DOE/NV/11718-032
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National Emission Standards for Hazardous Air Pollutants Submittal - 1995

By
Stuart C. Black

June 1996

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

Prepared by:
Bechtel Nevada
Post Office Box 98521
Las Vegas, Nevada 89193-8521

DISCLAIMER

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Yvonne E. Townsend

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LIST OF ACRONYMS

ARL/SORD	Air Resources Laboratory Special Operations and Research Division
DNA	Defense Nuclear Agency
DRA	Desert Rock Meteorological Observatory
DOE/NV	U.S. Department of Energy Nevada Operations Office
EDE	Effective Dose Equivalent
EIS	Effluent Information System
EPA	U.S. Environmental Protection Agency
ES&H	Environment, Safety, and Health
GCD	Greater Confinement Disposal
HEPA	High Efficiency Particulate Air - an Air Filter
HTO	Tritiated Water
LANL	Los Alamos National Laboratory
LGFSTF	Liquified Gaseous Fuels Spill Test Facility
LLNL	Lawrence Livermore National Laboratory
LLW	Low-Level Waste
LOS	Line-of-Sight
LPG	Liquified Petroleum Gas
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
OR	Occurrence Report
Pu	Plutonium
REECo	Reynolds Electrical & Engineering Co., Inc.
RSL-LV	EPA Radiation Sciences Laboratory - Las Vegas
RWMS	Radioactive Waste Management Site
SNL	Sandia National Laboratories
STAR	Stability Array - Grouping of Meteorological Data
TRU	Transuranic - Nuclides with Atomic Numbers Greater than Uranium
UCC	Elevation 3924 ft, Station No. 6
WSNSO	Weather Service Nuclear Support Office

U.S. Department of Energy
Air Emissions Annual Report
(under Subpart H, 40 C.F.R. 61.94)
Calendar Year 1995

Site Name: Nevada Test Site

Operations Office Information

Office: DOE Nevada Operations Office

Address: P. O. Box 98518

Las Vegas, NV 89193-8518

Contact: Kenneth A. Hoar, Director Phone: (702) 295-1428

Environmental Protection Division

Site Information

Operator: Bechtel Nevada Corp.

Address: P. O. Box 98521

Las Vegas, NV 89193-8521

Contact: James R. Kannard Phone: (702) 295-5689

Assistant General Manager, Environmental Management

SECTION I
FACILITY INFORMATION

SITE DESCRIPTION

The Nevada Test Site (NTS) is operated by the U.S. Department of Energy Nevada Operations Office (DOE/NV) as the site for nuclear weapons testing. 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 3500 km^2 (1350 mi^2), 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 Base Range) 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 source includes current and previous activities conducted on the NTS. Figure 2.0 is a map of the NTS which shows the areas used for such activities. The NTS has been the primary location for testing of nuclear explosives in the Continental U.S. since 1951. 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. By order of the President, no nuclear tests have been conducted since September 1992. Limited non-nuclear testing includes spills of hazardous materials at the Liquefied Gaseous Fuels Spill Test Facility (LGFSTF). 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 a radioactive waste management site (RWMS) 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 1995 were releases: (1) from evaporation of tritiated water from containment ponds that receive drainage water from E tunnel in Area 12 and from wells used for site characterization studies, (2) from onsite radioanalytical laboratories, (3) from the Area 5 RWMS facility, and (4) from diffuse sources of krypton 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 EG&G Energy Measurements, there was an Unusual Occurrence that led to an insignificant potential exposure to an offsite person. The incident involved the release of tritiated water (HTO), and 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 pump 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.

Krypton-85 is generally detected on the NTS at air concentrations consistent with data previously collected in offsite areas by the Radiation Sciences Laboratory of the EPA in Las Vegas (RSL-LV). During 1995, krypton-85 was detected at all environmental monitoring stations as it has been in previous years. The sampler located at the Area 20 camp detected an average annual concentration of 6.1 pCi/m^3 (0.23 Bq/m^3) greater than the average concentration outside of Pahute Mesa. A source term can be calculated as shown in Appendix B.

Tunnel Operations

Nuclear tests have been conducted within tunnel complexes mined into the Rainier Mesa region; no such tests were conducted in 1995. When tests were conducted, purging gases from the tunnel occasionally resulted in releases of radioactivity, and contaminated water drained from them (see below). Figure 3.0 is a photograph of a tunnel portal.

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 4.0. Because some of the tunnels have been sealed, water seeped only from E Tunnel in 1995. The only radiological contaminant which produces a measurable air emission from evaporation of the water is ^3H (as HTO). It is expected to cease completely in the near future as remedial actions are being implemented. Calculation of the source term is described in Appendix C.

To characterize the groundwater regime under the NTS, suitable wells are being drilled in the vicinity of certain underground tests as well as at other locations. During these drilling operations, contaminated water can 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 calculations for this activity are also described in Appendix C.

Drillbacks

Following underground nuclear tests, core samples are 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 1995.

Laboratories

Radiological analyses are conducted by REECo 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 5.0 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 and for Building 650 is described in Appendix D. 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 40 C.F.R. 61 as shown in Appendix D.

Radioactive Waste Management Sites

These sites in Areas 3 and 5 are used for the disposal of low-level radioactive waste, and the Area 5 site 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 Area 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 E. The Area 3 low-level waste (LLW) site is in a location where surface soil has been contaminated by deposited plutonium, 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 of the NTS were contaminated with plutonium from either nuclear device safety, atmospheric, or cratering tests (the Plowshare Program) using nuclear explosives. An investigation of these areas during the Nevada Applied Ecology Group studies[1] 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 6.0 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 2 standard deviation (2s) counting error. The results that are different 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 plutonium contaminated areas is explained in Appendix F.

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[1] Friesen, H.N., 1992, Summary of the Nevada Applied Ecology Group and Correlative Programs, Report DOE/NV-357, Nevada Field Office, U.S. Dept. of Energy, Las Vegas, Nevada.

Table 1.0 Summary of Estimated Inventory of $^{239+240}Pu$ 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)	$^{239+240}Pu$ AIR CONC. ANNUAL AVG. ($\bar{X} \pm 2s$) IN 10^{-18} µCi/mL UNITS
PROJECT 56 (AREA 11)(1)	4.83	205	36	28 - 44	23 ± 39
GMX (AREA 5)(1)	0.125	111	1.5	1.1 - 1.9	5 ± 5
LITTLE FELLER II (Area 18)(4)	0.375	712	32(3)	22 - 41	
PALANQUIN (AREA 20)(2)	3.895	148	13(3)	6 - 21	1.6 ± 1.2
SEDAN (AREA 10)(2)	28.264		111.2		12 ± 13
T2 SERIES (AREA 2)(4)	30.100		26.7		8 ± 16
VARIOUS TESTS (AREA 9)			89		245 ± 216
AREA 13 (1)	4.02	169	46	28 - 64	
CLEAN SLATE & DOUBLE TRACKS (1)	2.6	236	61.8		

(1) Safety tests of nuclear devices.
(2) Plowshare tests (PALANQUIN and CABRIOLET sites in Area 20 combined).
(3) Inventory consists of $^{239+240}Pu + ^{241}Am$
(Gilbert, NVO-181 p. 425; NVO-272, pp. 381-429; McArthur, DOE/NV10162-20).
(4) Weapons effects tests.

SECTION II
AIR EMISSIONS DATA

Each potential source of NTS emissions was characterized by one of the following methods: (1) by monitoring methods and procedures previously developed at the NTS; (2) by a yearly radionuclide inventory of the source, assuming that volatile radionuclides are released to the environment; (3) by the measurement of tritiated water (as HTO or T_2O) 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) by using a combination of environmental measurements and CAP88-PC to calculate emissions (generally confirmed by offsite air measurements). Appendices A through F describe the methods used to determine the emissions from the sources listed in Section I. In accordance with 40 C.F.R. 61.93.(b).(4), no credit was taken for pollution control equipment in determining air emissions.

These National Emission Standards for Hazardous Air Pollutants (NESHAP) emissions as listed in Table 2.0, are very conservative (worst-case); are used in Section III to calculate the EDE to the Maximally Exposed Individual offsite (MEI); and exceed, in some cases, those reported in DOE's Effluent Information System (EIS). The NESHAP's worst-case emissions that exceed the EIS reported emissions are noted by a (1) in Table 2.0. Offsite environmental surveillance data, where available, are used to confirm that calculated emissions are, indeed, conservative.

A summary of the NTS total CY 1995 emissions for NESHAP's reporting, by radionuclide, is provided in Table 3.0.

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

Point Source	Type of Control	Efficiency	Distance to Nearest Receptor	Nuclide	Quantity (Ci)
Building 701 (1)	None	0%	24 km	^{3}H	5.0×10^{-4}
Building A-1 (Atlas)	None	0%	0.1 km	^{3}H	0.25
Grouped Sources					
Building 650 (1) Laboratory (12)(4)	None	0%	24 km	^{3}H ^{85}Kr ^{129}I	2.0×10^{-4} 1.9×10^{-2} 1.5×10^{-6}
Containment (2) Pond: Area 12	None	0%	56 km	^{3}H	20.7
Area 20			42 km	^{3}H	261
Non-Point Sources					
Yucca Flat: (3)					
Area 3	None	0%	54 km	$^{239+240}Pu$	2.3×10^{-2}
Area 9	None	0%	53 km	$^{239+240}Pu$	4.8×10^{-2}
RWMS-5 (3)	None	0%	42 km	^{3}H	0.97
Other Areas	None	0%	42 km	$^{239+240}Pu$	0.33
Area 20	None	0%	42 km	^{85}Kr	300

(1) Not on the EIS Report. Potential (worst-case) emissions only.
(2) Evaporation of all tritiated water effluents is assumed.
(3) Emissions based on environmental surveillance data.
(4) (x) is number of vents or stacks.

Table 3.0 Total Emissions for CY 1995 (Multiply Ci by 37 to obtain GBq)

Radionuclide	Half-Life (days)	Annual Quantity (Ci)
^{3}H	4510	283
^{85}Kr	3900	300
^{129}I	5.7×10^{9}	1.5×10^{-6}
$^{239+240}Pu$	8.8×10^{6}	4.0×10^{-1}

Note: This table includes all worst-case point and diffuse source releases. Actual estimated releases are reported on DOE/NV Effluent Information System reports.

SECTION III
DOSE ASSESSMENTS

SUMMARY OF INPUT PARAMETERS

CAP88-PC was used to calculate effective dose equivalents to offsite residents. The input parameters were the radionuclide releases listed in Section II above as determined from effluent monitoring performed by the NTS operating contractor (REECo), from evaporation of tritiated water, and from calculations of diffuse source emissions that are based on environmental monitoring data. The latter include measurable particulate emissions of $^{239+240}Pu$ originating in certain areas of the NTS and Nellis Base Range, krypton seepage from Area 20, and HTO detected at the boundary of the RWMS.

To calculate the amount of HTO evaporated, measurements of HTO concentration 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, so all the HTO influent to the ponds during 1992 was assumed to have evaporated. This was a conservative estimate, as no allowance for infiltration into the soil column is made. A description of the source term estimated for this emission source is contained in the Appendices.

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 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 Desert Rock airstrip. The ARL/SORD assessment is attached as Appendix G. For each of these five STARs there may be a different location for the maximally exposed individual; but when the contributions of all the NTS sources to a given location are considered, only one location would receive the maximum exposure, Amargosa Valley (Lathrop Wells), Nevada, in this case. See Figure 1.0 for residences and communities around the NTS.

The EDE, in mrem, to the maximally exposed individual (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 NESHAP 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 F contain estimates of radionuclides, which have or could have been released in 1995.

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

Table 4.0 Summary of CY 1995 CAP88-PC Calculations of EDE to the Maximally Exposed Offsite Individual - Springdale, Nevada [a]

Source	Distance to Individual and Direction	Effective Dose Equivalent (mrem)[b]
Tunnel Pond (Area 12)	56 km WSW	4.8×10^{-5}[c]
Laboratories (Area 23)	78 km WNW	1.9×10^{-8}
Yucca Flat (Area 3)	62 km W	9.6×10^{-3}
(Area 9)	64 km W	1.9×10^{-2}
RWMS (Area 5)	74 km WNW	1.1×10^{-5}
Area 20	42 km SW	1.0×10^{-3}
Other Areas 1.46×10^{-1}		---
	TOTAL EDE	1.8×10^{-1} 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 tritiated water influents to ponds.

Table 5.0 Effective Dose Equivalent Tabulation by Location (Multiply mrem by 10^{-2} for Equivalent mSv Units)

Location	Pop.[3]	EDE (10^{-6} mrem/year) Due to Releases from:							Collective
		Area 12[1] Tritium	Other Areas[2]	YUCCA Flat Area 3[1]	YUCCA Flat Area 9[1]	Area 5[1] RWMS	Area 20 Tritium	Total EDE 10^{-3} mrem	EDE man-mrem
Alamo	1000		15					0.015	0.015
Amargosa Valley	1200	48	85000	7200	19000	13.2	540	112	134
Ash Meadows	10	(see note[4])	20000	7600		8.9		27.6	0.28
Ash Springs	70		3800					3.8	0.27
Beatty	1500	44	123000	9400	19000	13.2	830	152	228
Clark Station	2		25600					26	0.052
Crystal	45	74	87000	7500	13000	13.2		108	4.86
Death Valley Jct	7					9.7		0.0097	6.8×10^{-5}
Desert Game Range	4					7.1		0.0071	1.8×10^{-5}
Goldfield	600		11300					11	6.6
Goldpoint	15		1200					1.2	0.018
Hiko	103	3700						3.7	0.38
Indian Springs	1200	101	30000	2800	8800	13.5		41.7	50
Lathrop Wells	30	52	124000	13000	23000	16.9	580	161	4.8
Lida	15		1200					1.2	0.018
Lida Junction	8		31000				800	31.8	0.25
Medlin's Ranch	2	52	53000	4700	11000	8.2	470	69.2	0.138

(1) Emissions calculated from surveillance data, included on EIS forms.
(2) Emissions calculated from engineering data, not included on EIS forms.
(3) Population at that location for 1995.
(4) Blank spaces represent locations farther than 80 km from the source for the column.

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

Location	Pop.[3]	EDE (10^{-6} mrem/year) Due to Releases from:							Collective
		Area 12[1] Tritium	Other Areas[2]	YUCCA Flat Area 3[1]	YUCCA Flat Area 9[1]	Area 5 [1] RWMS	Area 20 Tritium	Total EDE 10^{-3} mrem	EDE man-mrem
Mt. Charleston	500					6.9		0.0069	3.4×10^{-3}
Pahrump	20000					8.5		0.0085	0.17
Penoyer Farm	16	52	66000	3800	8800		530	79.2	1.27
Rachel	105	52	57000	3600	8600		480	69.7	7.32
Sarcobatus Flats	40	70	54000	2300			1000	57.4	2.30
Silver Peak	200		500					0.5	0.1
S NV Corr. Ctr	2000		2900	2200		10.8		5.1	10.2
Springdale	20	48	150000	9600	19000	10.9	1000	180	3.6
Stateline & Area	70		21000	6200		10.2		27.2	1.90
Stone Cabin Rn.	6		19000					19	0.11
Tonopah	3400		10000		7700			17.7	74.3
Twin Springs Rn.	6		4800					4.8	0.03
U.S. Ecology	35	48	89000	9400	17000	14.5	660	116	4.06

Total Population - 32,210 Maximally Exposed Individual: 0.18 mrem Location of Max: Springdale, Nev.	Maximum Individual Dose Calculated for Each Release Point - 10^{-3} mrem					Total Person-rem:
	Area 12	Other Areas	YUCCA Flat	Area 5	Area 20	0.53
	0.10	150	36	0.017	1.0	

(1) Emissions calculated from surveillance data, included on EIS forms.
(2) Emissions calculated from engineering data, not included on EIS forms.
(3) Population at that location for 1995.
(4) 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: Terry A. Vaeth, Acting Manager, Nevada Operations Office

Signature: Terry A Vaeth Date: 6/14/96

SECTION IV
ADDITIONAL INFORMATION

NEW CONSTRUCTION/MODIFICATION ACTIVITIES AT THE NTS

No new construction or modification to existing permanent structures that emit radionuclides during normal operations was completed at the NTS in calendar year 1995.

UNPLANNED RELEASES DURING THIS CALENDAR YEAR

All releases on the NTS during this calendar year were operational. There was a detectable unplanned release at the Atlas Facility of EG&G Energy Measurements located in North Las Vegas (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 20; resuspension of $^{239+240}Pu$ from soil deposits on the NTS in Areas 3, 9, and safety test areas; seepage of noble gases from Pahute Mesa; and seepage of tritium from packages buried at the RWMS in Area 5 (see Appendix H).

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

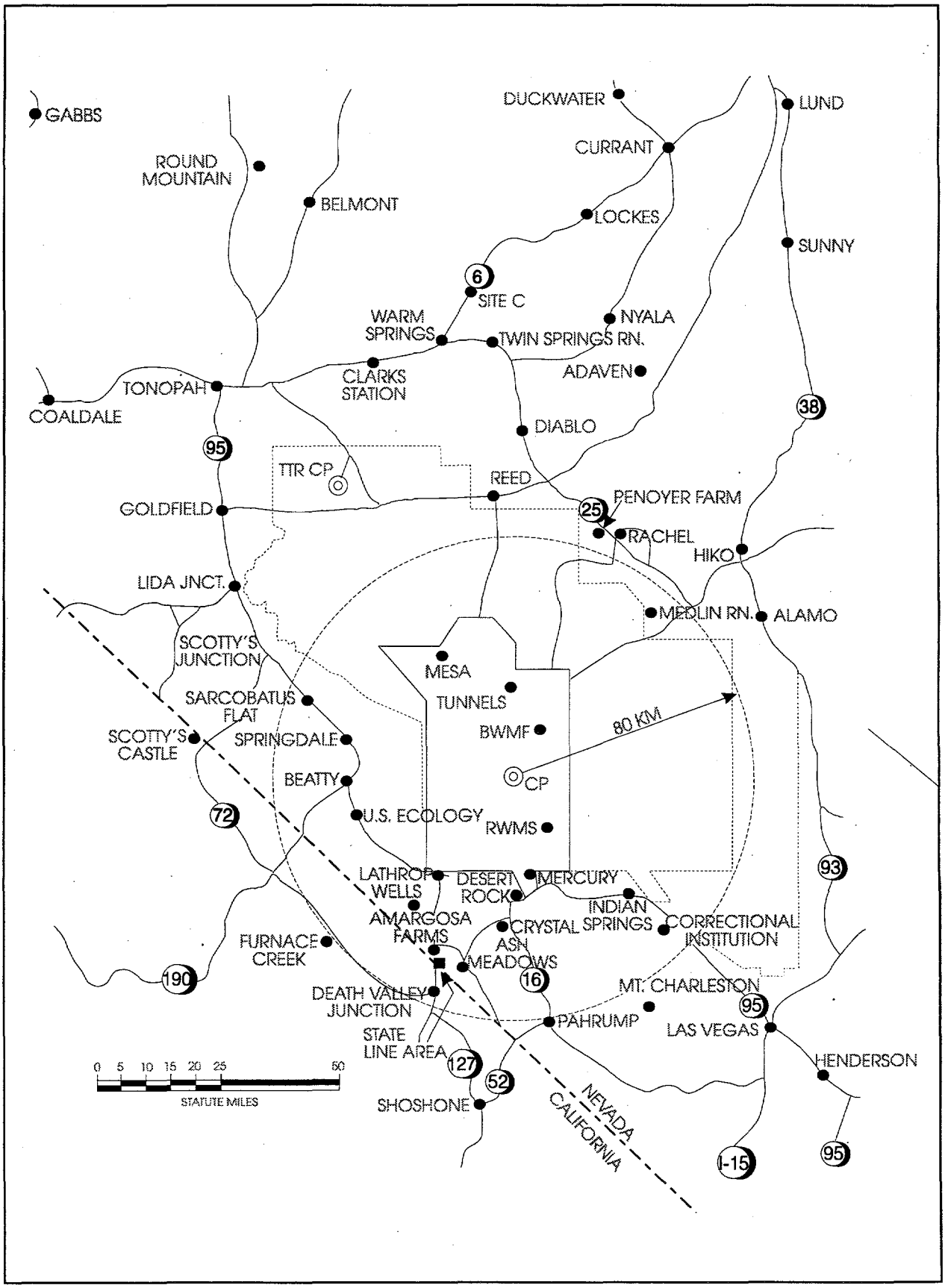

Figure 1.0 Map of the Area Around the NTS

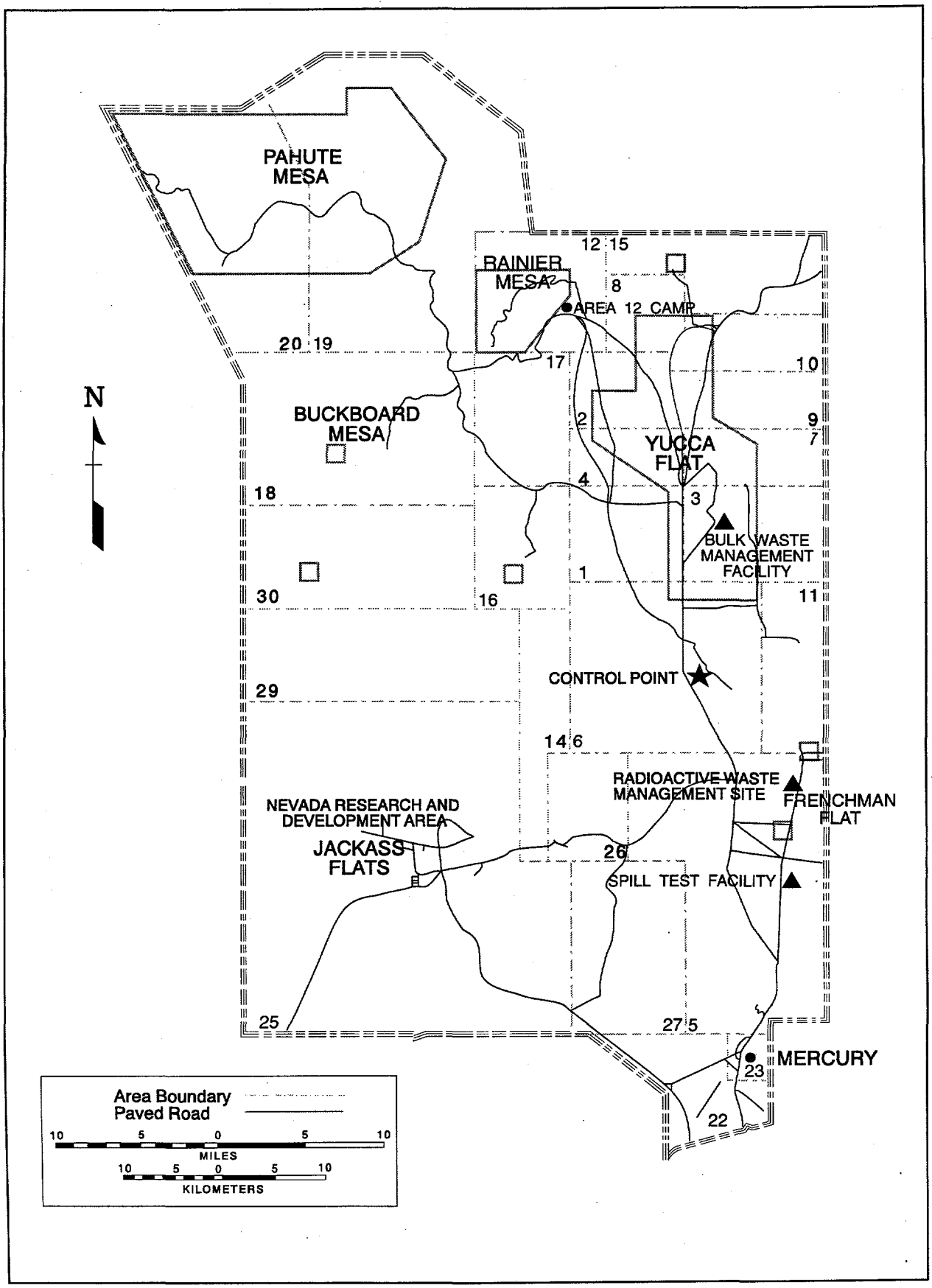

Figure 2.0 Nuclear Testing Areas on the NTS

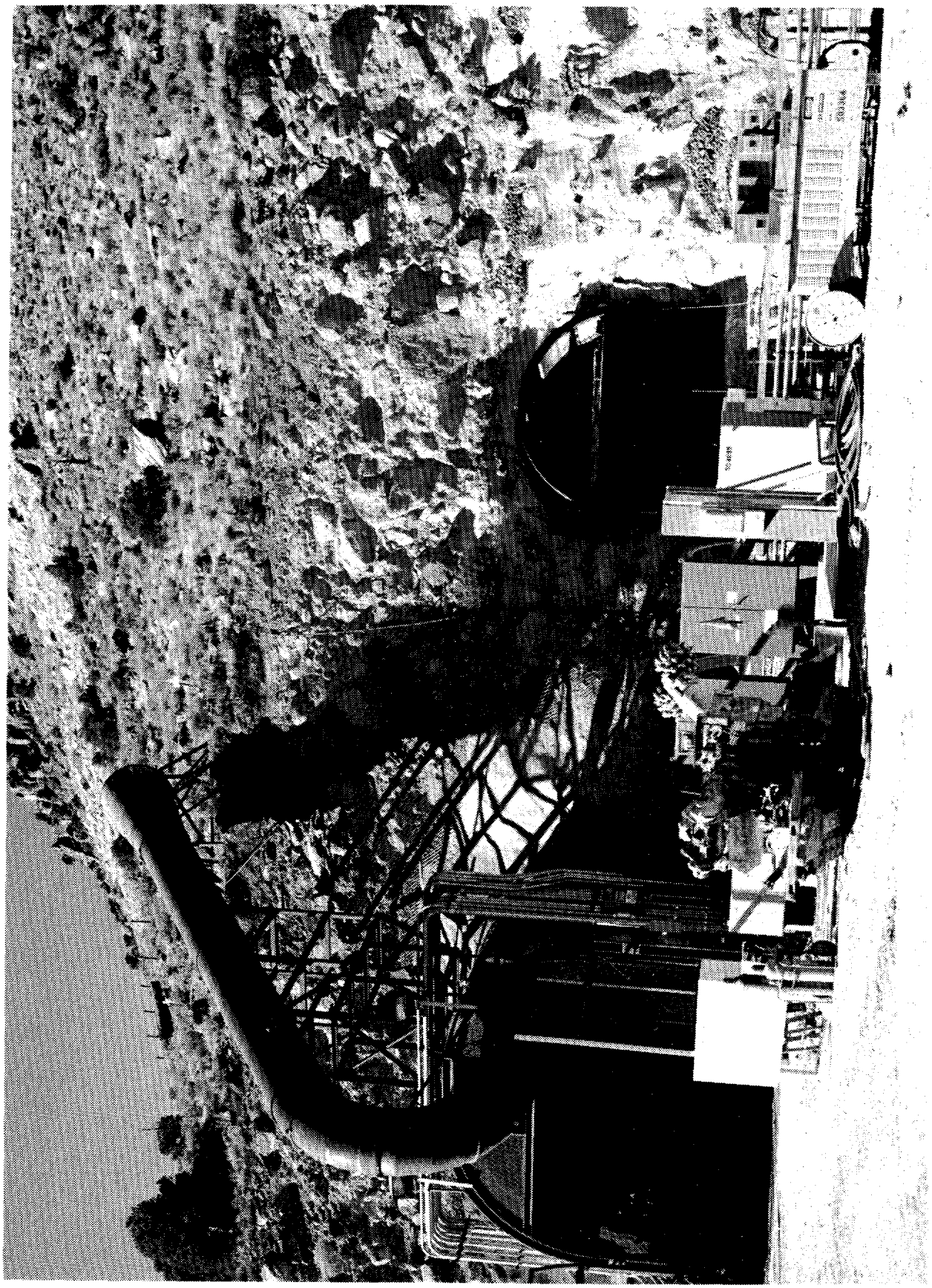

Figure 3.0 Photograph of a Tunnel Portal

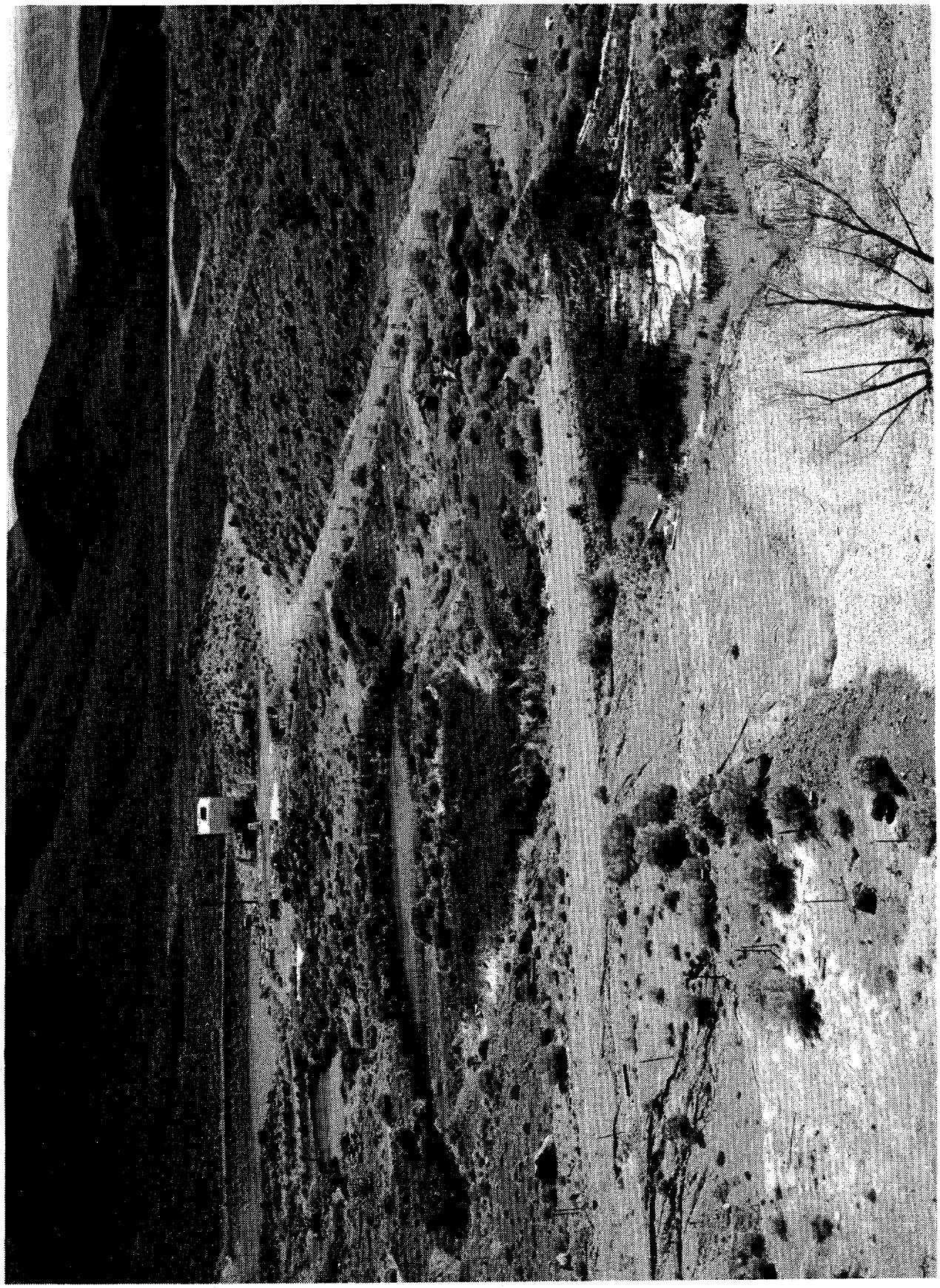

Figure 4.0 Photograph of Tunnel Containment Ponds

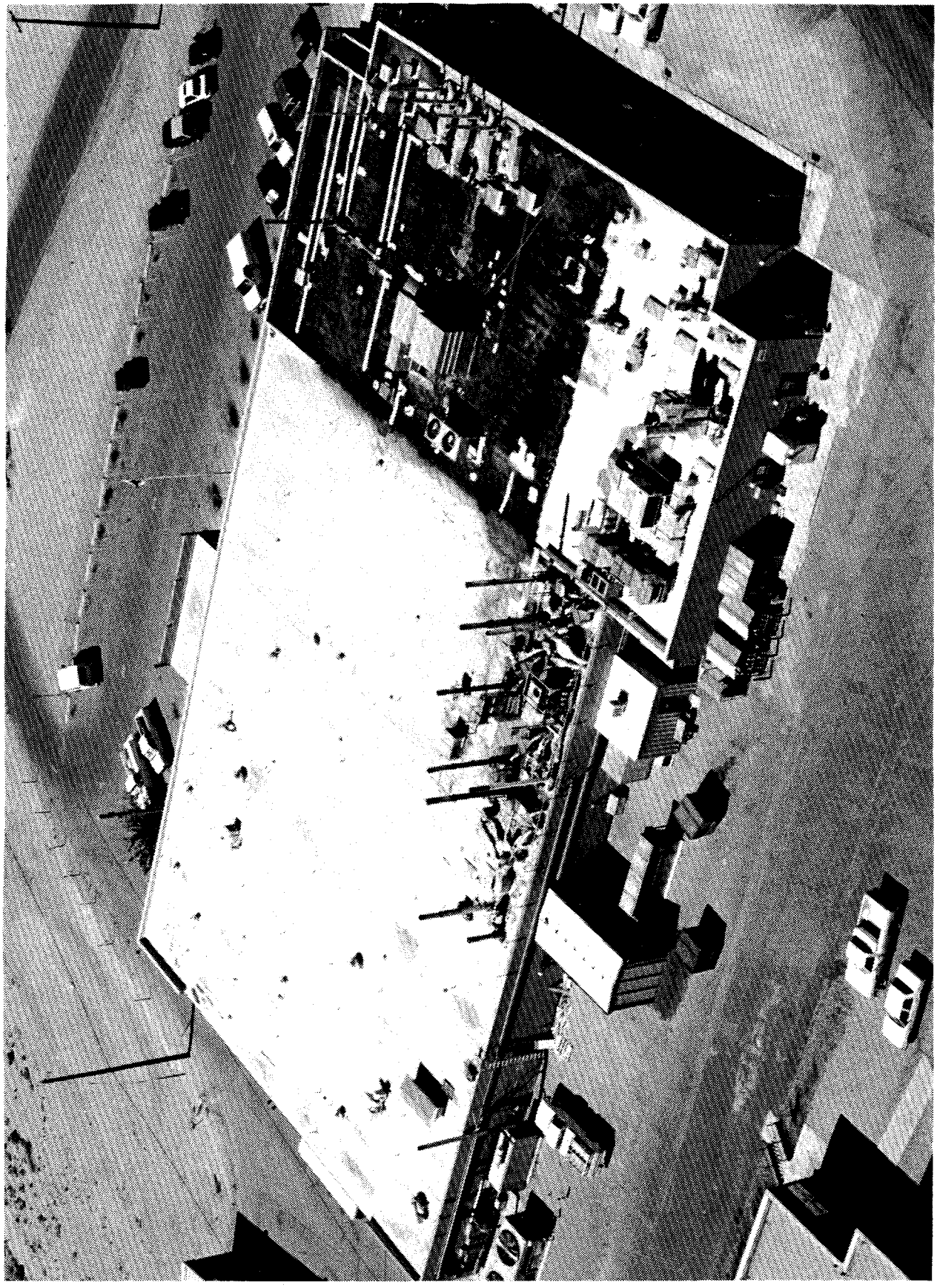

Figure 5.0 Photograph of the Building 650 Hood Ventilation Stacks Seen from Above

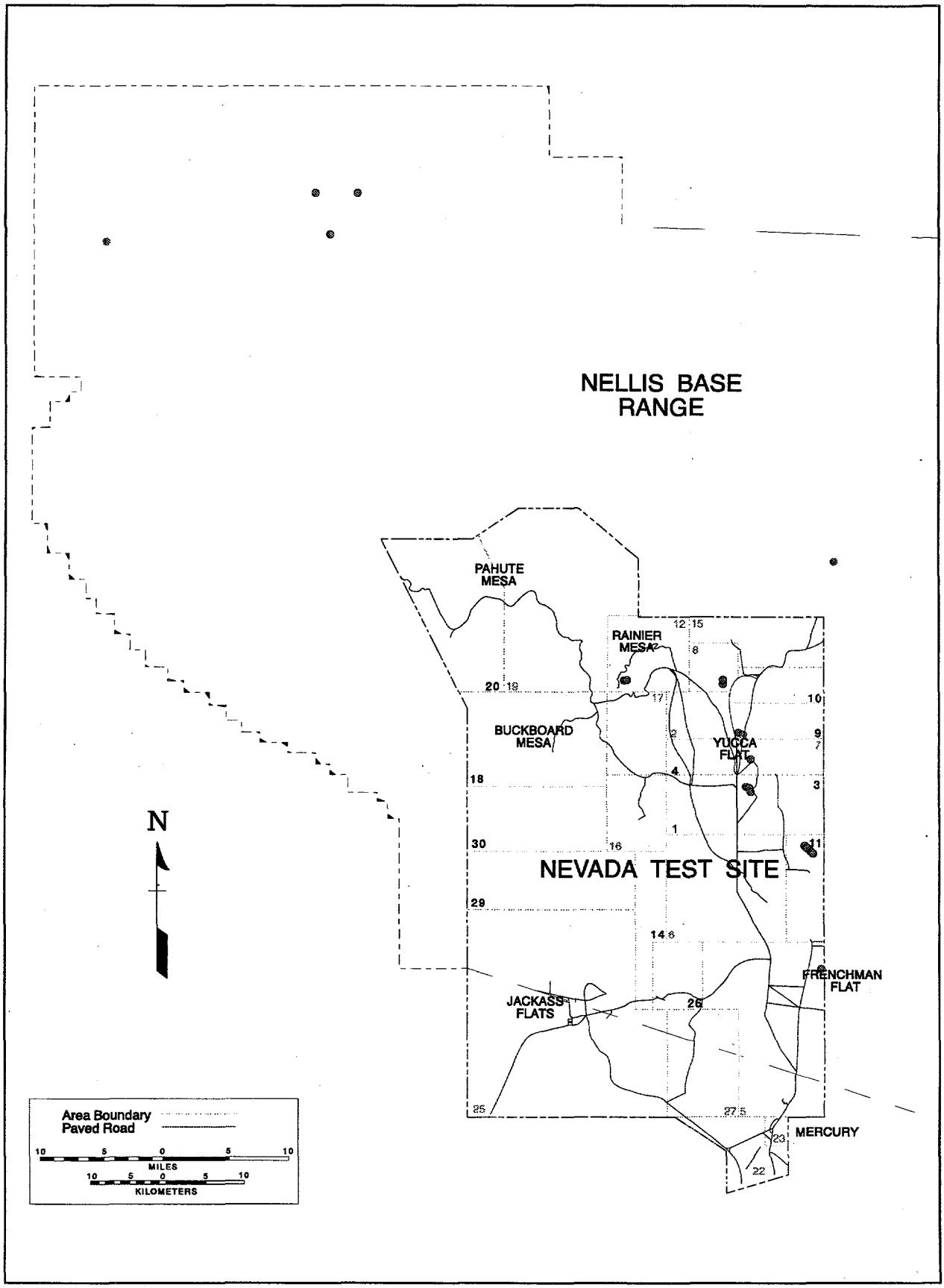

Figure 6.0 Locations of Nuclear Device Safety Tests (●) on the NTS

APPENDICES

APPENDIX A

PUBLIC DOSE CALCULATIONS FOR THE ATLAS TRITIUM INCIDENT

November 21, 1995

ENVIRONMENTAL SURVEILLANCE AT THE ATLAS FACILITY

July 17 - November 19, 1995

The environmental surveillance effort began with notification on Friday, July 14, that a tritium leak had occurred in Building A-1 (the Atlas Facility) of the EG&G Energy Measurements site in North Las Vegas. Prior to a briefing on the particulars of the accident, meteorological data were obtained from the ARL/SORD National Oceanic and Atmospheric Administration (NOAA) in order to begin an offsite dose assessment.

At the briefing on Monday, July 17, a chronology of events leading to the discovery of the tritium leakage was discussed by the EG&G Energy Measurements health physicist. Also, a map of the Losee Road site with the surrounding area was obtained from the Engineering Department so that the distance and direction of nearby offsite structures could be determined. After the briefing, REECo Environmental Surveillance personnel chose three sites for placement of air samplers that would collect atmospheric moisture samples for subsequent analysis of tritium (as HTO) concentration in air. The sampler sites included one sampler in the direct downwind path from the Atlas Building A-1 vent pipe. The samples were collected on a 2-, 2-, 3-day schedule to obtain prompt information on the airborne concentration of tritium. As the concentration of tritium in atmospheric moisture samples decreased, the sampling period was increased (see Table A.1).

On August 3, 1995, a sampler was placed in operation close to the vent pipe that exhausts air from the source range. On September 1, 1995 a sampler was installed near an operation where tritiated water was being evaporated. Finally, a sampler was installed in the basement of Building A-1 on September 26. These are not considered environmental samplers.

The objective of the environmental surveillance was to determine the EDE to offsite people and, in particular, to calculate the EDE for the MEI. To accomplish this requires knowledge of the amount of HTO released from the site which then is input to EPA's CAP88PC program to determine the EDES. To operate CAP88PC, a wind stability array is needed. The wind data obtained from ARL/SORD was a wind rose from average wind speed and direction data collected from 1948 to 1985 for Las Vegas. These data were revised to fit CAP88PC requirements and then the program was run 6 times to cover the Pasquill categories A through F while assuming a release of 0.5 Ci of tritium. It was found that the MEI would be north of Atlas when the Pasquill stability was D. An aerial photo of the North Las Vegas Site was used to locate the nearest building or residence to the Atlas facility and a 16-sector array centered on that facility was drawn. From an engineering drawing of the Site, the size of buildings could be determined, and these were used to form a ratio with the same buildings on the aerial photo to obtain a distance scale. It was found that the nearest offsite structure was 100 m NW of the Atlas vent pipe.

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:

- Calculate a weighted average pCi/m^3 for the air sampler location (weighted by sampling time).
- Use the dose conversion factor for tritium inhalation (6.4×10^{-8} mrem/pCi), multiplied by 1.5 to correct for skin absorption, and by 8400 m^3yr breathed by a normal adult to obtain an EDE for that sampler location.
- Use a 1 mCi release in CAP88PC, D stability, Las Vegas wind data, to obtain an EDE at the location of the air sampler.
- Divide the calculated EDE from step 2 by the EDE/mCi from step 3 to obtain an estimated release in mCi.

As an example of this calculation, the weighted average data for the N sampler (2.85×10^{-11} µCi/mL = 28.5 pCi/m3) was used from Attachment 5 of a memorandum to REECo Health Protection Department dated November 21, 1995:

$$EDE = 28.5\ pCi/m^3 \times 1.5 \times 8400\ m^3/yr \times 6.4 \times 10^{-8}\ mrem/pCi$$
$$= 0.023\ mrem.$$

A CAP88PC run with 1 mCi release yields 4.8×10^{-5} *mrem at the sampler position.*

$$\therefore \text{ the estimated effluent would be: } \frac{0.023\ mrem}{4.8 \times 10^{-5}\ mrem/mCi}$$
$$= 479\ mCi.$$

However, since the measurement period was only 94 days, not 365, the emission would be 94/365 or 123 mCi. A similar calculation for the other two samplers yielded emissions less than 123 mCi.

The CAP88PC run with a 1 mCi emission of tritium also yielded data for other locations around the site, namely the data for the nearest building of 4.8×10^{-6} mrem/mCi. So, assuming there is a person at that location, it would be the MEI and the EDE would be 123 mCi x 4.8×10^{-6} mrem/mCi = 5.9×10^{-4} mrem or 0.59 µrem.

CONCLUSION

The best estimate of offsite EDE to the MEI was 0.59 µrem. For comparison, the National Emission Standards for Hazardous Air Pollutants: Radionuclides specifies a limit of 10 mrem to the MEI or about 20,000 times that calculated. Also, the EDE calculated assumes the person resides at the nearest building location year around. That building is not a residence so the dose to an occupant would be much less.

Table A.1 HTO in Air Results for the North Sampler, Atlas Facility - 1995

Tritium Calculation for the Atlas Facility

Date Collected (North Sampler)	No. Days	Concentration (µCi/mL)	µCi(Day/mL)
07/19/95	2	1.04×10^{-10}	2.08×10^{-10}
07/21/95	2	2.55×10^{-10}	5.10×10^{-10}
07/24/95	3	6.13×10^{-11}	1.84×10^{-10}
07/27/95	3	4.79×10^{-11}	1.44×10^{-10}
07/31/95	4	5.61×10^{-11}	2.24×10^{-10}
08/03/95	3	4.08×10^{-11}	1.22×10^{-10}
08/07/95	4	3.62×10^{-11}	1.45×10^{-10}
08/10/95	3	2.35×10^{-11}	7.05×10^{-11}
08/14/95	4	3.29×10^{-11}	1.32×10^{-10}
08/17/95	3	3.19×10^{-11}	9.57×10^{-11}
08/21/95	4	2.06×10^{-11}	8.24×10^{-11}
08/24/95	3	2.88×10^{-11}	8.64×10^{-11}
08/28/95	4	1.63×10^{-11}	6.52×10^{-11}
08/31/95	3	1.32×10^{-11}	3.96×10^{-11}
09/05/95	5	3.91×10^{-11}	1.96×10^{-10}
09/07/95	2	1.03×10^{-11}	2.06×10^{-11}
09/11/95	4	1.36×10^{-11}	5.44×10^{-11}
09/14/95	3	1.08×10^{-11}	3.24×10^{-11}
09/18/95	4	1.57×10^{-11}	6.28×10^{-11}
09/21/95	3	1.21×10^{-11}	3.63×10^{-11}
09/25/95	4	9.00×10^{-12}	3.60×10^{-11}
09/28/95	3	5.33×10^{-12}	1.60×10^{-11}
10/05/95	7	4.33×10^{-12}	3.03×10^{-11}
10/12/95	7	6.44×10^{-12}	4.51×10^{-11}
10/19/95	7	6.01×10^{-12}	4.21×10^{-11}
	94	2.85×10^{-11}	2.68×10^{-9}

APPENDIX B

SEEPAGE CALCULATION FOR PAHUTE MESA

NOBLE GAS SEEPAGE ON PAHUTE MESA

Previous environmental surveillance and test monitoring results on Pahute Mesa have suggested that the noble gas ^{85}Kr seeps up from nuclear test cavities to be emitted at ground surface with the result that the concentration in environmental surveillance samples is increased when compared to ambient levels measured in other locations. The process evidently requires a lengthy period of time because ^{133}Xe, 5.25 days half-life, is not normally detected in these samples.

In 1992, additional permanent noble gas sampling locations were established in Areas 18, 19, and 20 to increase the number of monitoring stations by 3. The locations are shown in Figure B.1. At each station air is pumped into steel pressure tanks for weekly periods. The noble gases are extracted from the compressed air in these tanks using a cryogenic technique, dissolved in a scintillation cocktail, and counted in a liquid scintillation counter. Because of equipment and laboratory failures, and inaccessibility during winter, fewer than 52 results are obtained for each station. The 1995 noble gas sampling results are shown in Table B.1. By the end of the year, only three samplers were operated, one on Area 20 and two control stations.

The results from the Area 20 sampler frequently have been higher than the results from the other NTS samplers. This also appears to be true for the 1995 results. The average of the stations other than Area 20 was 27.6 pCi/m^3 (1.02 Bq/m^3), while the results for the Area 20 Camp sampler were 33.7 pCi/m^3 (1.25 Bq/m^3), or an annual average of 6.1 pCi/m^3 (0.23 Bq/m^3) higher. The wind roses shown on Figure B.2 suggest that, for the Area 20 Camp sampler, the source is to the south.

The nearest emplacement hole is U-20a, used for a 70-kt device, that is about 3660 m (12,000 ft) to the south. Using a procedure similar to that in Appendices E and F, and also using a CAP88-PC run with an assumed release of 1 Ci (37 GBq) of ^{85}Kr, yields a result of 200 Ci (7.4 Pbq) of emission from ground seepage on Pahute Mesa. The calculation for this emission is shown below. The dose conversion factor (DCF) for ^{85}Kr is obtained from the derived air concentration for submersion given in the International Commission on Radiological Protection, Report 30. The DCF is multiplied by the krypton concentration to obtain the EDE at the sampler location. To determine the emission necessary to cause this EDE, an assumed emission of 1 Ci (37 GBq), the distance to the sampler (3050 m), and the STAR (stability array) meteorology for Pahute Mesa were entered into the CAP88-PC program. At a distance of 3050 m to the north, the CAP88-PC run with 1 Ci (37 GBq) indicates an EDE of 3.8×10^{-7} mrem/yr (3.8 pSv) at the sampler location. The calculations are displayed in the following three equations:

$$DCF \text{ for } Kr^{85} = 1.6x10^{-5} \text{ mrem/yr per } pCi/m^3$$

$$[EDE \text{ at sampler}] \quad 6.1 \text{ } pCi/m^3 \times 1.6x10^{-5} = 9.8 \times 10^{-5} \text{ mrem/yr}$$

$$\left[\frac{EDE \text{ at sampler}}{CAP88 \text{ } EDE}\right] \quad \frac{9.8 \times 10^{-5} \text{ mrem/yr}}{3.3 \times 10^{-7} \text{ mrem/Ci}} = 300 \text{ Ci/yr}$$

Table B.1 ^{85}Kr Concentrations on the NTS in 1995 (pCi/m^3)

Station Location	Number	Arithmetic Average	Standard Deviation
BJY	40	27.5	7.5
Gate 200	29	28.4	13.1
Area 12 Camp	20	27.4	4.9
Area 20 Camp	15	33.7	12.0
Pahute Substation	16	27.2	7.6
Gate 400	25	27.0	6.2

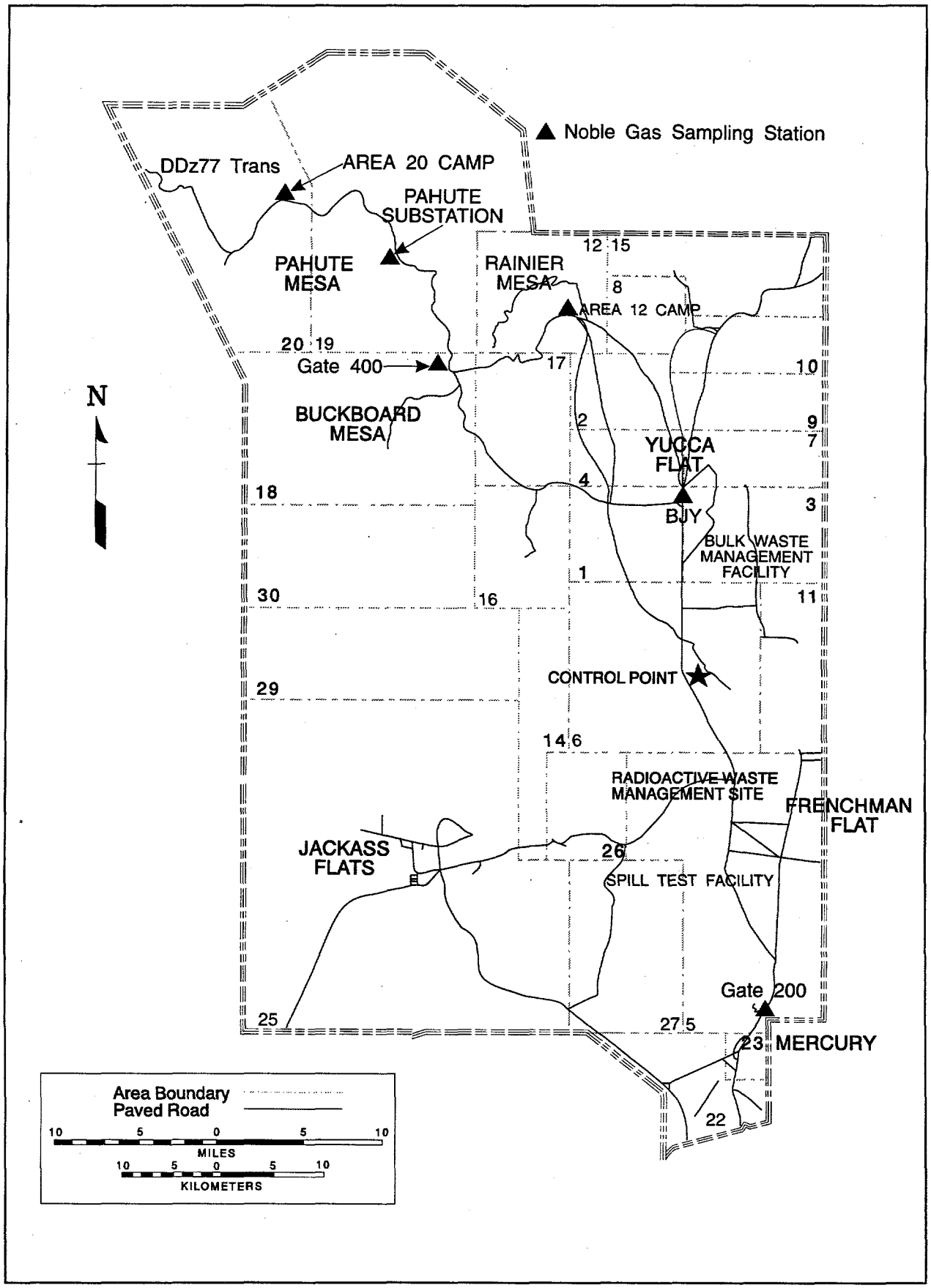

Figure B.1 Noble Gas Sampling Sites on the NTS

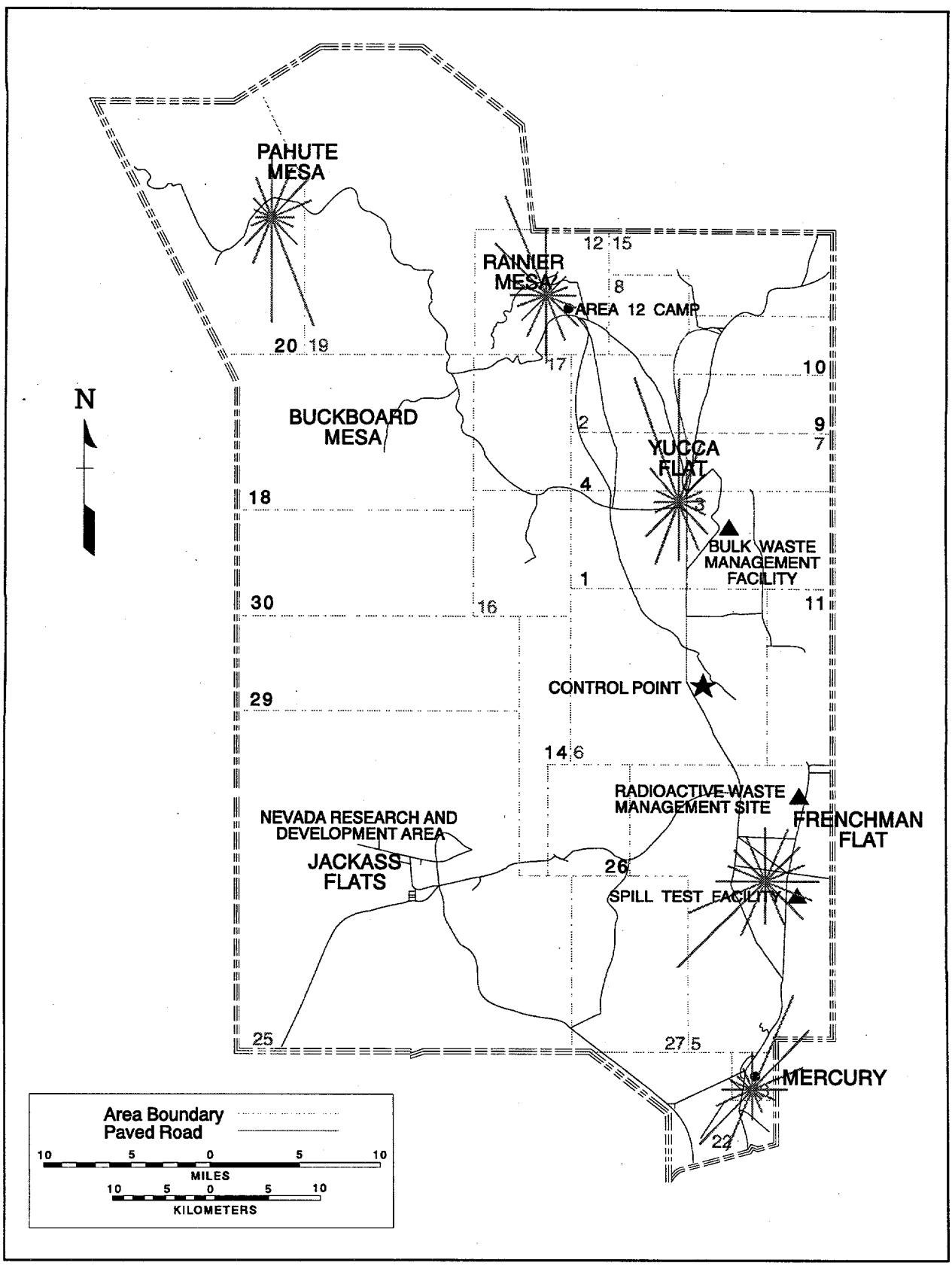

Figure B.2 Wind Roses for the Various Areas on the NTS

APPENDIX C

EMISSIONS FROM CONTAINMENT PONDS

EMISSION FROM THE TUNNELS AND PONDS

Effluent water and the containment ponds located at the Area 12 tunnel complexes that receive that water were sampled once each month. These water samples are analyzed for radionuclides by gamma spectroscopy, for gross beta, and for tritium. Less frequently, other samples are collected for analysis of plutonium and strontium. 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. The volume of water discharged from the tunnels was measured by use of a weir.

In order to calculate doses using CAP88-PC, an airborne source term must be known. As described above, the total liquid effluent volume is measured and the radionuclide concentrations are determined from analysis of monthly samples. By assuming that the total amount of tritium (as HTO) measured in the liquid effluent during the year evaporates and becomes airborne, an airborne source term is obtained. It is unlikely that this is a true source term for the containment ponds 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[(2)] lends credence to this calculation. The tunnels are in the process of being sealed so the effluents are decreasing. E Tunnel is now the only source of HTO to tunnel ponds.

During this calendar year, three characterization wells were drilled near an underground cavity created by a nuclear explosive test. Water was continually pumped from the wells into lined containment ponds. Measurement of tritium occurred on water samples taken from the conduit leading to the ponds.

Table C.1 lists the total quantity of tritium discharged into the containment ponds (and assumed to be released as airborne effluents) as measured during CY-1995.

Table C.1 Tritium Effluents into Containment Ponds - 1995

Location	Area (m^2)	Total ^3H Discharged (Ci)
Area 12, E Tunnel	336	20.7
Area 20, ER-20 wells		260.8
	Total Effluent	281.5

The MEI for the Area 12 emission resides in Indian Springs, Nevada and would receive an EDE of 0.101 µrem (1.0×10^{-6} mSv). The offsite network average HTO in air was 0.36 pCi/m^3 but was only 0.3 pCi/m^3 at Indian Springs so the tunnel pond emission was not detected.

The MEI for the Area 20 emission resides in Sarcobatus Flats and would receive an EDE of 1.0 µrem (1.0×10^{-5} mSV).

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(2) For example: Tunnel Pond

	Result ($\bar{X}$)	Qtr/Yr.
E #2	5.65×10^{-4}	1st
	4.91×10^{-4}	4th

The following calculation was performed to estimate tritium emission from the E Tunnel Pond during 1994 using the methods for estimating diffuse emissions in the U.S. Environmental Protection Agency (EPA) report dated July 1994 for comparison with the above method.

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, m^2
U = wind speed, m/s
P_s = equilibrium water vapor pressure at ambient temp., mm Hg
T = ^{o}K = ^{o}C + 273.2

If tritium concentration (a = pCi/g) is known, then the emission rate is R = a x E, pci/s.

Weather information in terms of 2-hourly readings with monthly weighted average data was obtained from ARL/SORD, courtesy of Douglas Soulè.

The area of the E Tunnel Pond, roughly square, was obtained from Sandia National Laboratory as 3620 ft^2. 3620 x 0.0929 (m^2/ft^2) = 336 m^2.

The average quarterly tunnel effluent in pCi/mL was obtained from Performance Indicator Reports. The results for the first thru the fourth quarter were 1.86, 1.75, 1.86, and 0.507 nCi/mL, respectively.

The weighted average wind speeds are listed in Table C.2. The vapor pressure in mm of Hg were obtained using the ^{o}K in the table and data in the Chemical Rubber Handbook.

The calculations were first performed with monthly weighted averages. The sum of the 12 calculations was 2.29 Ci of tritium evaporated. Calculating average daytime and nighttime temperatures, 12 hr each, gives 24 calculations per year, and the total evaporated was 2.36 Ci (cf. 2.29). The calculations are shown in Table C.2.

An example of total emission for a daylight period, using March daylight hours (31 days x 12 hr x 3600 s/hr = 1.379 x 10^6 s), first quarter effluent = 1.86 x 10^3 pCi/g:

36.21 g/s x 1.86 x 10^3 pci/g x 1.379 x 10^6 s = 9.29 x 10^{10} pCi/0.5 month.

Assuming all influent to the pond evaporates yields of 47.3 Ci (the total in Table C.1, 1994) or about 20 times the above calculated amount, then this latter method is more conservative.

In 1994, 47.3 Ci of ^3H were influent to the tunnel ponds. CAP88 calculated an EDE of 0.23 µrem at Indian Springs. The RSL-LV measurement of HTO in air, at Indian Springs in 1994 was 0.2 pCi/m^3 as an annual average. The 0.23 µrem implies 0.44 pCi/m^3 of HTO in air at that location, a factor of 2 higher than actually measured, suggesting that total evaporation is sufficiently conservative.

Because of this result, the calculation was not repeated for 1995.

Table C.2 Calculation of Evaporative Emissions from E Tunnel Pond - 1995

Month	Temp	Temp	Temp	Wind Sp.	Wind	Pressure	E (evap)	R (rate)	Total
		°C	°K	knots	m/s	mm Hg	g/s	pCi/s	pCi x 10^{10}
Jan N	32.5	0.3	273.5	8	4.11	4.61	14.55	27.1 x 10^3	3.63
Day	37.1	2.8	276.0	8	4.11	5.60	17.44	32.4 x 10^3	4.34
Feb N	33.3	0.72	273.9	8	4.11	4.82	15.18	28.2 x 10^3	3.41
Day	39.2	4.0	277.2	8	4.11	6.10	18.87	35.1 x 10^3	4.24
Mar N	43.9	6.6	279.8	10	5.14	7.31	26.68	49.6 x 10^3	6.84
Day	52.7	11.5	284.7	10	5.14	10.18	36.21	67.4 x 10^3	9.29
Apr N	50.7	10.4	283.6	13	6.68	9.46	41.74	73.0 x 10^3	9.46
Day	58.7	14.8	288.0	13	6.68	12.62	54.44	95.3 x 10^3	12.4
May N	57.2	14	287.2	11	5.65	11.99	45.42	79.5 x 10^3	10.96
Day	68.5	20.3	293.5	11	5.65	17.85	65.49	114.6 x 10^3	15.8
Jun N	62.1	16.7	289.9	12	6.17	14.26	57.17	100 x 10^3	12.96
Day	74.0	23.3	296.5	12	6.17	21.45	83.19	145.6 x 10^3	18.87
Jul N	70.4	21.3	294.5	11	5.65	19.0	69.36	129 x 10^3	17.79
Day	82.3	27.9	301.1	11	5.65	28.18	99.58	185.2 x 10^3	25.54

Table C.2 (Calculation of Evaporative Emissions from E Tunnel Pond - 1995, cont.)

Month	Temp	Temp	Temp	Wind Sp.	Wind Sp.	Pressure	E (evap)	R (rate)	Total
		^{o}C	^{o}K	knots	m/s	mm Hg	g/s	pCi/s	pCi x 10^{10}
Aug N	68.8	20.4	293.6	10	5.14	17.97	61.1	113.6 x 10^{3}	15.66
Day	80.6	27.0	300.2	10	5.14	26.74	88.0	163.7 x 10^{3}	22.57
Sep N	63.5	17.5	290.7	10	5.14	15.0	51.7	96.2 x 10^{3}	12.47
Day	75.4	24.1	297.3	10	5.14	22.51	75.14	139.8 x 10^{3}	18.12
Oct N	52.2	11.2	284.4	10	5.14	9.98	35.56	18.0 x 10^{3}	2.5
Day	62.0	16.7	289.9	10	5.14	14.26	49.4	25.0 x 10^{3}	3.45
Nov N	38.7	3.7	276.9	10	5.14	5.97	22.12	11.2 x 10^{3}	1.45
Day	46.2	7.9	281.1	10	5.14	7.99	28.96	14.7 x 10^{3}	1.90
Dec N	34.0	1.1	274.3	8	4.11	4.96	15.58	7.9 x 10^{3}	1.09
Day	40.8	4.9	278.1	8	4.11	6.50	20.01	10.1 x 10^{3}	1.39

APPENDIX D

RADIONUCLIDE INVENTORY OF RADIOANALYTICAL LABORATORIES

REECo 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 D.1 on the next page.

From the inventory, only three of the items are volatile and may become a source of air emissions. These are ^{3}H (as HTO), the ^{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 40 C.F.R. 61, Appendix E, and all are less than one percent of those limits as shown in the last column of Table D.1.

LANL Laboratory

In previous years this laboratory maintained standards of radioactivity containing ^{133}Xe, ^{131}I, and ^{3}H. 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 1995 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 REECo.

Table D.1 Building 650 Health Physics Laboratory Inventory Compared to NESHAP

Radionuclide	Annual Inventory (µCi/Year)	Possession Limit (Ci/Year Liquid Form)	Ratio %
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 (1)	12	0.0042	2.8×10^{-1}
Beta Emitters (2)	15	0.52	2.9×10^{-3}
Gamma Emitters (3)	6	0.016	3.8×10^{-2}

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

(2) 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 (40 C.F.R. 61 Appendix E, Table 1).

(3) Gamma emitters is the sum of cobalt, chromium, and the mixed gamma sources, and the possession limit is for ^{60}Co (40 C.F.R. 61 Appendix E, Table 1).

APPENDIX E

DIFFUSE SOURCE ATMOSPHERIC TRITIUM EMISSIONS

BACKGROUND INFORMATION

Environmental monitoring for tritium in atmospheric moisture is conducted at 21 locations spread around the NTS for varying amounts of time. There are 9 air samplers around the RWMS perimeter in RWMS-5 because many curies of ^{3}H are buried at that facility. Some of these samplers collect tritium concentrations that are higher than background levels. This year the monitor at the EPA Farm in Area 15 did not have the next highest tritium concentration. The monitoring results from these sampling stations are provided in Table E.1, Airborne Tritium Sampling Results during CY 1995. The other CY-1995 monitoring data indicate that gross beta and $^{239+240}Pu$ concentrations in air at RWMS-5 are not statistically different from site wide NTS levels.

SOURCE TERM

It is estimated that 0.97 Ci (35 GBq) of ^{3}H is emitted annually from the RWMS. This source term is calculated to give an EDE of 17 nrem (0.17 nSv) to an individual residing in Lathrop Wells, Nevada. As in Appendix F, this is the location of the MEI for a source in Area 5. The method used to calculate this quantity is described below.

Once again, only environmental monitoring data were available and there was no information on the volume of air discharged from the RWMS. Considering that the RWMS 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 F, and the result for the MEI offsite can be compared with measured values obtained at that offsite location.

The mean annual airborne HTO concentrations from the RWMS tritium samplers surrounding the site were used along with the DOE/EH-0071 dose conversion factors to calculate a dose at each sampler location. For example, an individual breathing 3.2×10^{-12} µCi/mL of HTO for one year receives 2.5 µrem EDE when skin absorption is included[3]. Doses are calculated similarly for the other sampler locations. The result of a CAP88-PC run, assuming a 1 Ci release of ^{3}H at the center of the RWMS, is that an individual 381 meters to the SE would receive an EDE of 14 µrem per year. Therefore, 2.5 µrem measured at that sampler divided by 14 µrem/Ci equals an estimated annual release of 0. 18 Ci. This calculation was performed for all sampler locations, as shown in Table E.1 and a release of 0.97 Ci (35 GBq) was the maximum estimate as shown in the last column of Table E.1. This calculated release was reported to the EIS Onsite Discharge Information System data bank.

Lathrop Wells, Nevada, is located WSW of the RWMS at 44 km. Use of CAP88-PC results in an EDE of 17×10^{-6} mrem to an individual residing in Lathrop Wells if 0.97 Ci (35 Gbq) of HTO were released from the RWMS-5.

The other sampler with elevated mean concentration of HTO in air is the one at the Area 15 Farm. The possible emission sources for this result are the Farm, the tunnels and ponds in Area 12, and the SEDAN crater. The ^{3}H experiments at the Farm used only mCi amounts in the early 1970s so it is unlikely to be a source. Since only 21 Ci (versus 700 Ci in 1993) was evaporated from E Tunnel Pond in 1995, it appears unlikely to be a major source. The emission from the SEDAN crater (calculated as above) is shown in the table, assuming it is the source. Note that

---

[3] The following equation was used to calculate an EDE at each sampler location:

EDE = $pCi/m^3 \times 8400\ m^3/yr$ (inhaled) x 1.5 (skin absorption) $\times 6.2 \times 10^{-8}$ mrem/pCi where pCi/m^3 is the annual average HTO concentration.

the sampler installed at SEDAN this year detected an HTO level higher than the Farm sampler. It also appears unlikely that 100 Ci of HTO are being emitted from the SEDAN crater. However, there is no other likely source of the tritium in atmospheric moisture measured at the Area 15 Farm. Therefore, the RWMS-5 and the SEDAN crater are considered to be the detectable sources of HTO on the NTS.

Table E.1 Airborne Tritium Sampling Results During CY-1995

Sampler Number	Direction[1] from Center		Mean µCi/mL	Mean bq/m^3	Average Standard Deviation 10^{-12} µCi/mL	Ratio to 1Ci Emission[2]
05915 No. 1	SE	381m	3.2×10^{-12}	0.12	3.1	0.18
05908 No. 2	ESE	366m	3.1×10^{-12}	0.11	3.1	0.17
05911 No. 3	E	305m	4.1×10^{-12}	0.15	3.7	0.13
05700 No. 4	NE	418m	15.0×10^{-12}	0.56	16.0	0.97
05707 No. 5	N	305m	3.0×10^{-12}	0.11	3.1	0.07
05708 No. 6	NW	418m	8.6×10^{-12}	0.32	13.0	0.40
05709 No. 7	W	305m	3.4×10^{-12}	0.12	3.0	0.06
05714 No. 8	SW	418m	3.4×10^{-12}	0.12	3.3	0.17
05716 No. 9	S	305m	6.0×10^{-12}	0.22	4.2	0.16
15115 Farm of SEDAN	N	3500m	5.1×10^{-12}	0.19	2.6	100
SEDAN Crater			6.6×10^{-12}	0.24	3.5	

(1) Sampler direction and distance from center of suspected source.
(2) This ratio = number curies emitted from RWMS that would give the sampler result.

APPENDIX F

RESUSPENDED PLUTONIUM FROM YUCCA FLAT

BACKGROUND INFORMATION

As previously described, Area 3 is a diffuse source of radionuclide effluents. Due to operational activities, such as vehicular traffic, equipment operation, etc., some soil becomes airborne. Results from the air samplers in the area indicate that only $^{239+240}Pu$ is routinely detected, but only in concentrations slightly above the MDC. Only a few of the 30 air sampler locations had concentrations exceeding the network average by four standard deviations.

Measurements of airborne $^{239+240}Pu$ in Area 3, during CY-1995, are provided in Table F.1. This table displays the number of samples analyzed, the median value and the standard deviation of the 3 to 12 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. In order to obtain a source term in Ci/yr from the area, the measured $^{239+240}Pu$ 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 that touches the six sampling locations (worst-case assumption).

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

		($\mu Ci/mL \times 10^{-18}$)	
Location	Number of Samples	Median	1 Standard Deviation
Area 03 Complex	3	29	31
Area 03 Mud Plant	4	95	78
Area 03 U3ah/at (4 Samplers)	48	64	97

SOURCE TERM

It is estimated that 1.2 mCi (44 Mbq) of $^{239+240}Pu$ 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 and an assumed location rather than on effluent monitoring. The method used to calculate this quantity is described below.

The CY-1995 median concentration of $^{239+240}Pu$ at the Area 3 samplers was tabulated as above. Using the dose conversion factor of 330 rem/μCi derived from ICRP EDE limits (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 that sampler location.

A trial run of CAP88-PC using a 1 Ci 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 sample in Table F.1 ($\mu Ci/mL \times 10^{12} = pCi/m^3$):

$$2.9 \times 10^{-5}\ pCi/m^3 \times 8400\ m^3/yr \times 0.33\ mrem/pCi = 0.08\ mrem$$

A CAP88 run using 1 Ci and 670 m distance indicates an EDE of 520 mrem at the location of the sampler. The ratio of 0.08 mrem (measured) to 520 gives 1.5×10^{-4} Ci as an emission. Using the data in the above table indicates the maximum emission (based on the Mud Plant sampler) would be 1.2 mCi (44 MBq). Wind transport has only extended the boundaries of the plutonium contaminated areas a few meters since the 1960s, and of the amount resuspended only a fraction would be in particle sizes small enough to be carried very far by the wind.

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 23 mCi per year. This would yield an EDE of 0.096 mrem to a person in Springdale, the offsite MEI.

ERROR TERM

The errors in the measurements are listed in Table F.1 as a standard deviation, so the EDE is most likely between 0 and 7.4×10^{-4} mrem (0 and 7.4 nSv). 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. MacArthur, in DOE/NV/10845-02, estimates a $^{238+240}$Pu deposit of 75.6 Ci on 7.5 mi^2 there. 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 0.1 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 2×10^{-11} per second, and the source term becomes:

75.6 Ci x 10^{12} pCi/Ci x 2 x 10^{-11} /s = 1500 pCi/s
1 year = 3600 s/hr x 24 hr/day x 365 days/yr = 3.15 x 10^7 s/yr

Annual source term becomes:

1500 pCi/s x 3.15 x 10^7 s/yr = 4.72 x 10^{10} pCi/yr (47.2 mCi/yr)

or, with other value:

4.72 x 10^9 pCi/yr (4.72 mCi/yr).

Therefore, using the above suspension rate, the emission is between 4.72 and 47.2 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 Base Range.

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:

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

where:
- E' = soil particles lost (tons/yr)
- k = particle size factor
- a = total suspended fraction lost to wind erosion
- I = soil erodibility (tons/acre-yr)
- K = surface roughness factor
- C = climatic factor - $C = 0.345\ (mph^3/PE^2)$ where $PE = 0.83$
- 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 kg/m = 0.224

Inputs: Yucca Flat is typical high plain desert with sparse vegetation.

Average wind speed is 6.0 knots = 6 x 0.514 m/s = 3.08 m/s = 11.1 km/hr 6.9 mph

- k = 0.5 (fraction of resuspended soil that is PM_{10})
- a = 0.025 portion of total erosion that is suspended particulates
- I = 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 $C = 0.345(mph)^3/(0.83)^2$
- L' = 0.3 as read from Figure 7-5 (IK = 28 x 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 IKCL'= 790)
- A = 7.5 mi^2 = 1.9 X 10^7 m^2 from McArthur' s report

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

Area 9 (From McArthur), 75.6 Ci on 7.5 mi^2 (7.5 x 2.59 x 10^6 m^2/mi^2) or 1.9 x 10^7 m^2
Total Emission = 3.7 kg/m^2-yr x 1.9 x 10^7 m^2 = 7.0 x 10^7 kg/yr

Pu concentration in dust:

1.9 x 10^7 m^2 x 10^4 cm^2/m^2 x 2 cm deep x 1.5 g/cm^3 = 5.7 x 10^{11} g
75.6 Ci x 10^{12} pCi/Ci ÷ 5.7 x 10^{11} g = 133 pCi/g or 133 nCi/kg

and the source-term becomes:

133 x 10^{-9} Ci/kg x 7.0 x 10^7 kg/yr = 9.3 Ci/yr

Fortunately there are two methods for checking the calculations above.

1) If the total deposit in Area 9 is 75.6 Ci and the E' calculation performed above is correct, then 75.6 Ci ÷ 9.3 Ci/yr yields a deposit duration of 8.1 yr so all the Pu would have been lost many years ago.

The resuspension equation calculation (0.047 Ci/yr) would require about 1600 years to deplete the deposit.

2) Enter the amounts into CAP88PC to obtain the EDE for an offsite individual where Pu in air measurements are made, and compare the two results.

RSL-LV continuous air sampling at Lathrop Wells in 1993 yielded an annual average Pu concentration of $3 \pm 12 \times 10^{-18}$ µCi/mL or $3 \pm 12 \times 10^{-6}$ pCi/m^3 (effectively 0 pCi/m^3).

CAP88 results at Lathrop Wells for a source in Area 9, NTS, emitting about 9.3 Ci of Pu as calculated by the diffusion equation above gives 4.4 mrem.

4.4 mrem ÷ 0.33 mrem/pCi = 13 pCi as the amount inhaled (at 8400 m^3) per year or 1.5×10^{-3} pCi/m^3. This is 500 times higher than measured.

If the emission rate were really 0.047 Ci/yr, the EDE at Lathrop Wells would be 0.023 mrem. The calculated annual average air concentration for this EDE would be:

- $0.023 \div (8400 \times 0.33) = 8.3 \times 10^{-6}$ pCi/m^3 or just about 2.8 times that measured in 1993, not counting the contribution from other areas. This is sufficiently conservative for a dose calculation.

- A resuspension factor of 10^{-9}, as frequently used, would make the calculated offsite concentration much greater than actually measured.

Conclusion: Both checks of the results from the use of the two methods confirm that the resuspension equation is superior to the soil erosion equation for calculating air entrainment and offsite dispersion of plutonium from the NTS.

APPENDIX G

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 1350 sq mi (see Figure G.1). Topography is complex with generally north-south oriented ridges and valleys typical of Nevada. Terrain elevations range from near 2700 ft in the extreme southwest corner of the NTS (Station No. 25) to near 7700 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 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 inches per year at Station No. 25 to 6.9 inches per year in Yucca Flat (Station No. 6) to 7.6 inches at Desert Rock, to 9.5 inches per year on Rainier Mesa (Station No. 12).

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 SORD personnel 24 hours per day, 365 days per year at the Desert Rock Meteorological Observatory (DRA, elevation 3304 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. DRA was built to replace a similar observatory that was located in Yucca Flat (UCC, elevation 3924 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 G.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 G.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-minute averages and are transmitted via microwave to a central processor every 15 minutes. 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 minutes 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 minutes 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 miles; from UCC to Frenchman Flat, 12 miles; and from DRA to Pahute Mesa, 40 miles.

Cloud, cover observations needed as input to the STAR (Stability Array) 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, in tenths, 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)[4] found that the northwest part of the NTS, including Pahute Mesa, is clearly an area of diminished precipitation for the given elevation (6500 ft). Furthermore, the total annual precipitation for Pahute Mesa (9.5 inches) is more compatible with that from DRA (7.6 inches) than from UCC (6.9 inches). 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.

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

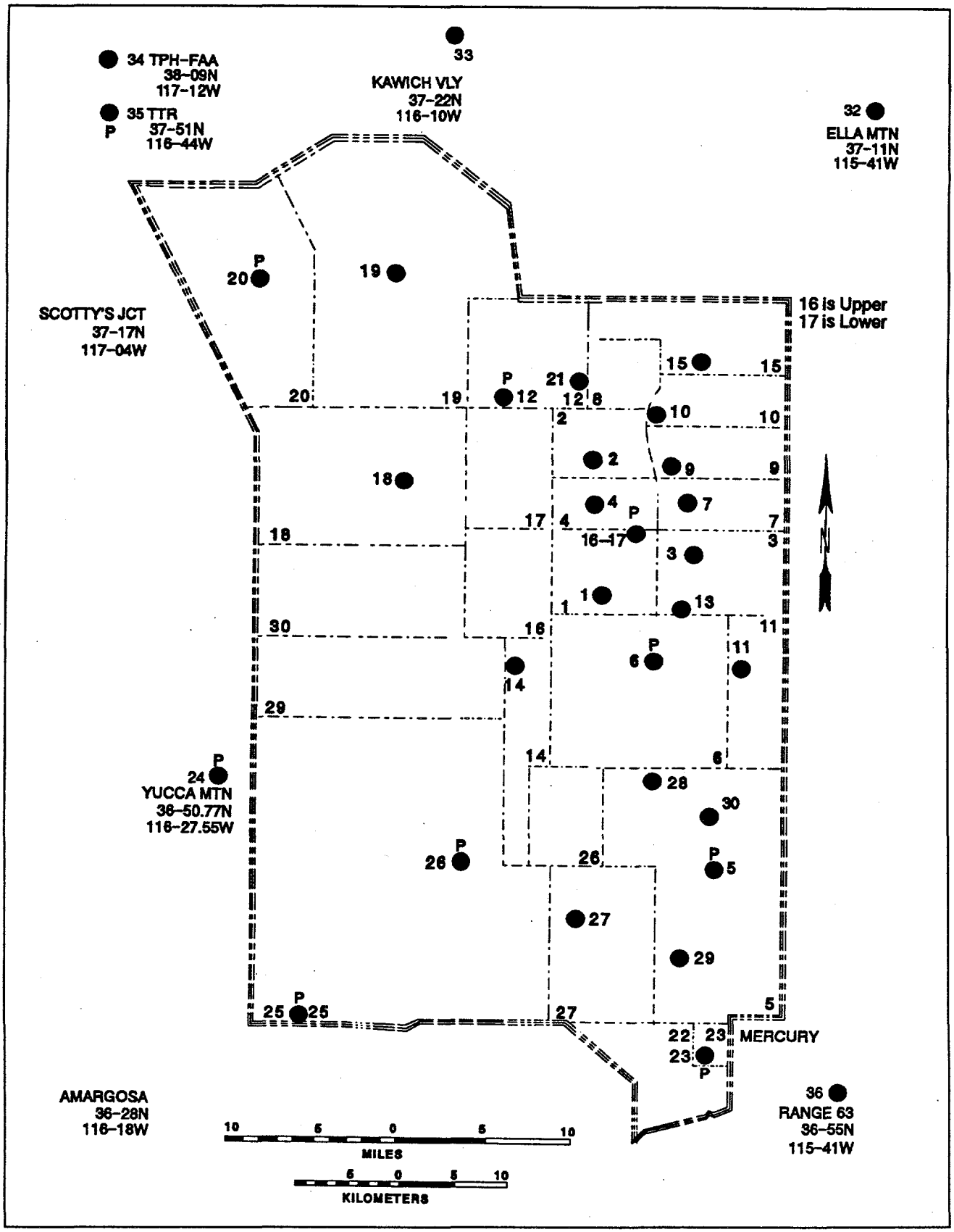

Figure G.1 Location of MEDA Stations on the NTS

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 3 mi 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 H

SUPPLEMENTAL INFORMATION

COMPARISON WITH PREVIOUS YEARS' DATA

Maximum Potential Individual EDE:

1995 - 1.8×10^{-1} mrem (1.8 μSv)
1994 - 1.5×10^{-1} mrem (1.5 μSv)
1993 - 3.8×10^{-3} mrem (38 nSv)
1992 - 1.2×10^{-2} mrem (120 nSv)
1991 - 8.6×10^{-3} mrem (86 nSv)
1990 - 5.8×10^{-3} mrem (58 nSv)

In 1990 containment pond evaporation of HTO was added to the NTS source term, the tritiated water effluents from the tunnels were 3 times higher in 1991. 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 this year (krypton seepage and HTO from characterization wells).

COLLECTIVE EFFECTIVE DOSE EQUIVALENT

The maximum potential collective effective dose equivalent to the 32,210 people who live within 80 km of the NTS emission sources was 0.53 person-mrem in 1994 due mostly to calculated resuspended plutonium exposure. Tritium exposure was higher than last year because of the effluent from characterization well ponds. 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 very 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	125
Area 5	0.24
Area 12	0.26
Other Areas	400
Area 20	2.1
	527.6 person-mrem
	(0.53 person-rem)

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 EDE was 0.15 mrem at Lathrop Wells due to resuspension. Using a dose conversion factor of 0.33 rem/μCi (from DOE/EH-0071) and an inhalation intake of 8400 m^3 per year, divide the 0.15 mrem by 0.33 mrem/μCi and 8400 to obtain a concentration of 54×10^{-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 40 C.F.R. 61, Subpart H, during calendar year 1994. Periodic confirmatory measurements and analysis of the NTS environs are provided in Appendices A through G. These measurements and analysis are the methods of determining NTS effluents presented in the April 24, 1991, meeting between Region 9 and DOE/NV and documented in the 1990 through 1994 DOE/NV annual reports.

COMPLIANCE WITH SUBPARTS Q AND T, 40 C.F.R. 61

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

RADON EMISSIONS FROM U-238 AND TH-232 SOURCES

Material from Mound Applied Technologies is stored in cargo containers at the RWMS site in Area 5. Thermoluminescent dosimeters placed around the containers have not detected an increase in gamma exposure that would occur as radon daughters accumulate in the cargo containers.

NON-DISPOSAL/NON-STORAGE SOURCES OF RADON EMISSION

None of these sources exist on the NTS.

NESHAP QUALITY ASSURANCE PROGRAM

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

APPENDIX I

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