	0.016	4.4×10^{-3}
Ni-63	6.490	140.000	4.6×10^{-6}
Kr-85	18600.000	840.000	2.2×10^{-3}
Sr-85	0.036	1.900	1.9×10^{-6}
Sr-89	0.190	21.000	9.0×10^{-7}
Sr-90	0.350	0.520	6.7×10^{-5}
Y-88	0.290	0.250	1.2×10^{-4}
Tc-99	6.940	9.000	7.7×10^{-5}
Cd-109	3.200	5.000	6.4×10^{-5}
Sn-113	0.430	1.900	2.3×10^{-5}
I-129	1.510	0.260	5.8×10^{-4}
I-131	0.000	6.700	0.0
Te-123	0.045	1.200	1.3×10^{-6}
Cs-137	0.720	0.023	3.1×10^{-3}
Pb-210	0.500	0.055	9.1×10^{-4}
Ra-226	10.100	0.006	1.8×10^{-1}
Ra-228	0.015	0.013	1.2×10^{-4}
Th-229	0.050	0.001	1.0×10^{-2}
Th-230	0.008	0.003	2.5×10^{-4}
Th-Nat	0.009	--	--
U-232	0.013	0.001	1.0×10^{-3}
U-Nat	0.120	0.009	1.4×10^{-3}
Np-237	0.013	0.002	7.2×10^{-4}
Pu-238	0.055	0.003	2.2×10^{-3}
Pu-241	0.040	0.130	3.1×10^{-5}
Pu-242	0.006	0.003	2.4×10^{-4}
Am-241	1.420	0.002	6.2×10^{-2}
Am-243	0.001	0.002	2.6×10^{-5}
Cm-244	0.000	0.004	0.0
Alpha Emitters ^(a)	12	0.0042	2.8×10^{-1}
Beta Emitters ^(b)	15	0.52	2.9×10^{-3}
Gamma Emitters ^(c)	6	0.016	3.8×10^{-2}

(a) Alpha emitters include Th, U, and transuranics. The possession limit is that for ^{244}Cm (Title 40 CFR 61 Appendix E, Table 1).

(b) Beta emitters include the sum of ^{14}C , ^{36}Cl , ^{89}Sr , ^{90}Sr , ^{99}Tc , and ^{155}Eu and are compared to the ^{90}Sr annual possession quantity (Title 40 CFR 61 Appendix E, Table 1).

(c) Gamma emitters include the sum of cobalt, chromium, and the mixed gamma sources, and the possession limit is for ^{60}Co (Title 40 CFR 61 Appendix E, Table 1).

APPENDIX D DIFFUSE SOURCE ATMOSPHERIC TRITIUM EMISSIONS

BACKGROUND INFORMATION

Environmental monitoring for tritium in atmospheric moisture was conducted at 13 locations on the NTS for varying amounts of time. There were four air samplers around the RWMS perimeter in RWMS-5 because many curies of ^3H are buried at that facility. Some of these samplers collect tritium concentrations that are higher than background levels. In 1997, the monitors at the tunnel pond area, near the SEDAN crater, and at the EPA Farm measured tritium at slightly higher than background concentrations. The monitoring results from these sampling stations are provided in Table D.1. The other CY 1997 monitoring data indicate that gross beta and $^{239+240}\text{Pu}$ concentrations in air at RWMS-5 are not statistically different from site-wide NTS levels.

SOURCE TERM

It is estimated that 0.24 Ci (8.9 Gbq) of ^3H were emitted from RWMS-5 during 1997. This source term is calculated to give an EDE of 3.2 nrem (0.032 nSv) to an individual residing in Amargosa Valley (Lathrop Wells), Nevada. This is the location of the MEI for a source in Area 5. The method used to calculate this quantity is described below.

Only environmental monitoring data were available, and there was no information on the volume of air discharged from the RWMS. Considering that the RWMS only processes packaged waste, it is not likely that an air volume or discharge can be determined. However, a source term can be calculated using a method similar to that described for Yucca Flat in Appendix E.

The mean annual airborne HTO concentrations from the tritium samplers surrounding the RWMS were used along with the DOE/EH-0071 dose conversion factors to calculate a dose at each sampler location. For example, an individual breathing 3.7×10^{-12} $\mu\text{Ci/mL}$ of HTO (at RWMS No. 4), for one year, receives 2.9 μrem EDE when skin absorption is included⁽⁴⁾. Doses are calculated similarly for the other sampler locations. The result of a CAP88-PC run, assuming a one curie release of ^3H at the center of the RWMS, is that an individual 418 meters to the northeast (the location of RWMS No. 4) would receive an EDE of 12 μrem per year. Therefore, 2.9 μrem measured at that sampler divided by 12 $\mu\text{rem/Ci}$ (from CAP88PC) equals an estimated annual release of 0.24 Ci. This calculation was performed for all sampler locations, as shown in Table D.1 and a release of 0.24 Ci (8.9 GBq) was the maximum estimate as shown in the last column of Table D.1.

Amargosa Valley, Nevada is located west-southwest of the RWMS at 44 km. Use of CAP88-PC results in an EDE of 3.2×10^{-6} mrem to an individual residing in Amargosa Valley if 0.24 Ci of HTO were released from the RWMS-5.

⁽⁴⁾ The following equation was used to calculate an EDE at each sampler location.

$$\text{EDE} = \text{pCi/m}^3 \times 8400 \text{ m}^3/\text{yr (inhaled)} \times 1.5 \text{ (skin abs.)} \times 6.4 \times 10^{-8} \text{ mrem/pCi}$$

where pCi/m^3 is the annual average HTO concentration.

The other samplers with elevated mean concentrations of HTO in air are at the Area 10 SEDAN crater and the E Tunnel Pond. The E Tunnel Pond emission is calculated in Appendix B. The emission from the SEDAN crater (calculated from air sampler data as above) is shown in the table, assuming SEDAN is the source. Note that the sampler installed there detected an HTO level higher than the Area 15 Farm sampler. It also appears unlikely that as much as 140 Ci of HTO are being emitted from the SEDAN crater. However, there is no other likely source for the tritium measured in atmospheric moisture in that area. Therefore, the RWMS-5 and the SEDAN crater are considered to be sources for emission of HTO on the NTS.

Table D.1 Airborne Tritium Sampling Results During CY 1997

Sampler Number	Direction ^(a) from Center		Mean		Ratio to 1 Ci Emission ^(b)
			$\mu\text{Ci/mL}$	Bq/m^3	
RWMS No. 1	SE	381 m	1.4×10^{-12}	0.05	0.03
RWMS No. 4	NE	418 m	3.7×10^{-12}	0.14	0.24
RWMS No. 6	NW	418 m	1.5×10^{-12}	0.006	0.02
RWMS No. 8	SW	418 m	8.4×10^{-12}	0.31	0.15
Area 15 Farm			7.3×10^{-12}	0.27	
SEDAN Crater	N	1290 m	8.6×10^{-12}	0.36	140
Area 12 Camp			0.4×10^{-12}	0.02	
E Tunnel Pond			12.9×10^{-12}	0.48	
U-3ah/at North			1.2×10^{-12}	0.04	
H&S Building			0.04×10^{-12}	0.002	

(a) Sampler direction and distance from center of suspected source.

(b) This ratio equals the number of curies emitted from RWMS that would give the sampler result.

APPENDIX E
RESUSPENDED PLUTONIUM FROM YUCCA FLAT AND OTHER AREAS

BACKGROUND INFORMATION

Many areas on the NTS are diffuse sources of radionuclide effluents because of previously deposited radionuclides. Due to operational activities, such as vehicular traffic, equipment operation, etc., some soil becomes airborne. Results from the air samplers indicate that $^{239+240}\text{Pu}$ is routinely detected in concentrations above the MDC. Few of the 31 air sampler locations on the NTS had concentrations exceeding the network average by four standard deviations (the criterion used for a high result).

Measurements of airborne $^{239+240}\text{Pu}$ in Area 3, during CY 1997, are provided in Table E.1. Other NTS areas had concentrations ranging from 10 to $236 \times 10^{-18} \mu\text{Ci/mL}$. The table displays the number of samples analyzed, the mean value, and the standard deviation of the values. Because Area 3 is an area source, it is difficult to measure the volume of air discharged. Therefore, the source term must be estimated. To estimate the curies per year from the area, the measured $^{239+240}\text{Pu}$ concentration was used in conjunction with CAP88-PC in order to back calculate a source term. For convenience, the source was assumed to be an area in the center of a circle of 620 m radius that touches the three sampling locations (worst-case assumption).

Table E.1 Airborne $^{239+240}\text{Pu}$ Detected by Area 3 Air Samplers

<u>Location</u>	<u>Number of Samples</u>	<u>($\mu\text{Ci/mL} \times 10^{-18}$)</u>	
		<u>Mean</u>	<u>1 Standard Deviation</u>
Area 3 Mud Plant	4	41.2	19
Area 3 U3ah/at (2 Samplers)	8	61.0	65

SOURCE TERM

It is estimated that 12 mCi (0.42 Gbq) of $^{239+240}\text{Pu}$ may have been emitted from Area 3. This source term is only probable, because it is a worst-case value that is based on calculations rather than on effluent monitoring. The method used to calculate it is described below.

The first method uses the CY 1997 mean concentration of $^{239+240}\text{Pu}$ as tabulated above. Using the dose conversion factor of 310 rem/ μCi derived from Federal Guidance Report No. 11 (using class Y) and 8400 m^3 annual average air intake per person, an EDE can be calculated for a person remaining all year at a sampler location.

A trial run of CAP88-PC using a one curie release from the center of the samplers gives an EDE at each of them. When the calculated EDE at each sampler, using that sampler's annual average concentration, is divided by the EDE/Ci from the CAP88-PC run, then an estimate of the curies released can be obtained.

The following shows a typical calculation, using the first datum in Table E.1 ($\mu\text{Ci}/\text{mL} \times 10^{12} = \text{pCi}/\text{m}^3$):

$$1.2 \times 10^{-6} \text{ pCi}/\text{m}^3 \times 8400 \text{ m}^3/\text{yr} \times 0.31 \text{ mrem}/\text{pCi} = 0.11 \text{ mrem}$$

A CAP88 run using one curie and 670 m distance indicates an EDE of 220 mrem at the location of the sampler. The ratio of 0.11 mrem (measured) to 220 gives 5×10^{-4} Ci as an emission. Using the higher value in the above table indicates the maximum emission would be 0.73 mCi (27 MBq). Wind transport has only extended the boundaries of the plutonium contaminated areas a few meters since the 1960s, so it is not very mobile, and of the amount resuspended, only a fraction would be in particle sizes small enough to be carried very far by the wind. This suggests that the calculated emission may be greater than the actual amount.

In the second method, a more conservative calculation is to use the resuspension equation as is done below for the plutonium deposit in Area 9. In that case the emission would be 12 mCi/yr. This would yield an EDE of 0.005 mrem to a person in Springdale, Nevada, the offsite MEI.

ERROR TERM

The errors in the measurements are listed in Table E.1 as a standard deviation, so the EDE is most likely between 0 and 1.5×10^{-2} mrem (0 and 1.5×10^{-4} mSv). However, the errors that occur in estimating a source term, as described above, are very difficult to assess.

CALCULATION OF PLUTONIUM RESUSPENSION FROM AREA 9

There is an air sampler in Area 9 at one end of a ground deposit of plutonium that usually collects air samples having a higher concentration than the NTS average, but it would require too many assumptions to use the above method. McArthur, in DOE/NV/10845-02, estimates a $^{238+240}\text{Pu}$ deposit of 75.6 Ci on 7.5 mi² in that area. If the rate of resuspension of that material can be calculated, then a source term would be available.

In the book "Radiological Assessment" by J. E. Till and H. R. Meyer, page 5-30, an equation for calculating a suspension rate (fraction resuspended per second) is given as follows:

$$S = K \times V_g$$

where: S = suspension rate (sec^{-1}) - fraction of the deposit resuspended/sec
K = resuspension factor (m^{-1})
 V_g = deposition velocity (m/s)

On page 75 of report DOE/NV-357, values of K are given for the NTS. An average of the values given is 2×10^{-10} per m. Deposition velocities in the range of 0.01 to 0.05 m/s will be used as conservative estimates. If these values are put into the above equation, the rate of suspension is between 2×10^{-12} and 1×10^{-11} per second, and the source term becomes:

$$\begin{aligned} 75.6 \text{ Ci} \times 10^{12} \text{ pCi}/\text{Ci} \times 1 \times 10^{-11}/\text{s} &= 756 \text{ pCi}/\text{s} \\ 1 \text{ year} &= 3600 \text{ s}/\text{hr} \times 24 \text{ hr}/\text{day} \times 365 \text{ days}/\text{yr} = 3.15 \times 10^7 \text{ s}/\text{yr} \end{aligned}$$

Annual source term becomes:

$$756 \text{ pCi}/\text{s} \times 3.15 \times 10^7 \text{ s}/\text{yr} = 2.38 \times 10^{10} \text{ pCi}/\text{yr} \text{ (24 mCi}/\text{yr)}$$

or, with other value:

$$4.76 \times 10^9 \text{ pCi}/\text{yr} \text{ (4.8 mCi}/\text{yr)}$$

Therefore, using the above suspension rate, the emission is between 4.7 and 24 mCi/yr. Using the larger value, this emission was input to the CAP88 program using the Area 9-300 bunker as the midpoint of the source. A similar calculation was performed for all other plutonium contaminated areas on the NTS and the Nellis Air Force Range Complex. That is, the estimate of Pu deposition on each area, from McArthur, are used with the resuspension equation to obtain the source terms shown in Table E-2.

Using the equation in EPA's Methods for Estimating Diffuse Emissions (July 1994 draft), another calculation can be done.

WIND EROSION CALCULATION FOR AREA 9 - COMPARISON WITH NTS NESHAP REPORT

The equation used is on page 18 of the EPA report:

$$E' = k \cdot a \cdot l \cdot K \cdot C \cdot L' \cdot V' \cdot A \cdot c$$

where:

- E' = soil particles lost (tons/yr)
- k = particle size factor
- a = total suspended fraction lost to wind erosion
- l = soil erodibility (tons/acre-yr)
- K = surface roughness factor
- C = climatic factor - $C = 0.345 (\text{mph}^3/\text{PE}^2)$ where $\text{PE} = 0.83$
- L' = unsheltered field width factor
- V' = vegetative cover factor
- A = site area (m^2) - use high density of 75.6 Ci on 7.5 mi^2
- c = conversion factor tons/acre to $\text{kg}/\text{m} = 0.224$

Inputs: Yucca Flat is typical high plain desert with sparse vegetation. Average wind speed is 6.0 knots = $6 \times 0.514 \text{ m/s} = 3.08 \text{ m/s} = 11.1 \text{ km/hr} (6.9 \text{ mph})$.

- k = 0.5 (fraction of resuspended soil that is PM_{10})
- a = 0.025 portion of total erosion that is suspended particulates
- l = 28 (silty clay loam from Table 7-1, desert pavement decreases erodibility)
- K = 1 (surface roughness - desert is smooth)
- C = 164 (climatic factor calculated from $C = 0.345(\text{mph})^3/(0.83)^2$)
- L' = 0.3 as read from Figure 7-5 ($lK = 28 \times 0.6 = 17$, $L = 500$ from Table 7-3)
- V' = 0.95 (read from Figure 7-6 using $V = 100$; from Table 7-3 and $lKCL' = 790$)
- A = $7.5 \text{ mi}^2 = 1.9 \times 10^7 \text{ m}^2$ (from McArthur's report)

so: $E' = 0.5 \times 0.025 \times 28 \times 1 \times 164 \times 0.3 \times 0.95 \times 0.224 = 3.7 \text{ kg}/\text{m}^2\text{-yr}$

Area 9 (From McArthur): $75.6 \text{ Ci on } 7.5 \text{ mi}^2 (7.5 \times 2.59 \times 10^6 \text{ m}^2/\text{mi}^2)$ or $1.9 \times 10^7 \text{ m}^2$
 Total Emission = $3.7 \text{ kg}/\text{m}^2\text{-yr} \times 1.9 \times 10^7 \text{ m}^2 = 7.0 \times 10^7 \text{ kg/yr}$

Pu concentration in dust (assuming all Pu is in top 5 cm):

$$1.9 \times 10^7 \text{ m}^2 \times 10^4 \text{ cm}^2/\text{m}^2 \times 5 \text{ cm deep} \times 1.5 \text{ g}/\text{cm}^3 = 1.4 \times 10^{12} \text{ g}$$

$$75.6 \text{ Ci} \times 10^{12} \text{ pCi/Ci} \div 1.4 \times 10^{12} \text{ g} = 53 \text{ pCi/g or } 53 \text{ nCi/kg}$$

and the source-term becomes:

$$53 \times 10^{-9} \text{ Ci/kg} \times 7.0 \times 10^7 \text{ kg/yr} = 3.7 \text{ Ci/yr}$$

If the total deposit in Area 9 is 75.6 Ci and the E' calculation performed above is correct, then $75.6 \text{ Ci} \div 3.7 \text{ Ci/yr} = 20.4$ suggests that the deposit would be depleted in little more than 20 years, so there would be none left to be resuspended.

The resuspension equation calculation (0.0238 Ci/yr) would require about 3,200 years to deplete the deposit, yet it gives offsite concentrations higher than actually measured.

Table E.2 Offsite EDE Calculated from Resuspension of Pu from NTS Areas - 1997 (µrem)

Location	Population	Area 3	Area 9	Area 10	Area 11	Area 13	Area 18	Area 19	CLEAN SLATE	SUM mrem
	Deposit	37 Ci	75.6 Ci	220 Ci	36 Ci	46 Ci	100 Ci	181 Ci	54 Ci	
Alamo	1000			5.8		1.6				0.0074
Amargosa Valley	30	6.8	12	30	6.5		15	11.4		0.0817
Amargosa Center	990	3.7	9.5	24	4.0		9.2	9.9		0.060
Ash Meadows	10	4.0			4.1		6			0.0141
Ash Springs	70					1.9				0.0019
Beatty	1570	4.9	9.5	26	3.8		3.3	29.1		0.077
Clarks Station	2								12	0.012
Crystal	45	3.9	6.5	17	7		20			0.0544
Goldfield	600								4.1	0.0041
Goldpoint	15									0
Hiko	103					1.8				0.0018
Indian Springs	1210	1.5	4.4	11	3.8					0.0207
Lida	15									0
Lida Junction	8							5.2	8.5	0.0137
Medlin's Ranch	2	2.4	5.5	13	2.3	6	1.9	3.6		0.0347
Mercury	550	9.7	12	29	10	3.8	29	5.7		0.0992

Table E.2 (Offsite EDE Calculated from Resuspension of Pu from NTS Areas - 1997 [µrem], cont.)

Location	Population	Area 3	Area 9	Area 10	Area 11	Area 13	Area 18	Area 19	CLEAN SLATE	SUM mrem
	Deposit	37 Ci	75.6 Ci	220 Ci	36 Ci	46 Ci	100 Ci	181 Ci	54 Ci	
Pahrump	18,700									
Penoyer Farm	16	2	4.4	16	1.5	5.5	2.1	7.3	0.85	0.0396
Rachel	105	1.9	4.3	15	1.6	6	2	4		0.0348
Sarcobatus Flat	40	2.3					7.6	15.6	4.4	0.0299
Silver Peak	200									0
So NV Corr Inst	2000	1.1			1.4					0.0025
Springdale	20	5	9.5	27	3.8		3.7	37	2.9	0.0889
Stateline	70	3.2			4.1		6.6			0.0139
Stone Cabin	6								8.9	0.0089
Tonopah	3450		3.8						4.0	0.0078
Twin Springs	6								2.4	0.0024
US Ecology	35	4.9	8.5	21	4.2		4.7	15.1		0.0584
Calculated Emission -		12	24	69	11	14	32	57	17	236

APPENDIX F
IDENTIFICATION AND JUSTIFICATION FOR THE DEVELOPMENT OF
METEOROLOGICAL DATA USED AS INPUT TO CAP88-PC

INTRODUCTION

The NTS is located in southern Nevada, approximately 90 km (56 mi) northwest of Las Vegas, and encompasses an approximate rectangular area of 3,500 Km² (1,350 mi²) (see Figure F.1). Topography is complex with generally north-south oriented ridges and valleys typical of Nevada. Terrain elevations range from near 2,700 ft in the extreme southwest corner of the NTS (Station No. 25) to near 7,700 ft on Rainier Mesa in the northern part of the NTS (Station No. 12).

In general, terrain slopes gently into broad valleys. In the few areas where steep canyons or cliffs exist, adequate wind and temperature data have been collected and analyzed to provide thorough documentation of the existence of typical up-slope and down-slope wind regimes as a function of time of day.

Meteorological support, observations, and climatological services for the NTS are provided to the DOE/NV by the ARL/SORD. The ARL/SORD is a National Oceanic and Atmospheric Administration (NOAA) office and supports DOE/NV programs under the authority of an Interagency Agreement between NOAA and DOE/NV.

An arid climate exists over the NTS. Annual precipitation ranges from 4.5 in/yr at Station No. 25 to 6.9 in/yr in Yucca Flat, to 7.6 in/yr at Desert Rock, and to 9.5 in/yr on Rainier Mesa.

METEOROLOGICAL OBSERVATIONS

The ARL/SORD manages, operates, and maintains a meteorological monitoring program that is designed and used to support the DOE/NV authorized activities on the NTS. This vital program consists of many meteorological monitoring systems that have been brought together under the acronym MIDNET, or Meteorological Data Network. This network has been operated on the NTS for over 25 years, has undergone several modernizations and upgrades, and serves as a solid basis for deriving climatological information.

MIDNET consists of communications systems, local area networks, upper air sounding stations, and surface-based instrumentation used to measure wind direction and speed, temperature, relative humidity, and precipitation. Routine and special surface observations are collected by trained ARL/SORD personnel 24 hr/da, 365 da/yr at the Desert Rock Meteorological Observatory (DRA, elevation 3,304 ft) located three miles southwest of Mercury, Nevada (Station No. 23). Upper-air observations (radiosondes) are taken twice daily from DRA. DRA has been in operation since June 1978. The DRA was built to replace a similar observatory that was located in Yucca Flat Meteorological Observatory (UCC, elevation 3,924 ft, Station No. 6) from January 1962 through April 1978. Consequently, surface and upper-air observations are also available from UCC for 1962-1978.

A key component of the MIDNET system is the Meteorological Data Acquisition System (MEDA). MEDA consists of an enclosed trailer, a portable 10-m tower, an electric generator (where needed), a microprocessor, and a microwave radio transmitter. Wind speed and direction sensors are located on booms oriented into the prevailing wind direction and at a minimum distance of two tower widths from the tower. Wind sensors are located 10 m above the ground.

Wind and temperature data have been collected on the NTS for more than 25 years. These and other meteorological data have been compiled into a comprehensive climatological database for the NTS. The MEDA data are specially useful in assessing boundary layer flow regimes on the NTS. MEDA station distribution and density (see Figure F.1) are sufficient to document individual basin flow regimes and potential interbasin air exchanges.

Ambient temperature and relative humidity sensors are located at the 3-m level. A total of 40-50 MEDA stations are located on or around the NTS (see Figure F.1) to ensure that meteorological conditions are thoroughly documented for the complex terrain environment found on the NTS.

Wind direction is measured to two degrees of azimuth, and wind speed is accurate to 0.15 mph. Wind data are collected as 4-min averages and are transmitted via microwave to a central processor every 15 min. These data are checked operationally by the duty forecaster, and quality control is assured by the ARL/SORD climatologist. Plotted wind products are generated every 15 min for operational use. The data are stored and archived for climatological purposes.

MEDA temperature is accurate to 0.035 percent between 0°C and 40°C. Temperature measurements are instantaneous and are taken every 15 min at all MEDA stations. These data are also transmitted via microwave to a computer for processing, display, and archiving.

To utilize the most representative meteorological data available for NTS sources, cloud observations from DRA were melded with the concomitant MEDA winds from Mercury and Pahute Mesa. Similarly, the cloud observations from UCC were melded with MEDA wind data from Yucca and Frenchman Flats. The straight-line distance from DRA to Mercury is 3 mi; from UCC to Frenchman Flat, 12 mi; and from DRA to Pahute Mesa, 40 mi.

Cloud cover observations needed as input to the STAR program are available from DRA (1978-present) and from UCC (1962-1978). Based on the available data, the cloud cover climatology from DRA and UCC are quite compatible. For example, UCC experiences 192 clear days annually while DRA has 191 days. In addition, the average annual sky cover, from sunrise to sunset for both stations, is 3.9 tenths daily. The total number of cloudy days for UCC is 81 days and 88 days for DRA, annually. Therefore, the cloud cover observations from DRA and UCC can be considered as representative for most of the NTS.

In a study of precipitation on the NTS, Quiring (1983)⁽⁵⁾ found that the northwest part of the NTS, including Pahute Mesa, is clearly an area of diminished precipitation for the given elevation (6,500 ft). Furthermore, the total annual precipitation for Pahute Mesa (9.5 in) is more compatible with that from DRA (7.6 in) than from UCC (6.9 in). Consequently, assuming that cloud cover is directly related to precipitation, it logically follows that the cloud cover for Pahute Mesa is better represented climatologically by the cloud observations from DRA.

⁽⁵⁾ Quiring, R.F., "Precipitation Climatology for the NTS," NOAA Weather Service Nuclear Service Office (WSNSO), Las Vegas, NV, WSNSO 351-88, 34 pp., 1983.

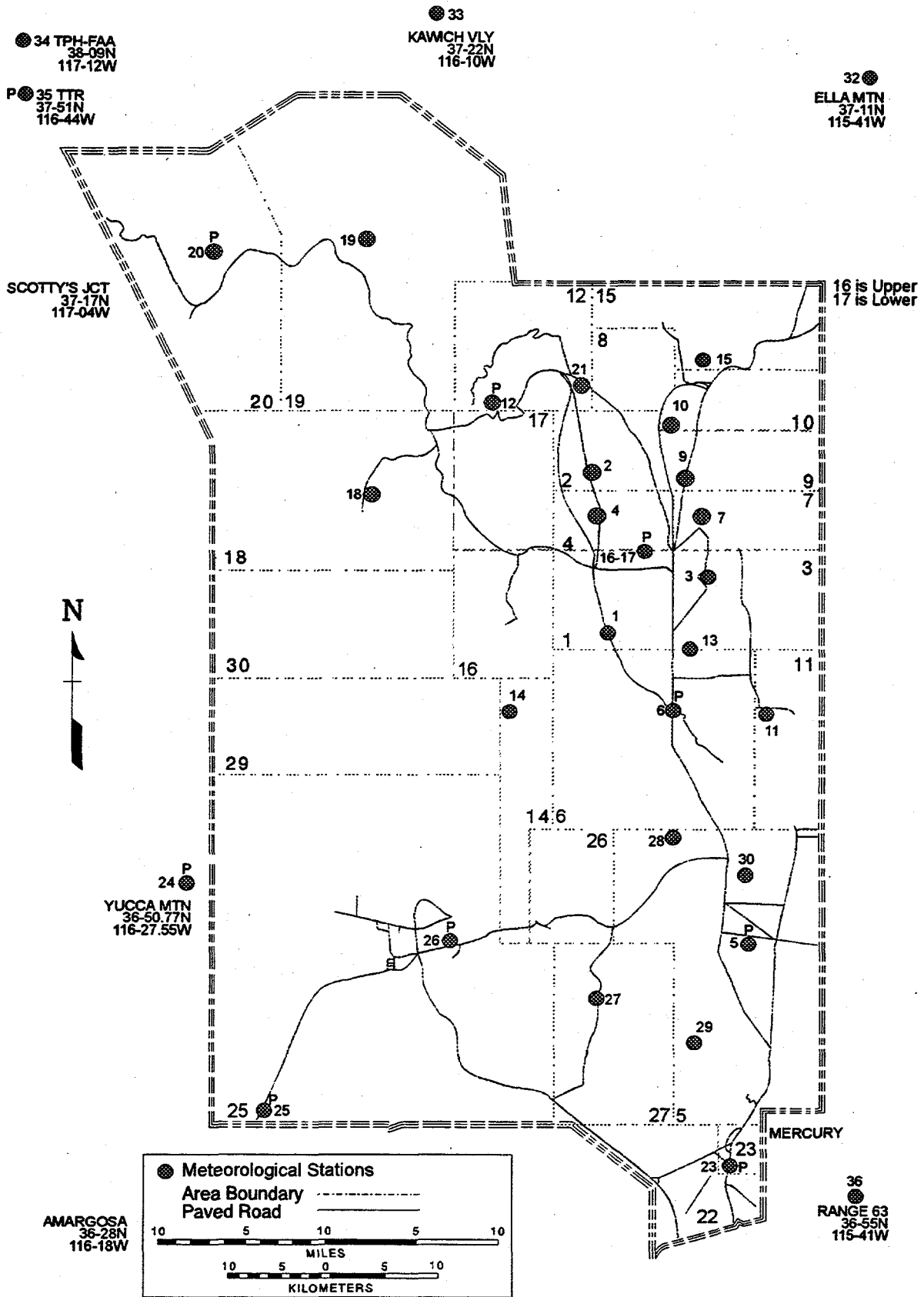


Figure F.1 Location of MEDA Stations on the NTS

CONCLUSIONS

Based on the above considerations and on the limitations of CAP88, the cloud cover data from DRA were considered to be representative of Pahute Mesa. Therefore, atmospheric soundings and cloud cover observations from DRA were melded with MEDA surface wind data, from Pahute Mesa, for input to the STAR program, to provide the very best data for calculating transport and dispersion processes.

For sources in Yucca Flat and Frenchman Flat, the cloud cover data from UCC were considered to be the most representative. Yucca Flat and Frenchman Flat are adjoining valleys of similar soil and vegetation types and similar meteorological and climatological conditions.

For sources at Mercury, the cloud observations from DRA are representative. DRA is only three miles from Mercury.

The STAR file is a matrix that includes 6 Pasquill stability categories (A through F), 6 wind speed categories, and 16 wind sectors from wind roses calculated for each specified MEDA station on the NTS.

**APPENDIX G
SUPPLEMENTAL INFORMATION**

COMPARISON WITH PREVIOUS YEARS' DATA

Maximum Potential Individual EDE:	1997 - 9.0×10^{-2} mrem (0.89 μ Sv)
	1996 - 1.1×10^{-1} mrem (1.1 μ Sv)
	1995 - 1.8×10^{-1} mrem (1.8 μ Sv)
	1994 - 1.5×10^{-1} mrem (1.5 μ Sv)
	1993 - 3.8×10^{-3} mrem (38 nSv)
	1992 - 1.2×10^{-2} mrem (0.12 μ Sv)
	1991 - 8.6×10^{-3} mrem (86 nSv)

In 1992, there was a 15 percent increase in HTO effluents, and the STAR for the tunnel area was developed that slightly changed the offsite distribution of the effluent. In 1993, tunnel effluents began decreasing because of sealing the tunnel drainage systems. In 1994, resuspension of plutonium from surface deposits was calculated. Area 20 emissions increased in 1995 (krypton seepage and HTO from characterization wells). The 1996 decrease was due to decreased emissions and cleanup of areas. The 1997 decrease was due to decreased emissions, cleanup of areas, and a small population decrease.

COLLECTIVE EDE

The maximum potential collective EDE to the 30,600 people who live within 80 km of the NTS emission sources was 0.26 person-mrem in 1997, due mostly to calculated resuspended plutonium exposure. Tritium exposure was less than last year because of the decrease in effluent from characterization wells. The collective EDE data are based on distance and direction from each of the sources of emission on the NTS and nearby areas. These data are displayed in the last column of Table 5.0. The collective EDE is the sum of the EDE to the community from each emission source multiplied by the population of the community.

Maximum Potential Collective EDE (person-mrem) by NTS Source:

Areas 3, 9	61
Areas 3, 5	0.12
Area 12	1.8
Other Areas	195
Area 10	1.25
	259 person-mrem
	(0.26 person-mrem)

The higher potential population doses from plutonium areas are due to the conservative assumptions about resuspension of plutonium from deposited material in those areas. The extent of overestimation was assessed in the 1994 report as follows: calculate the concentration of ^{239}Pu necessary to cause the CAP88-PC estimate of EDE. The CAP88-PC estimate was 0.15 mrem at Lathrop Wells due to resuspension. With a dose conversion factor of 308 rem/ μ Ci (from Federal Guidance Report 11) and an inhalation intake of 8,400 m^3/yr , obtain the concentration by dividing the 0.15 mrem by 0.31 mrem/ μ Ci and by 8,400 m^3/yr to obtain a concentration of 58×10^{-5} pCi/ m^3 . This is higher than the 3×10^{-6} pCi/ m^3 measured at Lathrop Wells by the EPA and indicates the conservatism in the calculation.

COMPLIANCE WITH NESHAP

DOE/NV was in compliance with Title 40 CFR 61, Subpart H, during CY 1997. Periodic confirmatory measurements and analyses of the NTS environs are provided in Appendices A through E. These measurements and analyses are the methods of determining NTS effluents presented in the April 24, 1991, meeting between Region 9 and DOE/NV and are documented in the 1990 through 1996 annual NESHAPs reports of DOE/NV.

COMPLIANCE WITH SUBPARTS Q AND T, Title 40 CFR 61

The NTS is regulated by Subpart H not Subparts Q and T. Measurements of ^{220}Rn and ^{222}Rn have not been made. Short-lived radon progeny may be detectable on particulate filters from air samplers deployed around the Radioactive Waste Management Facility.

RADON EMISSIONS FROM ^{238}U AND ^{232}Th SOURCES

Material from Mound Applied Technologies is stored in cargo containers at the RWMS-5. Thermoluminescent dosimeters placed around the containers have not detected an increase in gamma exposure that would occur as radon progeny accumulate in the cargo containers. During 1997, these materials were shipped offsite for recycling.

NON-DISPOSAL/NON-STORAGE SOURCES OF RADON EMISSION

None of these sources exist on the NTS.

NESHAPs QUALITY ASSURANCE PROGRAM

Provisions in Method 114 described in Appendix B of Title 40 CFR 61 are related to continuous monitoring of major sources. The NTS has only minor sources.

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