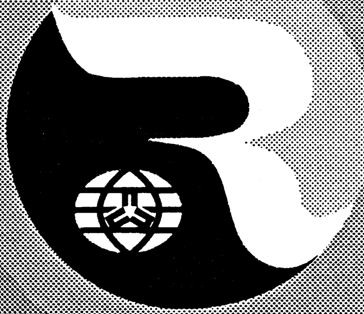
National Emission Standards for Hazardous Air Pollutants Submittal - 1992

By
Stuart C. Black



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U.S. Department of Energy
Air Emissions Annual Report
(under Subpart H, 40 CFR 61.94)
Calendar Year 1992

Site Name: NEVADA TEST SITE

Operations Office Information

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Las Vegas, NV 89193-8518

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Environmental Protection Division

Site Information

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Environmental Management Division

Section I. Facility Information

Site Description

The Nevada Test Site (NTS) is operated by the Nevada Field Office, U.S. Department of Energy, as the on-continent test 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, NV. The NTS covers about 3500 km^2 (1350 mi^2), an area larger than Rhode Island. Its size being 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 Base Range Complex) that provide another 15 to 65 miles between the NTS and public lands (Figure 1). 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 kilometer, 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 are great depths to slow-moving groundwater resources. Processing of radioactive materials is limited to laboratory analyses. Handling of these materials is limited to transport, assembly, and underground placement of nuclear explosive devices and operation of a waste disposal (LLW) site.

Source Description

Figure 2 is a map of the NTS which shows the areas used for nuclear testing. 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 engine testing. Since the mid 1960s, testing of nuclear devices has occurred underground in drilled vertical holes or in mined tunnels. Limited non-nuclear testing has included spills of hazardous material at the Liquified Gaseous Fuels Spill Test Facility (LGFSTF). Facilities for the storage and disposal of mixed and low-level radioactive waste are also operated on the NTS. Monitoring and evaluation of the various activities conducted onsite indicates that the potential sources of offsite radiation exposure in 1992 were releases: (1) from sampling activities following underground nuclear tests in the Yucca Flat and Rainier Mesa areas of the NTS; (2) from evaporation of tritiated water from containment ponds that receive drainage water from tunnels E, N, and T in Area 12 and from the Decontamination Facility in Area 6; (3) from onsite radioanalytical laboratories and a protective clothing laundry; (4) from the Area 5 low-level waste storage and disposal facility; and (5) from other diffuse sources that are discussed later. The following sections present a general description of the effluent sources on the NTS.

Ground Seepage

Ground seepage may occur when changes in ambient pressure pump noble gases up from the cavity created by the nuclear test through the overburden and into the atmosphere. 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 NTS. These seepages were from nuclear tests conducted prior to 1992.

Krypton-85 was detected at all environmental sampling locations on the NTS as it has been in previous years. The Area 20 environmental sampler was about 4 pCi/m^3 above the onsite network average, but the precise source is unknown. Assuming this seepage occurs from an area under which several underground tests were conducted, a source term can be calculated as shown in Appendix 9.

Tunnel Operations

Nuclear tests are sometimes conducted within tunnel complexes drilled into the Rainier Mesa region. Following this type of test, mine-back operations may discharge radiological effluents into the tunnel; the tunnel air is then purged to the atmosphere by a ventilation system. The active tunnels, i.e. those tunnels used for nuclear testing in 1992, are called "P Tunnel" and "N Tunnel". Analysis of the airborne radiological contaminants is performed on samples collected at the discharge point of the tunnel air. Figure 3 is a photograph of a tunnel portal and Appendix 3 contains the Defense Nuclear Agency (DNA) procedures for this activity. Isokinetic sampling equipment has been installed in P Tunnel and is being operated by REECo. The results obtained tend to confirm the DNA measurement methodology (described in Appendix 3) within a factor of 2 or 3.

Containment Ponds

Water which is radiologically contaminated is held within containment ponds. The sources of the water for evaporation are the tunnels in Area 12 and a decontamination facility located in Area 6. A photograph of tunnel containment ponds is provided as Figure 4. The only significant radiological contaminant which produces an air emission from evaporation of the water is ^3H (as HTO). The calculation of the source term is described in Appendix 5.

Drillbacks

Following underground nuclear tests, core samples are taken for analysis from the nuclear cavity formed by the detonation of the device. This is referred to as core-sampling and is accomplished by drilling into the area of interest and recovering the sample using special drilling equipment. Radioactive material may be discharged into the atmosphere during the drilling operations, subsequent core-sampling, and cement-back operations. Because of different engineering designs, there are two methods for handling potential effluents during drillbacks. These are described in Appendices 1 and 2.

Laboratories

Radiological analyses are conducted by REECo in a laboratory located in Building 650, and LANL conducts similar analyses in Building 701 at Mercury (see Appendix 2). Because these facilities primarily process environmental samples, very little radioactivity passes through them. However, there is potential for some quantity of radionuclides to be discharged into the atmosphere through the hood ventilation system during sample processing, particularly spiked samples, or from loss of radioactive standards. Figure 5 is a photograph of the Building 650 hood ventilation stacks seen from above. The source term for Bldg. 701 is contained in Appendix 2 and for Bldg. 650 in Appendix 4. In general, evaporation and spills from samples containing HTO, radioiodines, or noble gases is conservatively estimated by assuming all such materials are released. Non-volatile materials are controlled by keeping their inventory below the possession limits set forth in Appendix E to 40CFR61.

Decontamination Laundry

Anti-contamination suits, which have acquired some radiological contamination, are washed and dried at the Area 6 Decontamination Facility. The potential for radionuclides to cling to the fabric during the washing phase is small, but the potential exists that they may be discharged into the atmosphere during the drying phase. A photograph of the effluent discharge point from the driers is provided as Figure 6. The louvered box (shown closed) located in the upper center of the photograph is the actual point of discharge., and the method of calculating the source term is explained in Appendix 8.

Area 5 Radioactive Waste Management Site (RWMS)

This site is used for the disposal of low-level waste, for storage of transuranic and mixed 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. Only packaged wastes are accepted for disposal. The facility is considered a diffuse source of radiological effluents. The only radioactive effluent picked up by the various types of samplers surrounding the site is HTO. The calculation of the HTO source term is explained in Appendix 7.

Plutonium Contaminated Surface Areas

Surface soils in certain areas on and off of the NTS were contaminated with plutonium from either safety, atmospheric, or cratering (the Plowshare Program) tests using nuclear explosives. An investigation of these areas during the Nevada Applied Ecology Group studies developed the inventories of plutonium shown in Table 1. These areas could become potential sources of plutonium exposure if the contaminated soils were to be resuspended, e.g., during surface cleanup or similar activities. Figure 7 is a map showing the approximate locations of the nuclear device tests on the NTS. There are air samplers at or near almost all onsite areas. Plutonium analyses of the glass-fiber filters from these samplers indicates 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 one area that is different is Area 3 where operational activities can cause contaminated surface soil to become resuspended. Area 3 is considered a diffuse source of radioactive effluents, although plutonium is the only detectable one. The calculation of the source term is explained in Appendix 6.

Table 1

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. ($\overline{X} \pm 2s$) IN 10^{-18} μCi/mL units
PROJECT 56 (AREA 11)(1)	4.83	205	36	28 - 44	28 ± 127
GMX (AREA 5)(1)	0.125	111	1.5	1.1 - 1.9	6.9 ± 13.4
LITTLE FELLER II(Area 18)(4)	0.375	712	32(3)	22 - 41	
PALANQUIN* (AREA 20)(2)	3.895	148	13(3)	6 - 21	7.2 ± 29.5
SEDAN (AREA 10)(2)	28.264		111.2		180 ± 190
T2 SERIES (AREA 2)(4)	30.100		26.7		19 ± 17

(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: (1) by monitoring methods and procedures previously developed at NTS (see Appendices 1, 2, and 3), (2) by a yearly radionuclide inventory of the source, assuming that volatile radionuclides are released to the environment, (3) by assuming that all surface contamination on anti-contamination clothing is released to the environment during laundering, (4) by the measurement of tritium (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 (5) by using a combination of environmental measurements and CAP88-PC to calculate emissions. Appendices 1 through 9 describe the methods used to determine the emissions from the sources listed in Section I. In accordance with 40 CFR 61.93.(b).(4).(ii), no credit was taken for pollution control equipment in determining air emissions.

These NESHAP emissions are listed in Table 2, are very conservative (worst case), are used in Section III to calculate the EDE to the Maximum Exposed Individual (MEI), and exceed, in some cases, those reported in DOE's Effluent Information System (EIS). The NESHAPs worst case emissions that exceed the EIS reported emissions are noted by a (1) in Table 2.

A summary of the NTS total emissions for NESHAPs reporting, by radionuclide, is provided in Table 3.

Table 2. Summary of Annual Air Emissions Data by Source

POINT SOURCE	Type of Control	Efficiency	Distance to Nearest Receptor	Nuclide	Quantity (Ci)
Drillback Area 3	None	0%	54 km	^{133}Xe	0.11
(1)Building 701 Laboratory	NONE	0%	24 km	^{3}H	5.0×10^{-4}
				^{131}I	2.0 X 10^{-6}
				^{133}Xe	4.0×10^{-2}
GROUPED SOURCE					
Tunnel Operations(3)*	HEPA Charcoal	>50% (^{131}I)	56 km	^{3}H	0.41
				^{37}Ar	2.9
				^{39}Ar	8.1×10^{-5}
				^{85}Kr	1.3
				^{127}Xe	5.7×10^{-6}
				^{129m}Xe	2.4×10^{-5}
				^{131m}Xe	1.5×10^{-2}
				^{133}Xe	0.28
				^{131}I	6.0×10^{-6}
(1,2)Decontamination Laundry (6)	NONE	0%	42 km	^{131}I	1.3×10^{-5}
(1)Building 650 Laboratory (12)	NONE	0%	24 km	^{3}H	6.5×10^{-6}
				^{131}I	5.6×10^{-5}

* (x) is number of vents or stacks.

(1) Not on the EIS Report. Potential emissions only.

(2) Assumes contaminant on Anti-C suits is ^{131}I.

Table 2. Summary of Annual Air Emissions Data by Source (continued)

NON-POINT SOURCE	Type of Control	Efficiency	Distance to Nearest Receptor	Nuclide	Quantity (Ci)
[3]Containment					
Pond: Area 6	None	0%	42 km	^{3}H	0.0048
Area 12	NONE	0%	56 km	^{3}H	2240
[4]Area 3	NONE	0%	54 km	$^{239+240}Pu$	2.5×10^{-3}
[4]RWMS	NONE	0%	42 km	^{3}H	0.60
[4]Pahute Mesa (Ground Seepage)	NONE	0%	42 km	^{85}Kr	280

(3) Evaporation of all tritiated water effluents is assumed, reported in EIS as liquid effluent to containment ponds.
(4) Source emissions calculated from environmental sampling, see Appendices.

These data are summarized by total quantity of radionuclide released during the year in Table 3.

Table 3

TOTAL EMISSIONS FOR CY 1992*

Radionuclide	Half-Life (days)	Annual Quantity (Ci)
^{3}H	4510	2200
^{37}Ar	35.02	2.9
^{39}Ar	9.8×10^{4}	8.1×10^{-5}
^{85}Kr	3.9×10^{3}	281
^{127}Xe	36.4	5.7×10^{-6}
^{129m}Xe	8.9	2.4×10^{-5}
^{131m}Xe	11.9	1.5×10^{-2}
^{133}Xe	5.24	0.43
^{131}I	8.04	7.7×10^{-5}
$^{239+240}Pu$	8.8×10^{6}	2.5×10^{-3}

* 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 persons. The input parameters were the radionuclide releases listed in Section II above as reported by Los Alamos National Laboratory, Lawrence Livermore National Laboratory, Sandia National Laboratories and the Defense Nuclear Agency plus liquid effluent monitoring performed by the NTS operating contractor (REECo). Gaseous releases occurred as part of drillback operations, tunnel purging, laundry and laboratory processes, the tunnel evaporative ponds, and from the Area 6 Decontamination Facility pond. The only measurable particulate emission was $^{239+240}$Pu originating in Area 3.

To calculate the amount of tritiated water (HTO) evaporated, measurements of HTO concentration in the containment ponds were compared for February 1992 and December 1992. These concentrations were assumed equal, i.e., within measurement error so all the HTO influent to the ponds during 1992 was assumed to have evaporated, a conservative estimate as no allowance for infiltration into the soil column is made. A description of the estimated source term for these emission sources 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 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 Weather Service Nuclear Support Office (WSNSO) 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 WSNSO assessment is attached as Appendix 10. For each of these five STARs there may be a different location for the maximally exposed individual, but, when the contributions of all NTS sources are considered, only one location would receive the maximum exposure, Indian Springs, Nevada. See Figure 1 for location residences and communities around the NTS.

The EDE, in mrem, to the maximally exposed individual (a resident in Indian Springs, NV) 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. Calculation of this EDE requires summing the contribution from all sources as shown in Table 5. The sources listed as containment ponds in Areas 6 and 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 added in this report, completes the possible sources of emission of radioactivity on the NTS. Appendices 1 - 9 contain estimates of radionuclides which could be released from each source. 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.

Table 4

Summary of CY 1992 CAP88-PC Calculation of EDE to the Maximally Exposed Individual in Indian Springs, Nevada*

Source	Distance to Individual and Direction	Effective Dose Equivalent (mrem)
Tunnel Operations (Area 12)	80 km SSE	2.8×10^{-6}
Drillback (Area 3)	64 km SE	1.9×10^{-9}
Containment Ponds**		
Area 6	54 km SE	2.2×10^{-10}
Area 12	80 km SSE	0.012
Laboratories		
REECo	34 km ESE	6.8×10^{-9}
LANL	34 km ESE	5.4×10^{-9}
Decontamination Laundry	54 km SE	4.5×10^{-9}
Plutonium Resuspension (Area 3)	64 km SE	2.9×10^{-4}
LLW Facility (Area 5)	42 km SE	8.4×10^{-6}
	TOTAL	0.012

* Location of residences and communities around the NTS is shown in Figure 1.
** Assumes evaporation of all tritiated water influents to ponds.

NOTE: To two significant figures, the MEI dose was due to diffuse emission sources. Therefore, the EDE from point sources was negligible.

TABLE 5. EFFECTIVE DOSE EQUIVALENT TABULATION BY LOCATION

LOCATION	POPUL.[5]	EDE (μREM/YEAR) DUE TO RELEASES FROM:							EDE μREM
		AREA 12		PAHUTE MESA[1]	YUCCA FLAT		CP-1		TOTAL THIS PAGE
		PONDS[1]	TUNNEL[2]		AREA 3[1]	DRILL[2]	POND[1]	LAUNDRY[3]	
AMARGOSA VALLEY	950	3.1	6.5E-4	1.1E-3	0.77	4.4E-6	7.3E-7	1.4E-5	3.87
ASH MEADOWS	10				0.82	4.7E-6	1.1E-6	1.4E-5	0.82
BEATTY	1500	2.5	5.1E-4	2.4E-3	1.0	7.0E-6	6.3E-7	1.1E-5	3.5
CRYSTAL	45	7.8	1.7E-3		0.80	4.5E-6	1.6E-6	1.2E-5	8.6
DEATH VALLEY JCT	7	(See Note 4)					6.8E-7	9.9E-6	1.1x10^{-5}
DESERT GAME RANGE	4								
FURNACE CREEK	200								
INDIAN SPRINGS	1500	12	2.8E-3		0.29	1.9E-6	2.2E-7	4.5E-6	12.29
LATHROP WELLS	30	3.7	7.9E-4	1.2E-3	1.4	6.7E-6	1.3E-6	1.7E-5	5.1
LIDA JUNCTION	8			2.0E-3					2.0x10^{-3}
MEDLIN'S RANCH	4	4.1	8.6E-4	7.7E-4	0.50	2.2E-6	9.4E-7	3.5E-6	4.6
MT. CHARLESTON	500						1.0E-7	9.1E-6	9.2x10^{-6}
PAHRUMP	15000								
PENOYER FARM	20	4.0	8.6E-4	1.0E-3	0.40	1.7E-6			4.4
RACHEL	105	3.8	8.2E-4	8.4E-4	0.39	1.6E-6			4.19
SARCOBATUS FLATS	20	6.7	1.4E-3	2.9E-3	0.23	1.1E-6			6.93
SHOSHONE	250								
S. NEV. CORR. CTR	1400				0.23	1.5E-6	1.3E-7	3.7E-6	0.23
SPRINGDALE	35	2.8	5.9E-4	2.9E-3	1.0	5.6E-6	5.7E-7	1.1E-5	3.8
STATELINE & AREA	127				0.66	4.4E-6	1.0E-6	1.2E-5	0.66
TEMPIUTE	2	3.5	7.3E-4	7.5E-4	0.34	1.5E-6			3.84
U.S. ECOLOGY	35	3.2	6.9E-4	1.5E-3	1.0	7.0E-6	3.4E-7	1.5E-5	4.2

TABLE 5. EFFECTIVE DOSE EQUIVALENT TABULATION BY LOCATION (Cont'd)

LOCATION	POPUL[5]		EDE (μREM/YR) FROM RELEASES AT:			TOTAL EDE	COLLECTIVE EDE
		EDE FORWARDED	AREA 5[1] RWMS	MERCURY LABS REECo[3]	LANL[3]	ALL SOURCES	PERSON-MREM
AMARGOSA VALLEY	950	3.87	0.0081	1.4E-5	1.5E-5	3.88	3.68
ASH MEADOWS	10	0.82	0.0055	1.0E-5	1.2E-5	0.83	8.3x10^{-3}
BEATTY	1500	3.5	0.0082	9.7E-7	1.1E-5	3.51	5.3
CRYSTAL	45	8.6	0.0085	3.0E-5	2.2E-5	8.61	0.39
DEATH VALLEY JCT	7	1.1x10^{-5}	0.0059	4.8E-6	8.1E-6	5.93x10^{-3}	4.1x10^{-5}
DESERT GAME RANGE	4		0.0044	1.5E-6	2.4E-6	4.4x10^{-3}	1.8x10^{-5}
FURNACE CREEK	200			2.6E-6	7.0E-6	7.29x10^{-6}	1.5x10^{-6}
INDIAN SPRINGS	1500	12.29	0.0084	6.8E-6	5.4E-6	12.35	18
LATHROP WELLS	30	5.1	0.010	7.5E-6	2.0E-5	5.12	0.15
LIDA JUNCTION	8	2.0x10^{-3}				2.0x10^{-3}	1.6x10^{-5}
MEDLIN'S RANCH	4	4.6	0.0049			4.69	0.018
MT. CHARLESTON	500	9.2x10^{-6}	0.0043	1.2E-6	3.0E-6	4.31x10^{-3}	2.2x10^{-3}
PAHRUMP	15000		0.0052	6.6E-6	8.3E-6	5.21x10^{-3}	0.078
PENOYER FARM	20	4.4				4.4	0.088
RACHEL	105	4.19				4.19	0.44
SARCOBATUS FLATS	20	6.93				6.93	0.14
SHOSHONE	250			7.8E-7	5.4E-6	5.5x10^{-6}	1.4x10^{-6}
S. NEV. CORR. CTR	1400	0.23	0.0066	2.1E-6	3.8E-6	0.24	0.33
SPRINGDALE	35	3.8	0.0068	7.8E-7	1.0E-5	3.87	0.13
STATELINE & AREA	127	0.66	0.0062	8.1E-6	1.0E-5	0.67	0.085
TEMPIUTE	2	3.84				3.84	7.7x10^{-3}
U.S. ECOLOGY	35	4.2	0.0091	1.4E-6	1.3E-5	4.21	0.14

[1] Emissions calculated from surveillance or engineering data, included on EIS forms.
[2] Monitored releases, included on EIS forms.
[3] Emissions calculated from engineering data, not included on EIS forms.
[4] Blank spaces represent locations farther than 80 km from the source for the column.
[5] Population at that location for 1992.

TABLE 5. EFFECTIVE DOSE EQUIVALENT TABULATION BY LOCATION (Cont'd)

TOTAL POPULATION - 21,750	MAX. INDIVIDUAL μREM CALCULATED FOR EACH RELEASE POINT						TOTAL PERSON-REM:
MAXIMALLY EXPOSED INDIVIDUAL: 0.012 MREM	AREA 12	PAHUTE MESA	YUCCA FLAT	CP-1	AREA 5	MERCURY	0.029
LOCATION OF MAX: INDIAN SPRINGS	12	2.9×10^{-3}	1.4	1.8×10^{-5}	0.010	2.5×10^{-5}	

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: Nick C. ~~Aquilina~~, Manager, Nevada Operations Office
for

Signature: Robert M Nelson Jr. Date: 5/24/93

Section IV. Additional Information

1. New Construction/Modification Activities at the NTS

No new construction or modification to existing permanent structures that emit radionuclides during normal operations were completed at the NTS in Calendar Year 1992.

2. Unplanned Releases During this Calendar Year.

All releases during calendar year were operational. There were no detectable unplanned releases.

3. Sources of Diffuse or Fugitive Emissions.

These sources included containment ponds for liquid effluents from E, N, & T tunnels, and a pond in Area 6, resuspension of $^{239+240}Pu$ from Area 3 on the NTS (plutonium was a negligible source of exposure to the offsite population), seepage of noble gases on Pahute Mesa, and seepage of tritium from packages buried at the RWMS in Area 5.

The EDE to the MEI was mostly due to 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.

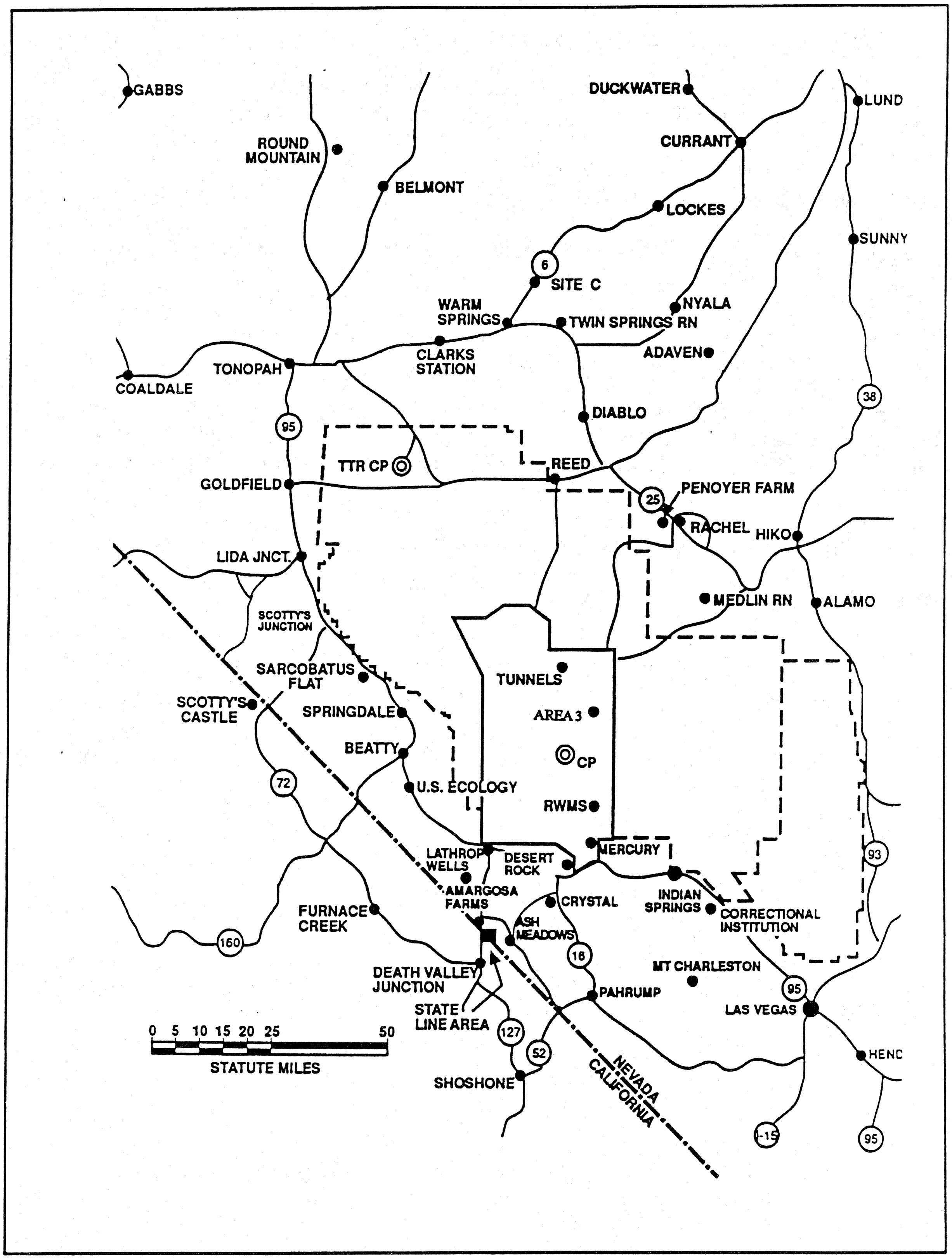
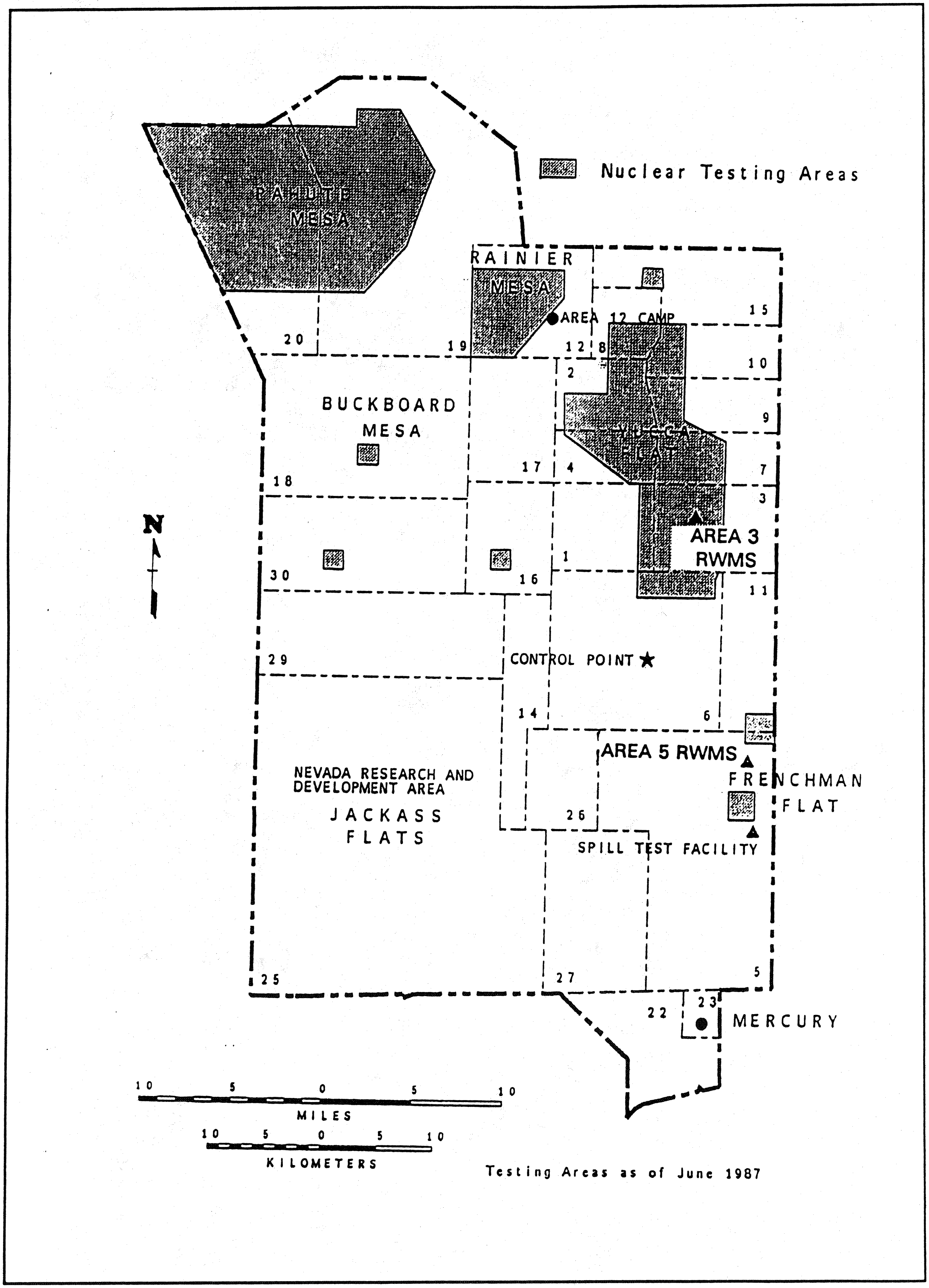


Figure 1 Map of the Area Around the NTS



Testing Areas as of June 1987

Figure 2. Nuclear Testing Areas on the Nevada Test Site

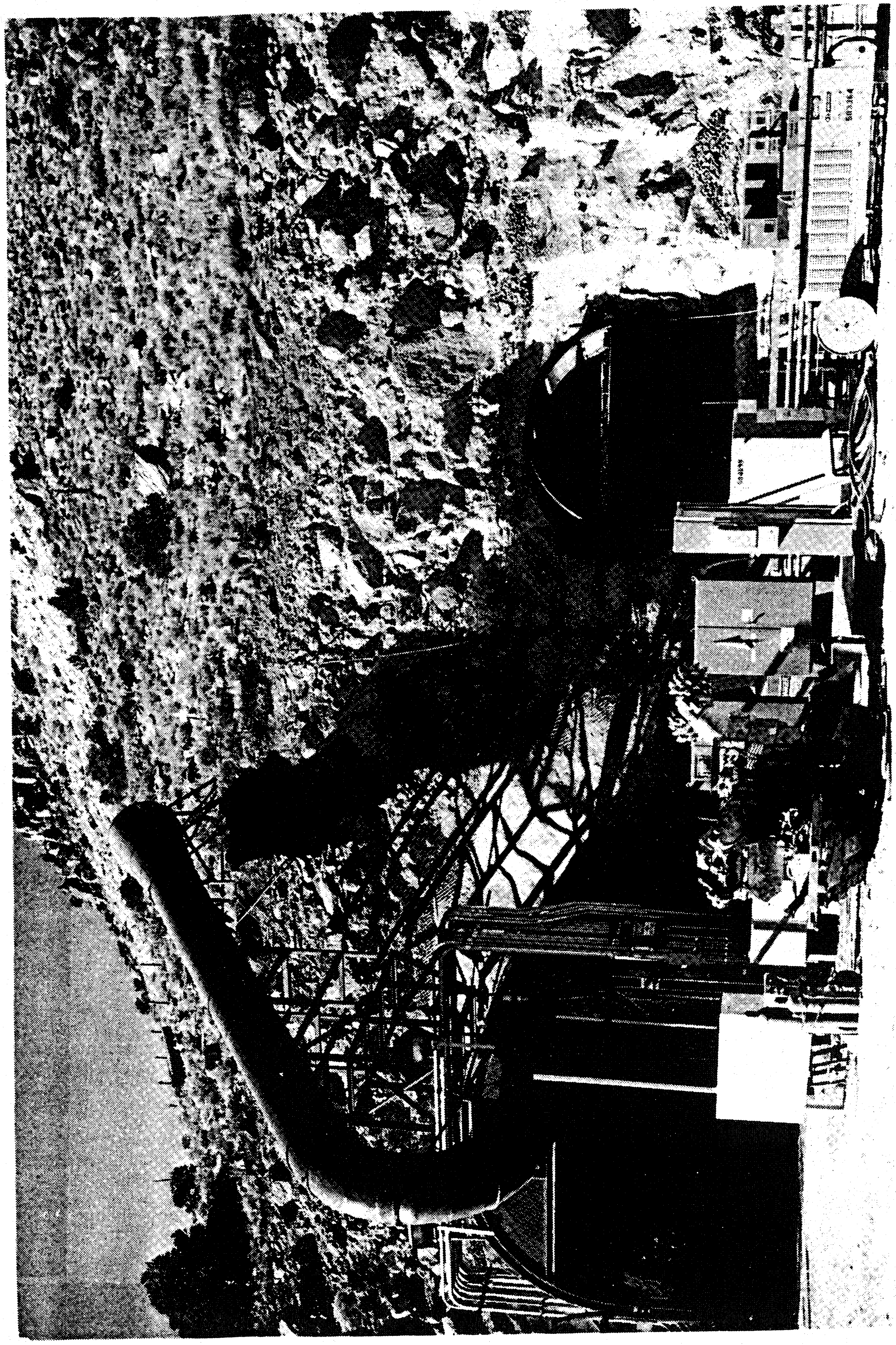


Figure 3. Photograph of a Tunnel Portal

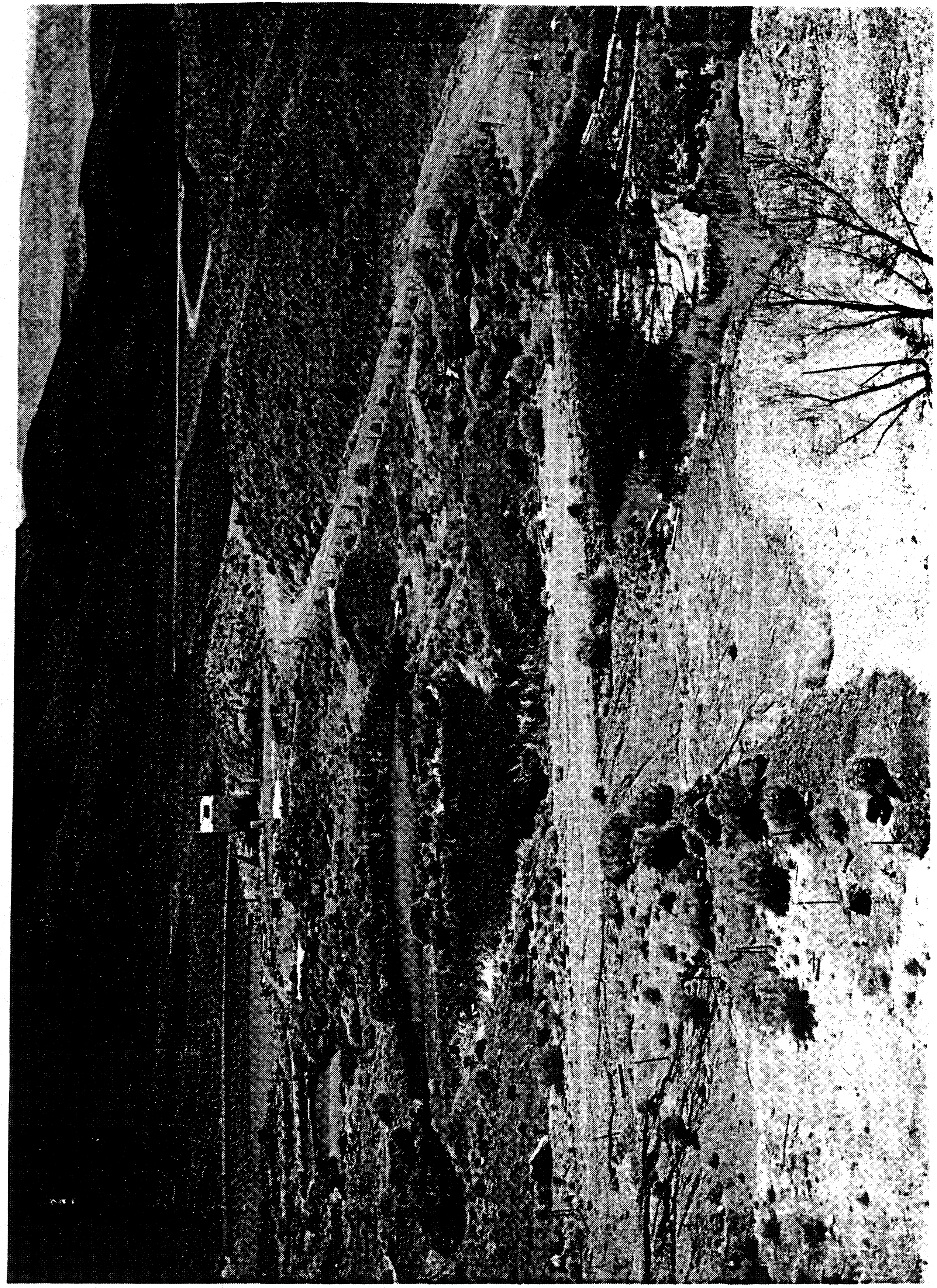


Figure 4. Photograph of Tunnel Containment Ponds

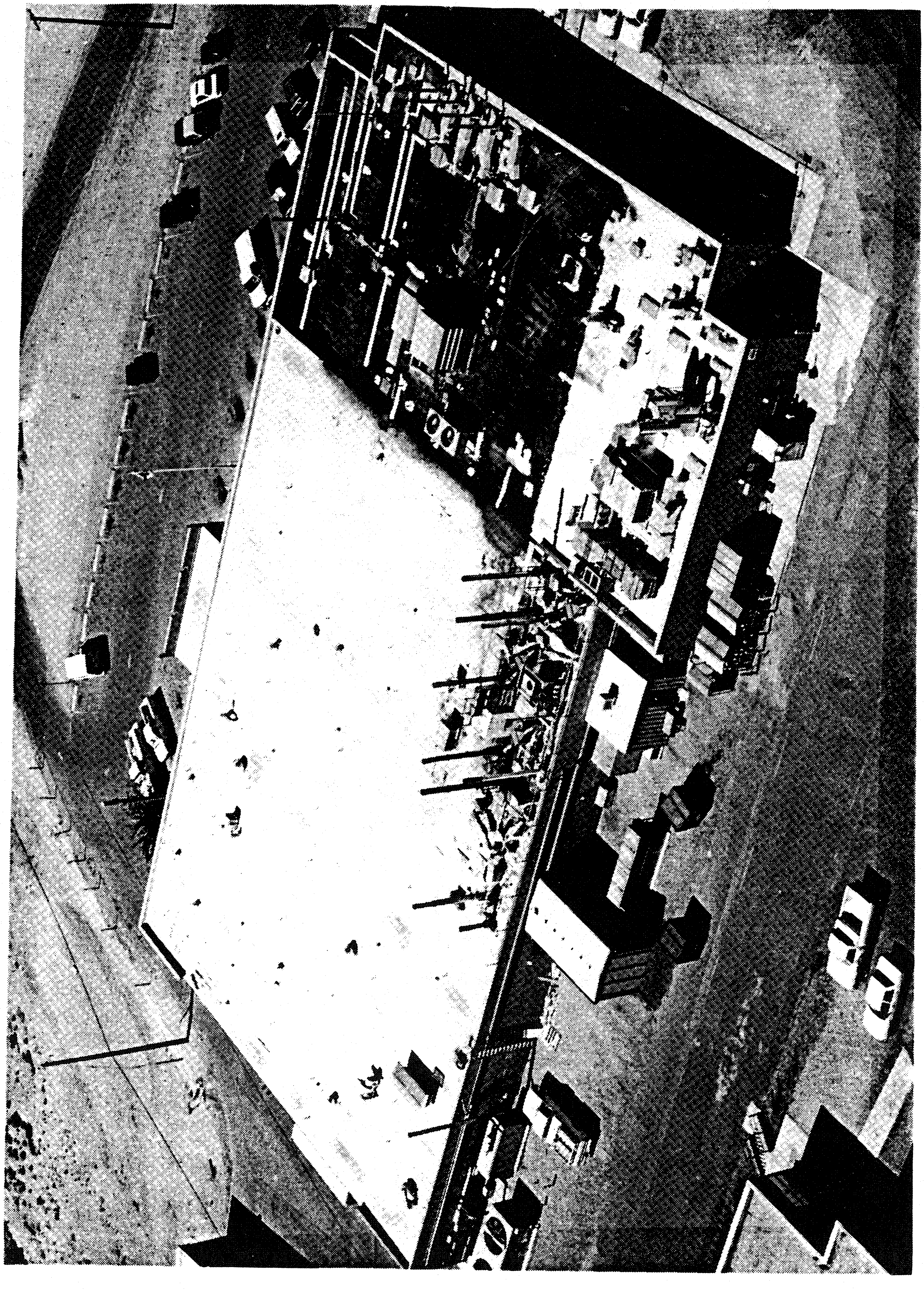


Figure 5. Photograph of the Building 650 Hood Ventilation Stacks Seen from Above

Figure 6. Photograph of the Effluent Discharge Point from the Area 6 Decontamination Laundry Driers

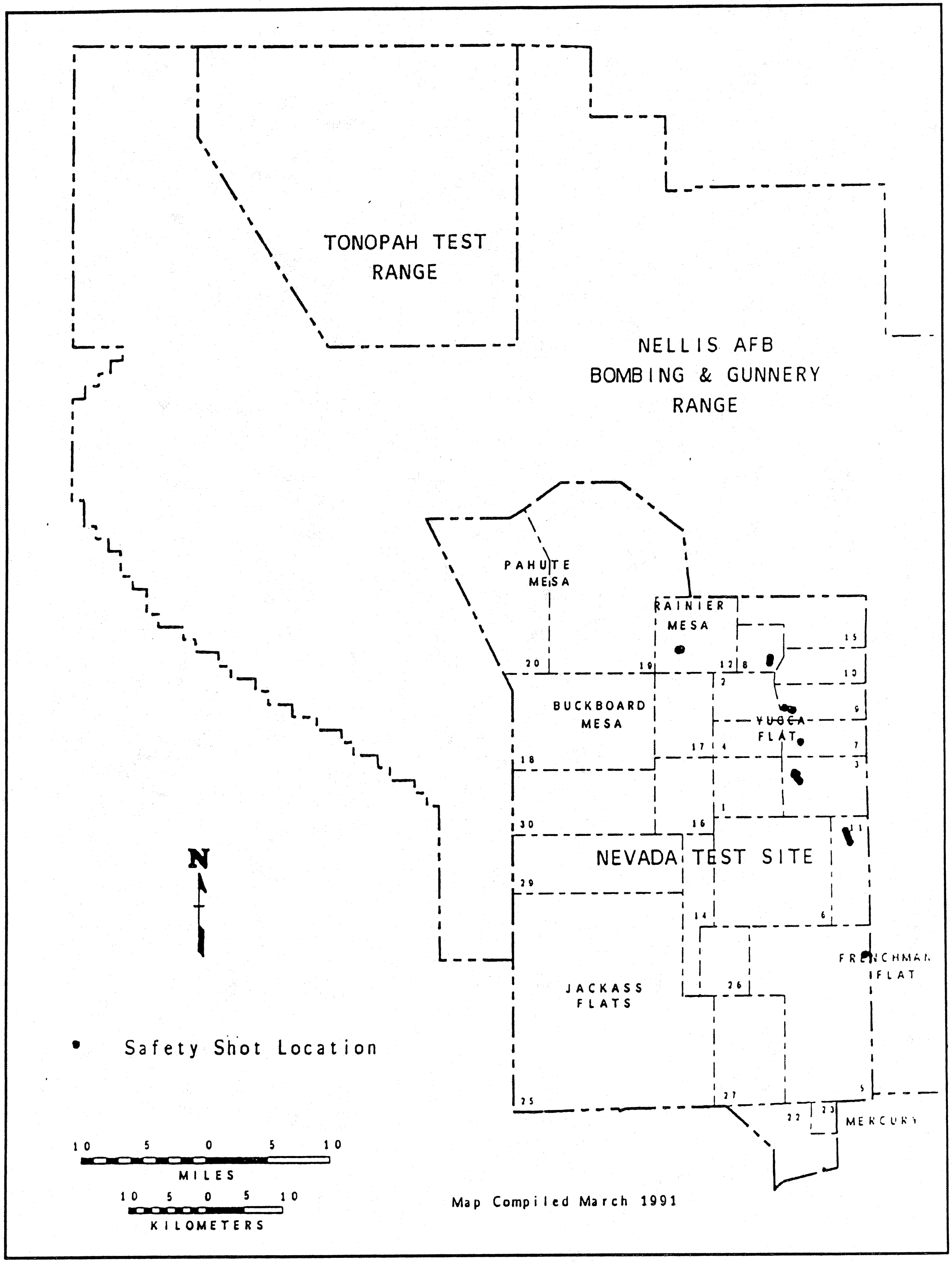


Figure 7. Locations of surface soil plutonium contamination on the NTS

Appendix 1. Lawrence Livermore National Laboratory

ANNUAL NATIONAL EMISSION STANDARDS FOR HAZARDOUS AIR POLLUTANTS EMISSIONS REPORT
LAWRENCE LIVERMORE NATIONAL LABORATORY
NUCLEAR TEST OPERATIONS DEPARTMENT

NEVADA TEST SITE

by

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March 30, 1993

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1.0 Introduction

Lawrence Livermore National Laboratory (LLNL) is one of the prime users of the Nevada Test Site (NTS). LLNL only performs effluent monitoring for its NTS projects. This plan includes the organizational structure and responsibility of LLNL, the present system of notification and reports, effluent monitoring programs with a brief discussion of any decisions made, quality assurance, dose calculation, and accuracy of effluent measurements. An exhibit (Appendix A) is attached to this plan as a descriptive aid.

Effluents may result because of an operation whose purpose was to sample the nuclear cavity region resulting from a nuclear explosion. The effluent quantity is small but the frequency of occurrence may be high.

1.1 Organizational Structure and Responsibility

LLNL's Health, Safety, and Environmental Program is administered through the Associate Director for Nuclear Test-Experimental Science. Although authority is delegated to either the LLNL-Nuclear Test Operations Department (NTOD) head or the Test Director, execution of the program resides with the LLNL-NTOD Environment, Safety and Health Group (ES&H).

The line contact for effluent monitoring of LLNL programs at the NTS is the LLNL-NTOD ES&H Group although responsibility may belong to the LLNL-NTOD Head or the LLNL Test Director.

1.2 Operational Areas

None of the activities for which the LLNL conducts effluent monitoring are permanent. Since the location of each underground nuclear explosion varies, an effluent monitoring system must be moved to that location. Effluent monitoring only takes place during the operation and at locations designated by DOE/NV as nuclear testing areas. The LLNL nuclear testing areas for underground testing in vertical shafts are Areas 2, 4, 8, 9, 10, 19, and 20. LLNL also has a permanent facility in Area 27 to conduct device assemblies. Normally, no effluents result from these operations.

2.0 Effluents

The sources of effluent release from LLNL operations at the NTS, their probability of occurrence, and the range of activity encountered are listed in Table 1.

Additionally, a maximum potential postshot drilling release can be calculated, e.g., for this maximum potential release it is assumed that: (a) all containment apparatus has failed, (b) the means to shut in the hole do not exist, and (c) the concentration of chimney gas is homogenous. Calculations indicate that

$$10 \mu\text{Ci/mL} \times 10^{-6} \text{Ci}/\mu\text{Ci} \times 3.0 \times 10^{7} \text{mL} = 300 \text{ Ci}$$

of radioxenons are released to the atmosphere. If it is additionally assumed that the ventline system does not work (therefore there is no filtering) some 40 mCi of radioiodines are released. It is estimated that the first case has a probability of occurrence of less than 10^{-4} and the second case has a probability of occurrence of less than 10^{-7}.

It is estimated that this would contribute some 7x10^{-4} mrem to an individual at 10 km from the release point.

The plans for monitoring this source are detailed in Attachment 1.

Table 1 List of Radioactive Effluents and Probability of Occurrence

Operation	Type	Probability of Occurrence	Isotopes	Effluent Activity Range
Seep	Air	$< 10^{-2}$	131m,133Xe 85Kr	5 to 1000 Ci
Postshot:				
Noble gases	Air	0.4	133,133m,135Xe	0 to 100 Ci
Iodine	Air	< 0.1	131,133I	0 to 2.0 mCi
Assembly	Air	$< 10^{-7}$	3H	0 to 100 Ci
Postshot Sumps*	Liquid	1	MFP	.01 to 5 mCi
Other	Unknown	Unknown	Unknown	Unknown

* For postshot operations after January 31, 1990, this liquid effluent stream was replaced by a containerized waste stream.

3.0 Effluent Monitoring Plan

The late-time seep of radioactive gases through the ground, driven by barometric changes, depends on the surface geology, yield, and barometric pressure. The probability of occurrence can be estimated before the event. No special monitoring is done because of continuous monitoring by the on-site Noble gas network, the low probability of occurrence, and minimal health impact. If a seep of this kind does occur, special monitoring will be requested when the source is identified.

Effluent monitoring of post-shot drilling activities is more complicated because its point of effluent release can vary in an unpredictable manner. For this reason, extensive monitoring is done (see Attachment 1). The majority of releases are through the ventline, which is continuously monitored. The linear flow rate in the ventline is measured hourly.

The ventline monitoring system and effluent calculation are explained in the references to Attachment 1.

To preclude any liquid disposal in soil columns, the cellar effluent from post-shot drilling operations is containerized and either re-injected or disposed of in waste burial grounds.

Alarm criteria for post-shot monitoring are set at low levels so that steps to mitigate effluent release can be taken.

Monitoring for nonradioactive effluent during postshot drilling operations is limited to work place monitoring using portable instrumentation.

Work-place monitoring during device assembly operations, for both airborne alpha emitters and elemental tritium (when necessary), is continuous during device assembly operations. Alarm levels are set so as to preclude false alarms but provide adequate warning. The probability of any effluent is almost nonexistent. Therefore, no routine effluent monitoring program is conducted at the assembly facility.

LLNL does perform other experiments which may produce an effluent stream. When such a project is instituted, efforts to measure the effluent (radioactive and/or nonradioactive) with proper meteorological support are taken.

4.0 Quality Assurance

The QA program for most effluent monitoring devices that LLNL-NTOD uses is administered through the contractors who provide those instruments. For example, the post-shot instrumentation is calibrated and maintained by the REECo HPD. LLNL provides general instructions concerning instrument calibration. Meteorological instruments are calibrated, fielded, and maintained by NOAA.

Performance validation of the post shot drilling effluent measuring instrument is as follows. The ventline monitor (only used for postshot operations) is checked with a sealed source of ^{109}Cd or ^{133}Ba (to simulate the low energy of ^{133}Xe) in conditions similar to those seen during postshot operations. It is also checked with a ^{60}Co source and a pulser before each use and is frequently checked during use. Also, since a linear superposition of xenon isotopes is assumed, verification of xenon ratios is obtained from postshot gas samples.

5.0 Dose Estimation and Effluent Error

Calculations using CAP88-PC indicate that at 10km (a conservative estimate of distance to the maximally exposed individual) effluent releases of 95,000 Ci of ^{133}Xe or 9.5 Ci of ^{131}I or 2300 Ci of ^{3}H would result in a receptor dose of 0.1 mrem and would require continuous monitoring. Using the maximum numbers in the effluent range given in Table 1 for postshot activities and the release figures for CY92 (no releases), the resultant effective dose equivalents are listed in Table 2.

Table 2

OPERATION	ISOTOPE	MAXIMUM DOSE AT 10KM	CY92 DOSE AT 10KM
Seep	^{133}Xe	$1x10^{-3}$ mrem	0 mrem
Postshot	^{133}Xe	$1x10^{-4}$ mrem	0 mrem
Postshot	^{131}I	$2x10^{-5}$ mrem	0 mrem
Assembly	^{3}H	$4X10^{-3}$ mrem	0 mrem

Because LLNL-NTOD is only responsible for a portion of the NTS, DOE/NV only requires total activity determinations. Dose estimations are done as a part of work-place monitoring and are based on both measurements and external and internal dosimetry data.

Special situations may arise in which dose estimations are made because of effluent releases. However, this estimate is only used for planning purposes. The final dose is based on all measurements made by DOE/NV's contractors and calculated by them.

The calculation of effluent is uncertain because of the type of release (diffuse or point), emanation point(s) of the release, assumptions made, and models used. Every effort is made to reduce this uncertainty by utilizing other on-site detection results. In some cases the releases can be easily defined geometrically and error could be as little as 30 percent. However, if Gaussian transport theory must be relied on, the result may be uncertain by a factor of ten. Effluent calculations done for postshot releases are less uncertain because transport theory is seldom used.

6.0 Notification and Reports

The procedure to be followed in notifying LLNL personnel is outlined in the NTS Health and Safety Manual. Notification of DOE personnel is also outlined in the NTS Health and Safety Manual.

It has been the policy of LLNL that upon notification of LLNL-NTOD ES&H, a decision, based on the possible health, safety and environmental consequences of the incident, is made as to whether or not DOE/NV should be notified immediately. However, LLNL has been directed to notify DOE/NV immediately of instantaneous post-shot releases above 10 curies (per NTS-SOP-5402, "Radiation Release Surveillance - Notification Procedures," June, 1990). This immediate notification is followed by written documents to DOE/NV. These documents include:

Daily Reports Generated by the Resident Manager

Individual operational reports generated by LLNL-NTOD ES&H within weeks after completion of the operation.

Completion reports of each fiscal year activity.

Annual Radioactive Effluent and On-Site Discharge Data Reports.

Final event reports (classified because of specific event information).

If an Occurrence Report (OR) or Off-Normal Report is required because of an effluent incident, the affected LLNL organization is responsible for investigating the occurrence and preparing the report. Both DOE/NV and DOE/SAN (San Francisco Operations Office) will receive copies of any OR.

The effluent calculations performed by LLNL-NTOD ES&H results of which are reported, will include those elements required by DOE/NV to perform dose calculations as recommended in DOE Environmental Regulatory Guide, DOE/EH-0173T. Source term calculations shall describe the variables used, conversion factors, identify the source of data, describe the calculational method, and the effluent memo will be signed and dated.

ATTACHMENT 1 - LAWRENCE LIVERMORE NATIONAL LABORATORY POSTSHOT DRILLING/EFFLUENT MONITORING

Monitoring for effluent during postshot drilling operations is briefly described herein. The approach to effluent calculations is outlined and the reporting procedures discussed. References for this document are internal to LLNL-NTOD. They are:

1) Postshot Ventline Calculations, 1-6-82
2) Postshot Ventline Release Calculations, 1-11-82
3) Postshot Ventline Backup Calculations, 2-9-83
4) Chemical Composition of Recent Drillstring and Tubing Gas Samples, 6-14-89
5) Postshot Instrument Requirements, 2-5-90
6) Radioactive Effluent Calculational Format, 1-29-90
7) Procedure No. NTS-113; Occurrence Reporting System, 11-16-90
8) Postshot Drilling Handbook, 1-19-84
9) OSP-NC-2, Operational and Safety Procedure for Containment on Postshot Drilling Operations Conducted at the Nevada Test Site, 01-31-89

I. GENERAL DESCRIPTION

A brief discussion of postshot drilling points of effluent and the monitoring of those effluents follows:

The four main types of effluent, monitoring frequency, radioactive isotopes released and the expected range of activity are shown in Table A1.1.

TABLE A1.1 - EFFLUENT AND MONITORING

EFFLUENT	MONITORING			RANGE OF	
POINT	TYPE	MONITOR	FREQUENCY	ISOTOPES	ACTIVITY
Ventline	Air	Scintillation Det. Ion Det.	Continuous	Xe-133,133m,135	0-100 Ci
Platform	Air	ION Detector	Continuous	Xe-133,133m,135	0-20 Ci
Platform	Air	Rig Filters	Continuous	I-131,133	0-2 mCi
Blooie Line	Liquid	ION Detector	Continuous During Operation	MFP	0.01-5 mCi(in sump)
Core Trl./Highgrade(Sample Shack	Air	Charcoal Prep) Filter	Continuous During Operation	MFP	<1 μCi

Release through ventline is the principal type of release encountered. The ventline is a 20" O.D. steel pipe conducting air from the postshot drilling cellar through banks of filters to a point of release to the atmosphere (see Figure). Also, releases do occur on the rig platform primarily through the top of the drillstring (see Figure, ref 8). Minor releases of radioactivity may occur from handling of the core material in the core trailer or the highgrading (sample prep.) shack. Finally, a release of liquid radioactive effluent into the postshot drilling sump occurs as a result of emptying the contents of the postshot drilling cellar into the sump. This point of effluent has been eliminated.

The operation and function of each monitoring system used is described in the following:

Ventline System

It is the purpose of this system to convey any airborne radioactive material not stopped by the drilling containment system away from the drilling area. This stream is diluted by mixing it with air. Particulates are removed by both gravity separation and HEPA and charcoal filters. Two detectors monitor the ventline continuously and finally the treated stream is released to the atmosphere.

Pertinent Information:

Ventline: O.D. - 20"
thickness of steel - 0.1012"
horizontal run - approximately 200'
release height - approximately 15'

Flow Rate: Linear - 900 to 1300 feet per minute
Volumetric - 1950 to 2850 CFM

Particulate Treatment: 10' vertical separator
HEPA Filter
Charcoal Filter - One foot in three banks

Detector: Primary - NaI Scintillator
Backup - Neher-White ionization chamber

The ventline detection system consists of a NaI scintillator primary detector and a Neher-White ionization chamber backup detector. It is the purpose of this ionization chamber to function at high intensities where the primary detector saturates and to act as a backup detector in case the primary detection system malfunctions. These detectors monitor radioactive effluent flow through the ventline before release to the atmosphere but after the filter bank (see Figure). Both systems have readouts, continuous strip chart recorders, and alarms in the core trailer.

Placement of the ventline detection system is predicated on three considerations, i.e., geometrical orientation, minimal interference (within operational constraints) and line source geometry.

Further requirements for performance checks and calibration are detailed in reference 5.

Cellar Detector

The cellar detector is placed on top of the drilling stack in the postshot drilling cellar (see Figure). Its purpose is to provide the drilling engineer with information concerning radioactive gas concentration in the drillstring. Although not used directly in effluent monitoring, it does inform the driller of impending problems. Requirements for installation, performance checks, and calibration are set forth in reference 5.

Rig Monitor

The rig monitor is a detection system placed on the rig platform (see Figure) to continuously monitor the platform exposure rate. Because its primary function is to warn working personnel, it has an audio alarm.

It is also used to determine the duration of a platform release.

Requirements for installation, performance checks and calibration are set forth in reference 5.

Blooie Line Monitor

The purpose of the blooie line monitor is to determine gross radiation levels of drillback returns passing through the blooie line. This detector monitors continuously and is recorded on a strip chart in the core trailer. The detector is placed on the blooie line near the blooie line's entrance into the sump (see Figure). Requirements for installation, performance checks, and calibration are enumerated in reference 5.

Drill Rig Filter Samplers

Drill Rig filter samplers provide information concerning platform operational conditions. They are located on the platform in the primary working areas (see Figure). The 4-inch diameter filters consist of a paper prefilter and a charcoal filter which are changed every 8 hours after approximately $50m^3$ of air pass through the filters. After removal, the rig filters are counted using gamma spectroscopy to provide after-the-fact isotopic information.

Because of the low sample collection efficiency for Xenon gases, the drill rig filter samples are only used to provide effluent information for platform Iodine releases.

Other

Because of the variability of postshot drilling operations and many operational constraints, it is not always possible to set up permanent detection systems. However, those points that require monitoring are monitored by the use of portable instruments, high volume filter samples or specially setup sampling equipment.

Platform releases of Xenon gases and evolving gas from core material are the two main types of effluent which are quantified by means of other samplers. Special monitoring equipment may be used for those operations in which either new points of effluent are created or sensitivity to a particular isotope needs to be enhanced.

In addition, grab samples may be collected to aid area control or to supplement effluent monitoring.

The above only addresses radioactive effluent. The only source of non-radioactive effluent is core material (an analysis of the cavity air in postshot drilling gas samples is provided, see reference 4). Any waste produced by the postshot drilling operations is sampled and analyzed for non-radioactive constituents, e.g., lead.

Post Operation

Upon completion of a postshot drilling operation, two types of samples are taken. They are cellar integrity samples to ascertain radioactive concentrations in the postshot drilling cellar and grab samples to determine the extent of environmental effect of the operation. Integrity samples are changed every 24 hours and the paper filter and charcoal filter are sent to the REECo Health Physics Department Laboratory for isotopic analysis. The flow rate of the integrity sampler is approximately 10 cfm.

Grab samples are taken when required and the analysis depends on the reasoning for sampling.

II. EFFLUENT CALCULATIONS

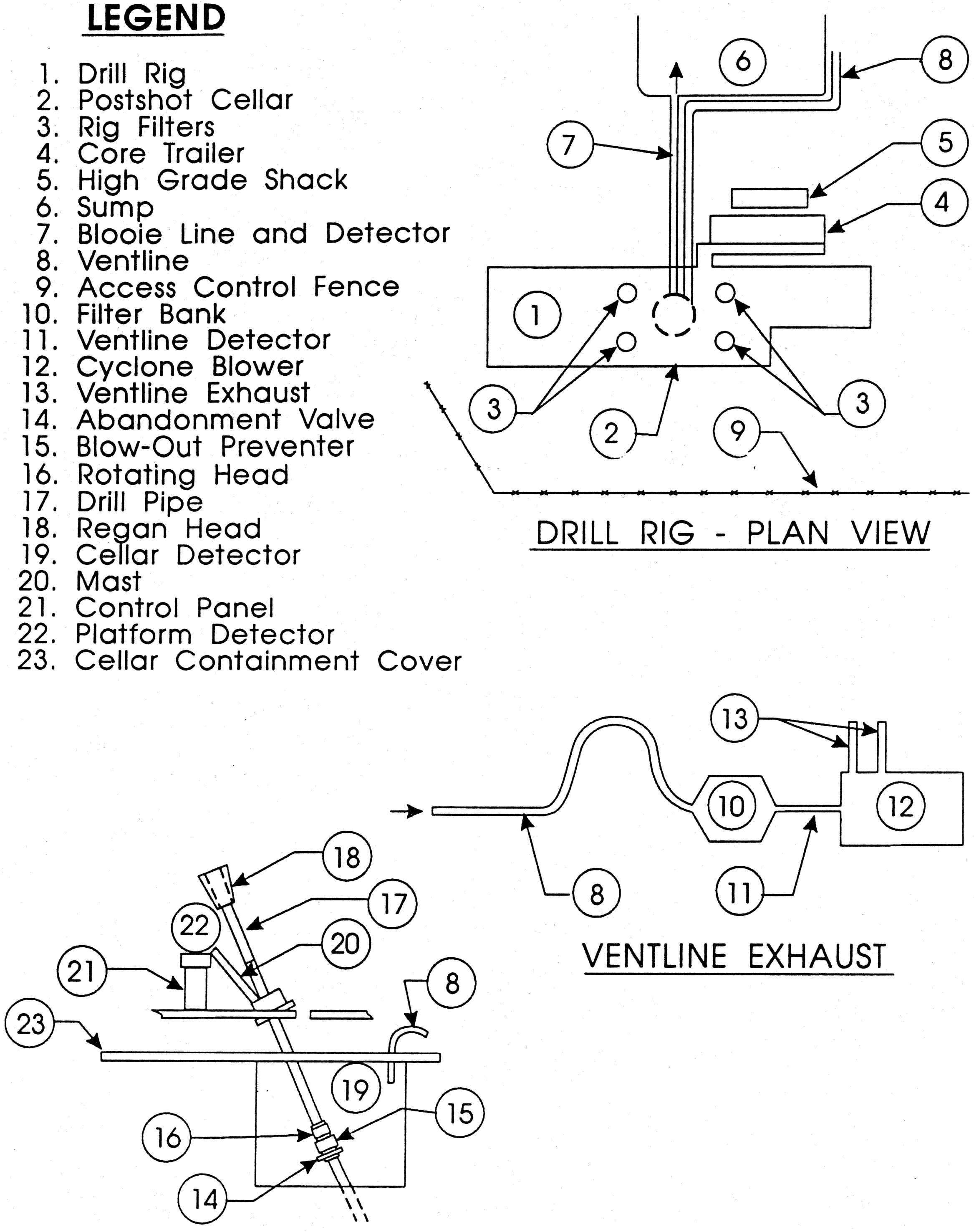
This section briefly describes the effluent calculation used by LLNL for postshot drilling. The calculational format needs to be both formal and descriptive (see reference 6).

Effluent calculations for a release through the ventline use three main assumptions. A line source geometry is assumed and it is assumed that the detector signal is a linear superposition of ^{133}Xe, ^{133m}Xe, and ^{135}Xe. It is further assumed that the ratios of isotopes can be obtained from abundance vs. time curves for the fissioning of ^{239}Pu. A more detailed description is given in references 1, 2, and 3.

Because ventline release calculations depend linearly on the volumetric flow rate, frequent and accurate measurements of the ventline flow rate are made (see reference 5).

Effluent releases at points other than the ventline must rely on detection systems that are not optimized for the purpose. Portable instruments may give very good information for a point in time, but give little or no time information whereas stationary instruments provide fairly reliable time information but very inaccurate intensity information. A combination of the two may give release information accurate to within 50%. Information from the onsite environmental surveillance network may provide an upper limit to the releases.

An exception to the above is a platform iodine release. The point of release is usually known and all that is required is to relate the total quantity on the filter to the point of release.



LEGEND

1. Drill Rig
2. Postshot Cellar
3. Rig Filters
4. Core Trailer
5. High Grade Shack
6. Sump
7. Blooie Line and Detector
8. Ventline
9. Access Control Fence
10. Filter Bank
11. Ventline Detector
12. Cyclone Blower
13. Ventline Exhaust
14. Abandonment Valve
15. Blow-Out Preventer
16. Rotating Head
17. Drill Pipe
18. Regan Head
19. Cellar Detector
20. Mast
21. Control Panel
22. Platform Detector
23. Cellar Containment Cover

DRILL RIG - PLAN VIEW

VENTLINE EXHAUST

POSTSHOT DRILLING CELLAR

FIGURE 1. LLNL CONTAINMENT HARDWARE

Appendix 2. Los Alamos National Laboratory

ANNUAL NATIONAL EMISSION STANDARDS FOR HAZARDOUS AIR POLLUTANTS
EMISSIONS REPORT
LOS ALAMOS NATIONAL LABORATORY
GROUP HS-12 FIELD TEST SECTION

by

R. W. Henderson
Group HS-12 Field Test Section

March 3, 1993

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Glossary of Terms and Acronyms

Building 701 LANL office and support building in Mercury (Area 23)

Drillback The recovery of solid debris samples from an underground nuclear event by means of a drilled sampling hole.

Cementback The filling of the drillback hole with cement following completion of the sampling operation.

Containment Stack or Stack The gas field hardware mounted on the top of the well casing designed to contain the radioactive and other gasses in the chimney. This is also referred to as the "blowout preventer" (BOP).

Cellar Excavated and cased area below the drill rig housing the containment stack.

Rad Lab A trailer containing analytical equipment for the analysis of various air streams. This includes a system that analyzes the air in the containment system for both radioactive gasses and combustible gasses.

Core Off-gas Airborne radioactive material arising from solid core material brought to the surface during coring operations.

Chimney or Cavity Gas Gaseous material, very rich in xenon, which fills the void spaces of the cavity and the rubble chimney.

1.0 Potential Emissions

1.1 Weapons Test Areas - Drillback: Potential for the release of radioactive material to the atmosphere during normal operations. There exists the potential to release volatile fission products, notably noble gasses and iodine during the operations required to recover solid samples of the fission product debris. The potential exists to release an estimated 10 curies of ^{133}Xe and 0.5 millicuries of ^{131}I during the operation.

1.1.a The 10 curie estimate is felt to represent an upper limit for the distribution of possible releases. The estimate is derived from LLNL and LANL experience with 16 releases from drillback operations that have occurred over the past few years. These have ranged from 24 microcuries to 14 curies of xenon. This is felt to probably represent, to one significant figure, the upper end of the spread of estimates. It is further estimated that about 4 curies of xenon were seen in the containment system during the BEXAR cementback in 1991, and about one half curie was released.

1.1.b The method of using actual experience is felt to be superior to a theoretical treatment of the subject. The LANL documentation of release includes the value for xenon. This element is held up by the cleanup system, but not retained. The values for release would be the same even if the cleanup system was not operational. The iodine value is the theoretical value, assuming the mix as reported in LA-3420-MS, "Analysis of Underground Weapon Test Effluent Samples," for the amount of xenon seen, and a delay time of about 1 week.

1.1.c From Yucca Flat, the Maximally Exposed Individual lives in Crystal, at a distance of 52 km due south. Assuming a release of 10 Ci of ^{133}Xe and 0.5 Ci of ^{131}I, the Effective Dose Equivalent for all radionuclides and all pathways would be 1.7×10^{-6} mrem.

Based on these data, no effluent monitoring is required to meet the standards. LANL will continue to monitor this potential source of emissions as a matter of Best Management Practices for Health Physics. The information generated is of great interest to both the resident Health Physicist and the drilling engineers.

1.2 Building 701 Radio-analytical Laboratory: Potential for the emission of xenon, iodine and tritium. Maximum emissions are estimated to be 40 millicuries of ^{133}Xe, 2 microcuries of ^{131}I, and 500 microcuries of tritium.

1.2.a The iodine and xenon values are based on sample measurements during the BEXAR cementback, and estimated possible numbers of samples. For the BEXAR cementback there were approximately 14 sets of samples with four samples containing ^{131}I in each set. The average concentration was of the order of 10^{-10} Ci/m^3, with a sample volume of 50 m^3. This implies an average value of 5 x 10^{-9} Ci per sample or 0.3 µCi for the whole operation. Assuming 6 such operations per year, the total inventory would be 2 µCi. No credit is taken for the fact that this iodine is very securely held on the charcoal cartridges on which it is collected: the whole amount is treated as a gas. For calibration purposes, ^{133}Xe is purchased in glass vials containing up to 20 mCi each. Accidents could result in a couple of these vials being broken during the year thus releasing the about 40 mCi. Tritium is received at the laboratory as HTO in 500 mL bottles. Concentrations as high as 50,000 pCi/mL have been measured (25 µCi per sample). It is assumed that no more than 20 of these would be on hand in the laboratory during any time during the year. The total inventory would then be no more than 500 µCi at any time.

1.2.b This method of estimating release from the laboratory is in compliance with Appendix D, with very adequate margins of conservatism.

1.2.c From Mercury, the Maximally Exposed Individual lives in Pahrump, at a distance of 51 km due south. Using the maximum activity for the radioisotopes in the Laboratory, the Effective Dose Equivalent for all radionuclides and all pathways would be 8 X 10^{-9} mrem. This is well below the threshold requiring effluent monitoring.

1.3 Weapons Area - Event Time: Potential for accidental release of radioactive material either as a "prompt massive venting" or as a "seep release".

1.4 Assembly Area: Potential for the accidental release of radioactive material to the atmosphere. There is no potential for atmospheric release aside from an accident.

2.0 Potential Sources

Potential sources of radioactive effluents are: (a) Weapons Test Area - Zero Time, accidental releases only, (b) Weapons Test Area - Drillback Operations, operational as well as accidental releases, (c) Assembly Area, accidental releases only, and (d) Building 701 Analytical Laboratory, accidental as well as operational releases.

2.1 Summarized Description of Drillback Responsibilities and Procedures

2.1.1 The Test Group Director is responsible for all Los Alamos National Laboratory operations on the NTS, including drillbacks. This includes HS&E responsibility for the area for which that responsibility has been specifically transferred. The specific responsibility for the preparation, setup, operation, and cleanup of the drillback location is delegated to a senior drilling engineer in LANL Field Engineering Group, J-6. Radiological safety responsibility is delegated to a senior health physicist in the LANL Radiation Protection Group, HS-12. The Field Test Section Leader, in HS-12, is responsible for the collection, reduction, and interpretation of all health and effluent data.

2.1.2 A detailed description of the LANL Post Shot Drilling Operations is given in

2.1.2 A detailed description of the LANL Post Shot Drilling Operations is given in "Los Alamos National Laboratory Post Shot Drillback Operations and Responsibilities, March 1990 Edition. This summary is extracted from that document. The containment system consists of the blowout preventer (BOP) located in the cellar under the drillrig, the recirculation trailer (housing the blowers and valving to generate and direct air flow through the containment system), the hoses connecting the BOP to the containment trailer, and the containment control panel used to operate the containment system. Once the surface casing is installed and cemented in place (cement pumped down the surface casing and forced up around the casing to create the cellar floor), the BOP is installed, and the containment trailer and recirculation system are made operational and connected to the BOP. The annulus pressure air line, used to blow air from the cellar down the annulus after the loss of mud circulation, and the test line, used during testing of the BOP and to monitor the gas in the annulus after circulation is lost, are connected at appropriate points on the BOP and the recirculation system. A schematic of the containment system from the published procedures is attached.

The Rad Lab trailer radiation and explosive gas detection and alarm systems are calibrated and connected to the appropriate sampling points on the containment system (the annulus pressure line to sample cellar air and the test line to sample annulus air). The details of these procedures are included in a collection of documents for specific parts of the operation.

The containment equipment test procedure (pressure check) is completed by the J-6 engineer as described in the procedures. This procedure checks the system for leaks in various configurations at pressures of 5 and 25 psig. The operation of the valves and indicators is checked.

Drilling commences only after the above setups and checks have been successfully completed. Initially, drilling fluid is returned to the surface through the mud flowline. Cuttings and debris are removed at the shaker table and the mud is recirculated downhole. During this phase of drilling, air is drawn from the cellar and exhausted up the mast through the containment system. This air is monitored for radioactive and explosive gasses by the equipment in the Rad Lab trailer, even though the path to the cavity is effectively blocked by a standing column of drilling fluid in the hole. Air samples are taken at four points on the drillrig floor and just outside the cellar door and are changed every eight hours to correspond to the workers' shifts.

When the drilling fluid begins to flow into fissures and voids in the formation, the fluid is no longer circulated back to the surface (loss of circulation). After loss of circulation, the mud return line is closed and cellar air is now blown down the annulus through the containment system annulus pressure air line. Radioactive and explosive gasses are now monitored both in the recirculation air and in the annulus.

Once the total required depth has been reached, drilling is discontinued and sidewall samples are collected through a sampling port in the drill string. Small amounts of drilling fluid may be pumped down the drill pipe to help control gas flow up the inside of the pipe. Air continues to be monitored and blown down the annulus through the containment system. Additional air samples are collected in the core sampling and handling areas adjacent to the rig.

When sampling is completed, the drill pipe is removed from the hole and the ball valve in the BOP is closed. The containment recirculation system and the Rad Lab monitoring systems are shut down, and the air sampling effort is reduced to a single sampler just outside the cellar door. The filters on this sampler are changed once a day until operations are resumed at the location.

After post shot drilling and sampling activities are completed, the hole is cemented to the surface. During this operation drillrig floor sampling is resumed as is monitoring through the Rad Lab Trailer. The containment recirculation system is activated and cellar air is blown downhole through the annulus pressure air line. The ball valve is opened and a bridge plug is run into the hole and set below a predefined minimum depth. The hole is then cemented to the surface in stages. At some point in this process, air can no longer be blown down hole, and the recirculation system is secured. Once the cement has been tagged at a satisfactory depth, the hole is considered secured and the BOP is removed.

2.2 Monitoring Equipment and Procedures

The Los Alamos National Laboratory hardware is designed to completely contain all chimney gas. During active drilling and sampling operations, air is drawn from the cellar, sampled, and returned to the annulus below the containment hardware. This provides a column of air moving down the annulus to keep gas from the cavity from reaching the containment hardware. This method of containment is used after drilling fluid no longer returns to the surface (loss of circulation), and before the hole is closed by either closing the ball valve or by the use of sufficient cement during the cementback. Figure 1 shows the hardware configured to contain the gasses.

When the air from the cellar cannot be blown down hole, it is exhausted up the mast. This happens before loss of circulation and after the hole is plugged with cement. The valve shown in Figure 1 can be rotated to cause this switch.

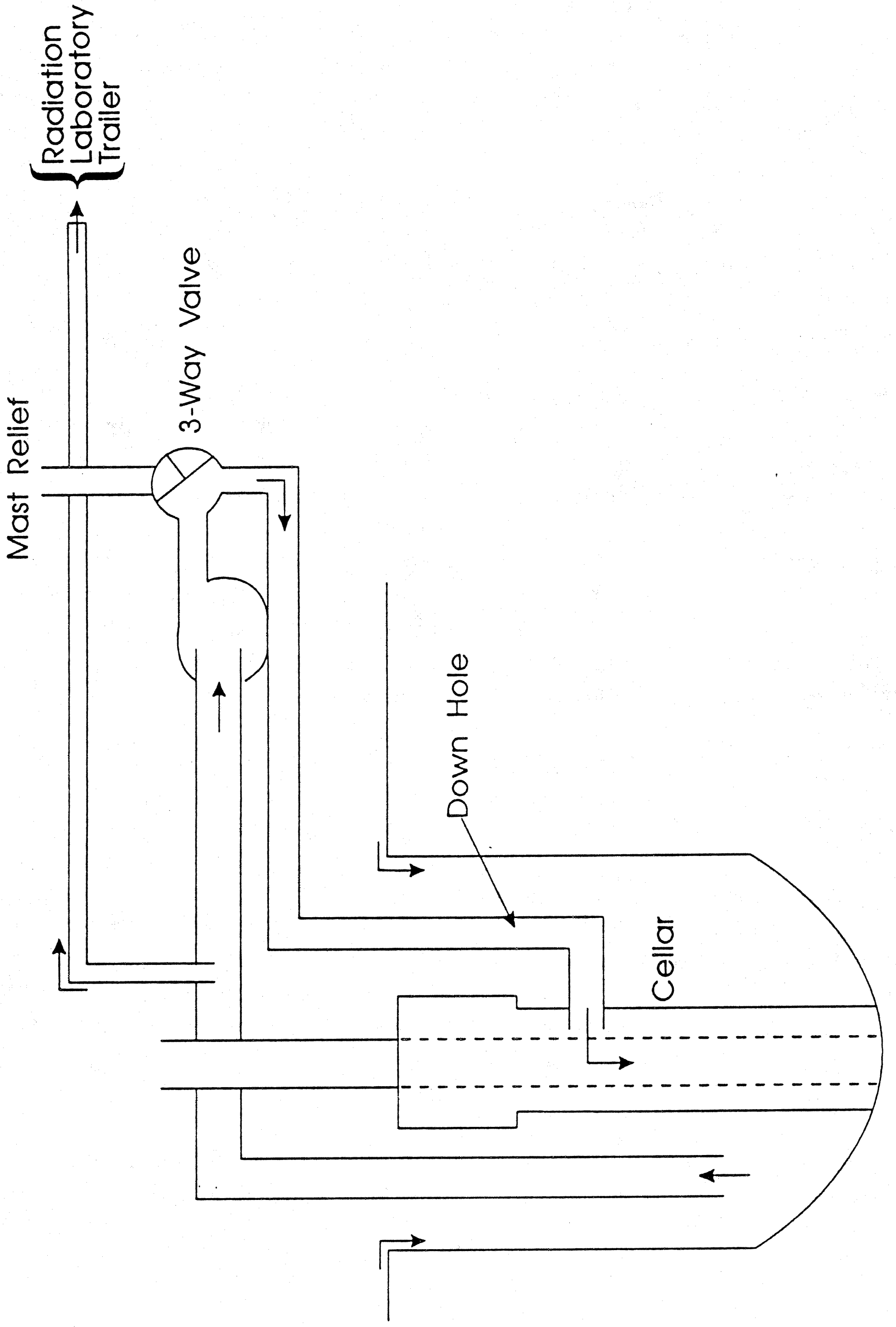


FIGURE 1. LANL CONTAINMENT HARDWARE

As long as the system is running, a sample of the air is analyzed for the presence of radionuclides emitting gamma rays with energies above 60 keV. The characteristic gamma ray of ^{133}Xe is about 80 keV. The system has been calibrated in terms of total ^{133}Xe in the system. A few vials of National Institute of Standards and Technology (NIST) traceable ^{133}Xe were obtained from DuPont/New England Nuclear. These vials were used to determine the activity in about 25 other vials that were released into the system under normal operating conditions, and the response of the detection system was thus calibrated. The few trials precludes a detailed treatment of error, but the data available suggest that the precision is probably better than a factor of 2. In the event chimney gas is detected by the system, the procedures set forth in "Field Test Health Physics Section Detailed Procedure for Estimation of Activity in the Containment System" are used. While the system is in the containment mode, the result is simply the ^{133}Xe captured. When the system is in the mast exhaust mode, the result is the release of ^{133}Xe . The release of ^{131}I is then inferred from the ^{133}Xe and the age of the gasses using the data presented in LA-3420-MS, Analysis of Underground Weapons Test Effluent Samples.

In the event that chimney gas is detected on the air samples collected on the platform, the procedures set forth in "Field Test Health Physics Section Detailed Procedure for Estimation of Release Using Health Samples" are used. This technique is based on the experience at the LOCKNEY drillback. Chimney gas was exhausted into the cellar after having been through the containment system. This allowed for the measurement of the source using the calibrated system. The measured concentration of iodine on all sample heads and the length of the sampling period are used to estimate the release, using LOCKNEY as an analogue.

The measured ^{131}I values are used since the samplers collect iodine almost quantitatively. Since this is a single point "calibration" of the technique a detailed treatment of error is not possible. The results of applying the technique to other events indicate that the precision is probably better than an order of magnitude, and is probably close to a factor of three. The data in LA-3420-MS are again used to infer the ^{133}Xe .

When the cementback does not directly follow the drillback, the containment hardware is closed, the recirculating air shut off, and a single sample is collected in the cellar. This sample verifies that the hole is properly closed. If chimney gas is detected on this sample an estimate of release is generated, again using LOCKNEY as an analogue. The technique is given in "Field Test Health Physics Section Detailed Procedure for Interpretation of Cellar Samples". Since this is a single point "calibration" of the technique a detailed treatment of error is not possible. The precision of this technique is probably not much better than an order of magnitude, depending on the material detected by the sampler. The data in LA-3420-MS are again used to infer the composition.

2.3 Other sources - none.

2.4 Inventory of Radionuclides

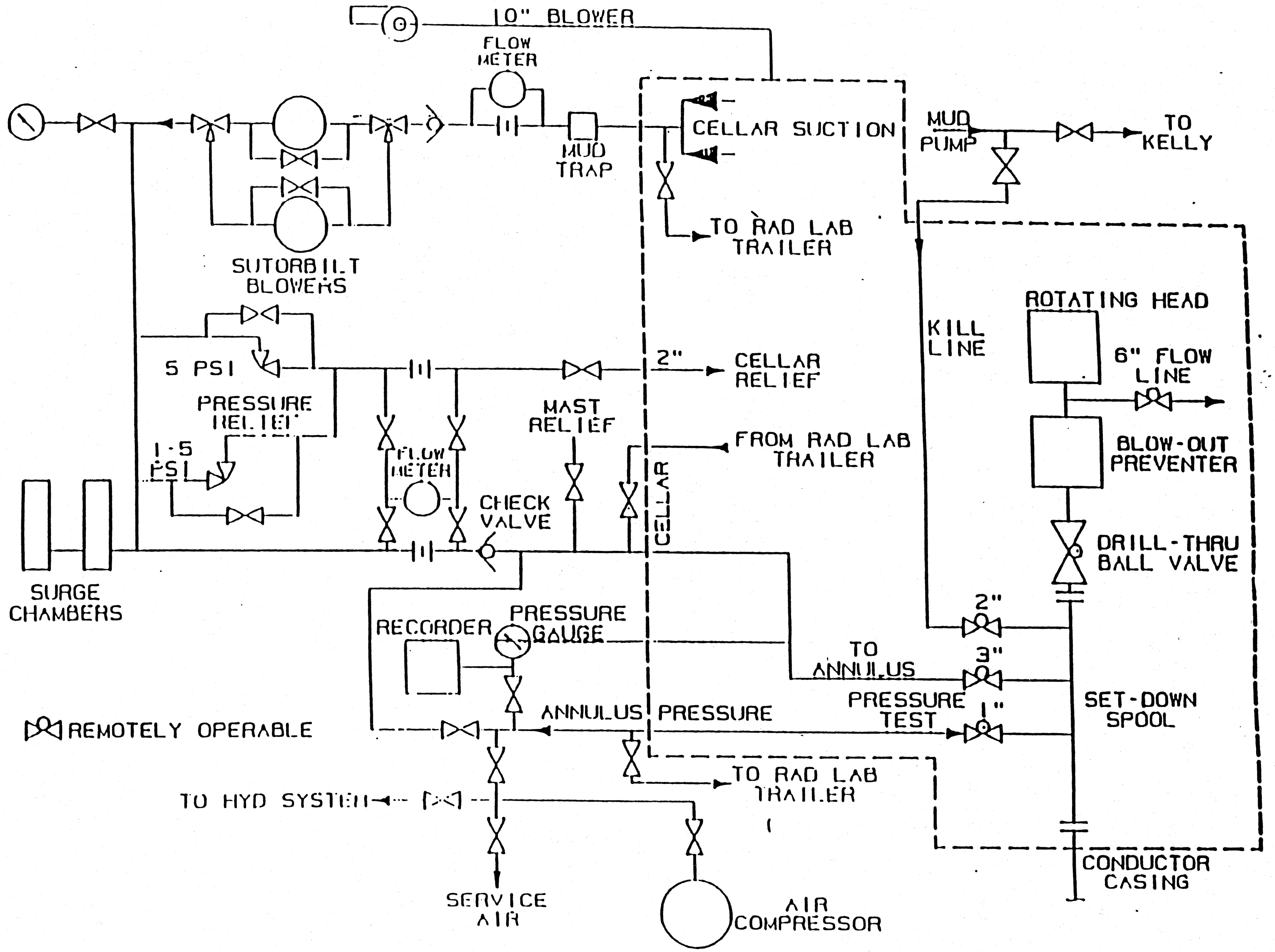
For 1992 the inventory of tritium, iodine and xenon in Building 701 was calculated as:

Tritium	5×10^{-05} curies (NIST Standard) (All other samples trivial).
Iodine	1×10^{-07} curies. Calculated from reported concentrations and volumes.
Xenon	4×10^{-01} curies. Xenon standard gas used for Radiological Laboratory calibration.

2.5 Reports

HS-12, NTS/Offsite Operations Section is responsible for the collection and interpretation of all health and effluent data. The results generated during drillbacks and cementbacks are reported to the Test Group Director at various times and in various forms during the course of the operations. At the completion of the operation, a report entitled, "Release and Health Sample Documentation for (EVENT NAME)" from HS-12 to the J Division Leader is generated that combines and summarizes the results generated. This report is distributed to the HS Division Office, the Test Group Director(s), the HS-12 Group Office, and the J-6 Group Office. These data are distributed as "Activity Released from (EVENT), Final Report" by the LANL J Division Office to Nuclear Test Organization, Test Controller, Attention: Chief, OMB CP-1 with copies to: NVOO Manager, LANL/ADNWT, and LANL/J-DO.

Annually, all results are combined and reported as "Effluent Information (EIS) and On-site Discharge Information (ODIS) for CY-(year) to Waste Reduction Operations, EG&G Idaho, Inc. Copies of this report are sent to: DOE/NV/ERWM, REECo/HPD, LANL/HS-DO, LANL/HS-12, LANL/EM-8, AND LANL/J-DO.



POST SHOT CONTAINMENT SYSTEM

J6-SK-2
6/5/80

Attachment A

Appendix 3 . Defense Nuclear Agency.

EMISSIONS DATA AND MONITORING PROCEDURES FOR THE DEFENSE NUCLEAR AGENCY COMPLIANCE WITH THE NATIONAL EMISSION STANDARDS FOR HAZARDOUS AIR POLLUTANTS (NESHAP)

by

David A. Bedsun
Defense Nuclear Agency

June, 1992

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1.0. INTRODUCTION

The weapons effects testing program conducted in NTS tunnels has the possibility of releasing some radioactive effluent into the tunnel ventilation system during several of the operations associated with executing a test and the subsequent tunnel reentry activities. The tunnel ponds and Test Support Compound may also release radioactive effluent to the atmosphere.

Modeling of these potential sources using CAP88-PC indicates that the dose to the maximally exposed individual (MEI) in the off-site area is well below 0.1 mrem/year; thus these sources are classified as small releases and the release point does not need to be continuously monitored. However, periodic measurements must be made to verify the small releases. These confirmatory measurements do not necessarily need to be made at the point of discharge.

2.0 ORGANIZATION

Figure 1 shows the DNA organization at the Nevada Test Site, and identifies the FCNV personnel responsible for each operation. The Chief, Field Command Nevada Operations (FCNV) maintains overall responsibility for underground nuclear weapons effects tests conducted by DNA. However, FCNV personnel depend on the expertise provided by the DNA health physics advisor for identifying and estimating radionuclides released during each operation. Table 1. lists the FCNV divisions responsible for each operation.

Table 1. Operational responsibilities by FCNV Division

NVCE	NVTO
* Preparation of the Test Bed	* Device Detonation
* Initial Tunnel Reentries and Purging of the Tunnel	* Test Support Compound
* Data Recovery	
* Removal of Containment Plugs	
* Experiment Recoveries, Instrumentation Removal and Cleanup Activities	
* Gas Sampling Operations	
* Reentry Mining	
* Assessment of Mechanical Closure Performance	
* Atmospheric Pumping	
* Tunnel Ponds	

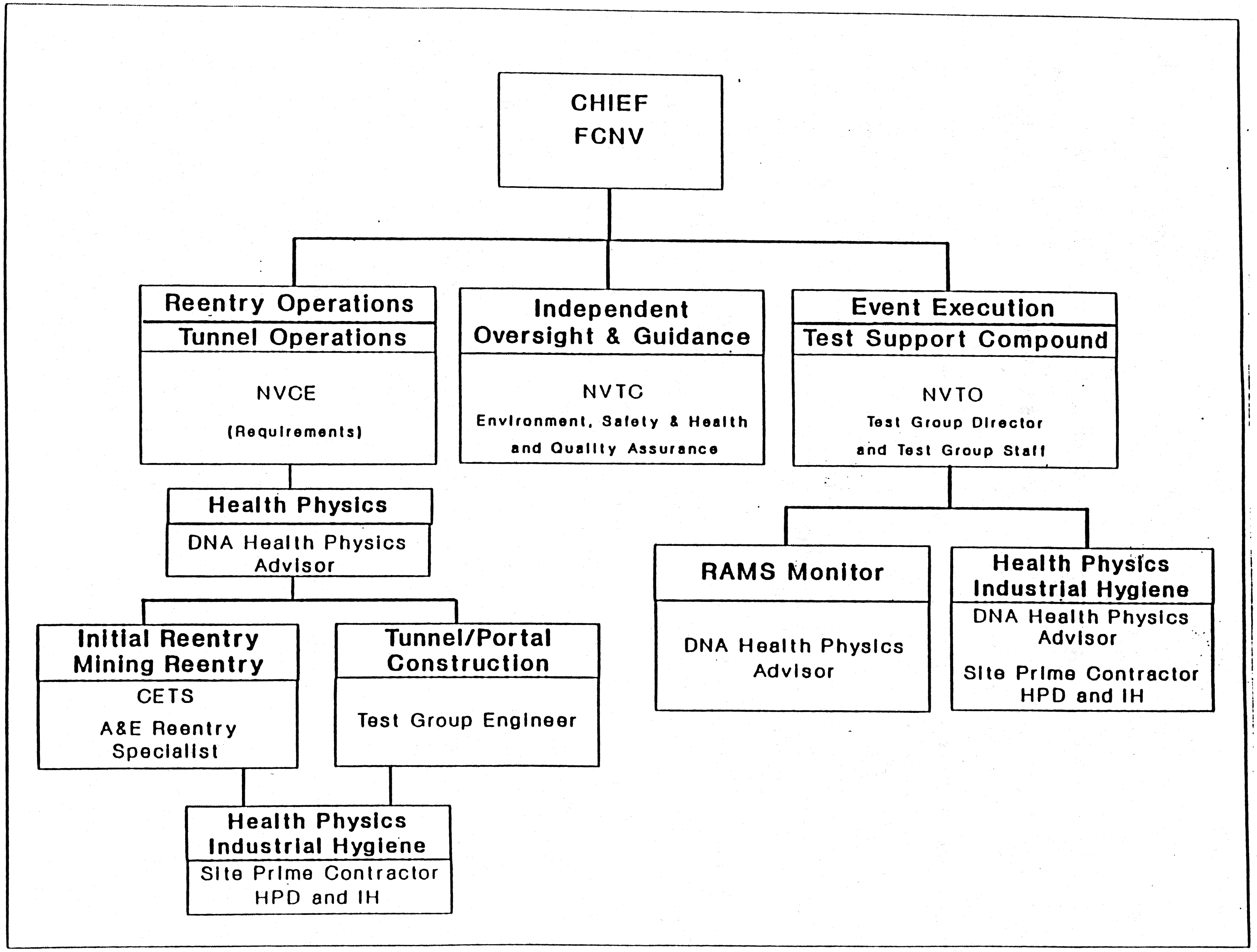


Figure 3.1 FCNV organization and operational responsibilities

3.0 DESCRIPTION OF OPERATIONS

3.1 Tunnel Activities

It should be noted that although the tunnel ventilation systems are operated continuously, the release of radioactive effluent is possible only during specific operations associated with a particular test, except for the release of radon and thoron and their associated decay products. It is recognized that radon and thoron and their progeny are being continuously released from the NTS tunnels, but monitoring for these natural radioactivities in this type of facility is excluded by both the EPA NESHAP and by DOE Orders. Therefore, these emissions will not be addressed further in this document.

The tunnels currently being used for nuclear testing are N and P tunnels. E, G, and T tunnels are now inactive, but are maintained in various states of readiness in case these areas are needed to support the test schedule. The ventilation systems in both G and E tunnels are not being operated at this time, so there is no airborne effluent from these tunnels. The T tunnel ventilation system is being operated occasionally, but there is no work being conducted underground which would generate any airborne effluent other than the heretofore mentioned radon and thoron.

Similar activities are conducted in both N and P tunnels, so the descriptions given in this document are pertinent to both tunnels. However, since the points of discharge are different, the distance to the maximally exposed individual offsite might vary slightly.

The ventilation systems in all NTS tunnels are operated in the exhaust mode. This means that fresh air is drawn in through the portal or adit of the tunnel, sweeps through the tunnel complex, and is exhausted through the ventilation lines from the active regions of the tunnel. Thus, any radioactive effluent released any place in the tunnel complex is drawn toward the end of the ventilation line, where it is picked up and removed from the tunnel. Therefore, samples of the air taken before the air stream enters the ventilation line represent the maximum concentration of radioactivity which can be discharged through that ventilation system.

3.1.1 Preparation of the Test Bed

The fielding of a typical tunnel event is initiated with the mining of the test bed according to the engineered design for that particular test. An experiment drift and parallel bypass drift are mined off of the main tunnel. Instrumentation alcoves and associated access drifts are also mined. Figure 3.2 contains a diagram of a typical tunnel complex. A tapered line-of-sight (LOS) pipe is installed in the experiment drift which provides a path for the prompt radiation from the source device to various experiments located internal to the pipe. The experiments to be exposed are installed in the LOS pipe by personnel from the various agencies associated with the test, and cables are emplaced from the experiments to the data recording instrumentation located in the instrumentation alcoves. The region of the LOS drift between the pipe and tunnel wall, as well as the bypass drift for some fixed distance, is filled with various grout mixtures to meet the containment criteria for the test. A simplified diagram of an LOS pipe is shown in Figure 3.3.

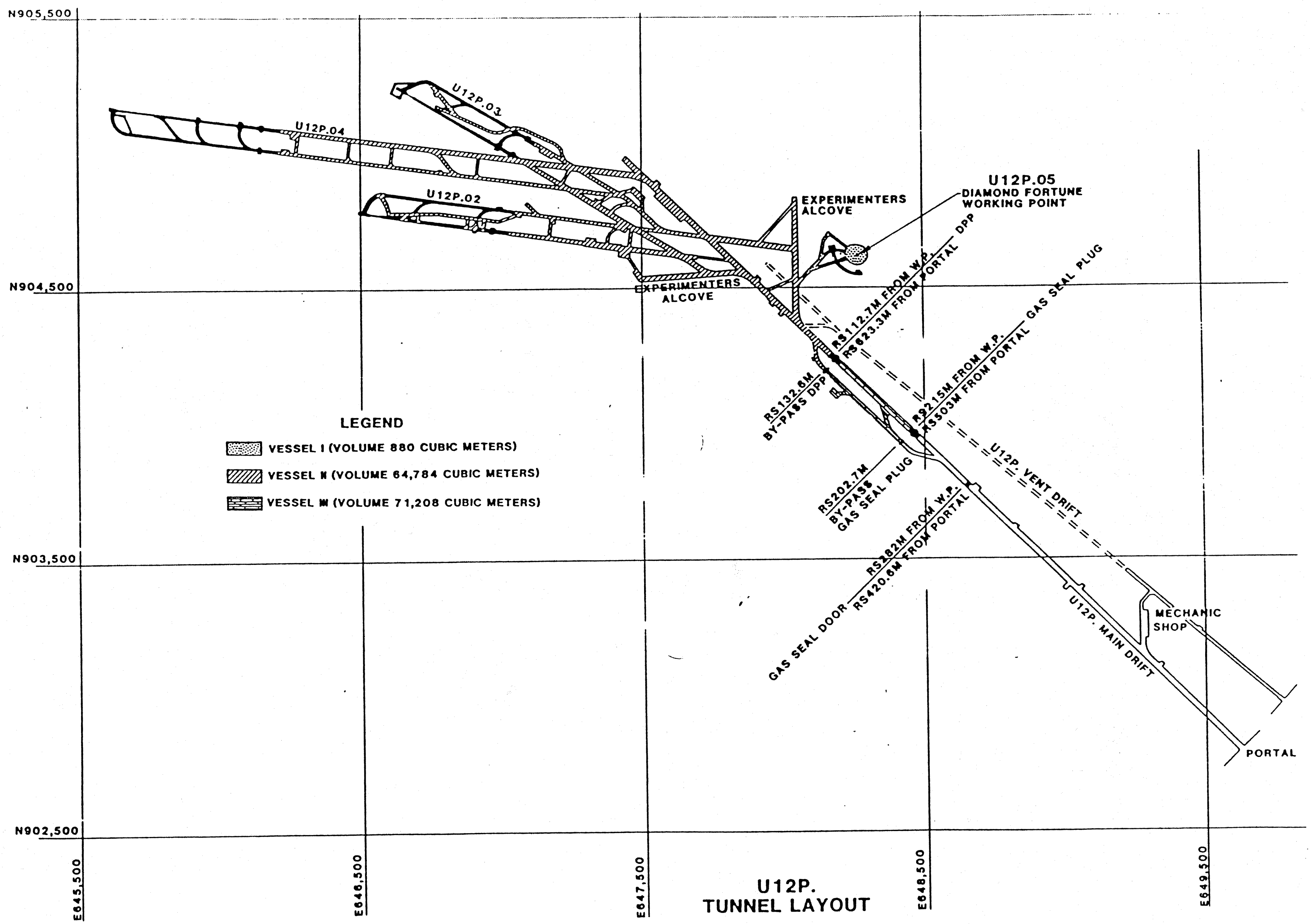
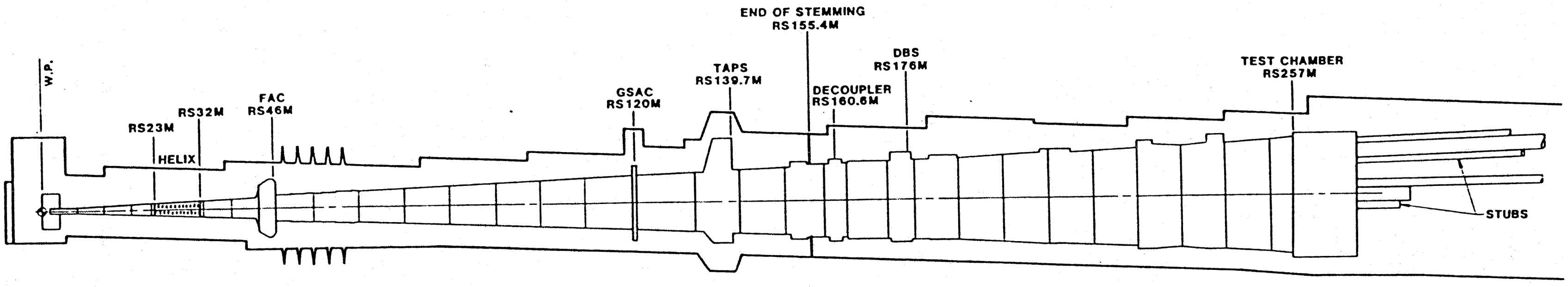


Figure 3.2 Typical tunnel layout for nuclear tests (1000 ft grid).



LEGEND:

DBS - DEBRIS BARRIER STATION

FAC - FAST ACTING CLOSURE

GSAC - GAS SEAL AUXILIARY CLOSURE

TAPS - TUNNEL AND PIPE SEAL

Figure 3.3 LOS pipe layout (from WP to TAPS typically 400 - 500 ft).

During device detonation, ionizing radiation from the source device travels down the LOS pipe to expose the experiments inside the pipe. Several mechanical closures in the pipe string seal the pipe immediately after the nuclear detonation. This design, utilizing the mechanical closures and the associated backfill materials, protects the experiments in the pipe from high velocity debris, and also provides containment of the fission products produced by the detonation of the device.

In addition to tests conducted in a horizontal line-of-sight configuration, some tests are executed in preconstructed hemispherical cavities without the use of an LOS pipe. In these tests, various detectors and experiments are placed in the walls and floor of the cavity. The source device is placed in the center of the cavity, and the access drifts are backfilled with various grout mixtures to contain the detonation products in the cavity region. Data from the test instrumentation are again recorded in the instrumentation alcoves.

During the mining and preparation of the test bed, and during experiment installation activities, no radioactive effluent is produced, so no radioactive effluent is released through the tunnel ventilation system.

3.1.2 Device Detonation

In general, an underground nuclear explosion initiates a series of events which culminate in the formation of a relatively large cavity-chimney structure in the rock. The initial cavity formation process includes the vaporization and melting of large quantities of rock and expendable experimental equipment. The containment process utilizes the energy of the device to squeeze part of the LOS pipe closed, thereby containing the detonation products in the cavity region. Much of the fission products produced is incorporated in the melted rock as it resolidifies, immobilizing this debris in the "puddle" produced at the bottom of the cavity.

Eventually the cavity gases cool and condense, which reduces pressure and allows the formation of a rubble chimney. The chimney forms by the successive collapse of overlying rock into the glass-lined cavity void. Depending on the yield, the height of the chimney may reach several hundred feet above the working point before the expansion process involved in chimney formation reaches equilibrium.

As a part of the containment design, several large concrete and steel plugs are constructed at strategic points within the tunnel complex. These plugs form a system of nested vessels which incorporate increasingly larger volumes of the tunnel. If containment of the detonation products within the cavity region is not completely successful, any radioactive debris which might be released into the experiment area of the test bed will be contained within one of these vessels. Since the ventilation system is shut down and sealed off at this time, there is no release to the environment. All releases associated with tunnel tests since 1971 have initially been completely contained within the tunnel complex, and releases have only occurred during controlled purging of the tunnel complex in order to restore the complex to normal operation.

The potential exists for a release to occur from the point of detonation to the surface by seepage through the overlying rock. However, tunnel tests are considerably overburied for the yields involved. No tunnel test conducted in the tuffaceous rocks of the Rainier Mesa test locations has released radioactivity to the atmosphere via this mechanism.

Although the potential exists for radioactive gases to be released into the working areas of the tunnel, this debris is expected to be contained within one of the nested containment vessels, and no radioactive effluent is expected to be released to the environment. Remote area monitors (radiation detectors) located within the tunnel complex and on the surface outside the tunnel confirm containment within the tunnel and indicate the movement of fission gases within the underground complex.

3.1.3 Initial Tunnel Reentries and Purging of the Tunnel

While the tunnel complex is being secured prior to detonation of the device, the ventilation line is disconnected at each containment plug and the penetration through the plug is sealed. Thus, it is necessary to reenter the tunnel in order to reestablish ventilation through the various containment plugs. If radioactive gases are present in a portion of the complex, it may be necessary to purge these gases from the tunnel. These gases, along with the toxic and explosive gases also produced, must be removed from the experiment areas before data and experiment recovery can begin. It is during these purging operations that the major potential exists for release of radioactive materials to the atmosphere.

3.1.4 Data Recovery

After the initial reentries have been completed, personnel from the experimenting agencies are allowed into the instrumentation alcoves and other areas to recover film, data tapes and activation foils. As the purging operations have already removed the gaseous fission products from the complex, there are no releases of radioactive materials to the atmosphere associated with data recovery.

3.1.5 Removal of Containment Plugs

After data recovery is complete, the mining department begins removal of the containment plugs in order to reestablish the railroad track through the plugs. During this time, electrical power and lights are also being restored into the experiment area so that the experiments can be removed from the LOS pipe. During this preparation phase, all potential safety hazards (loose rock, damaged rail and/or ventilation line, etc.) are removed or repaired. There is no potential for the release of radioactive material during this phase of the operation.

3.1.6 Experiment Recoveries, Instrumentation Removal and Clean-up Activities

The experiments from inside the LOS pipe are removed to allow visual observation of the condition of each experiment following exposure to the radiation from the source device. These physical assessments of the experiments allow correlation to be made between the condition of the experiment and the active measurements made on the experiment at the time of the exposure. These observations make interpretation of the data easier and more meaningful.

During experiment recovery, some radioactive dust may become airborne and entrained in the exhaust air removed from the tunnel. This dust is the result of the deposition of the radiation energy in the experiment components and the resultant spall of the exposed surfaces (a phenomenon referred to as blowoff). This dust may be radioactive as the result of neutron activation of the materials exposed, and may also contain some particulate fission products if the device debris was not completely contained. Releases during this phase of tunnel operations are composed of airborne dust which contains activation products and, occasionally, particulate daughters of the noble gases which were not contained. Removal of instrumentation from alcoves and cleanup of the test bed region generally do not generate any radioactive effluent.

3.1.7 Gas Sampling Operations

Gas samples are occasionally taken from the chimney region after a nuclear test to provide information useful in understanding containment phenomenology. Prior to the test, containers of tracer gases may be located in various stemming regions and in drill holes in the insitu rock around ground zero. Some time after device detonation (usually 30 days or more) a hole is drilled into the chimney region through which samples of the cavity gases can be withdrawn. These gases are analyzed in the laboratory, and the data are used to provide a better understanding of cavity formation and growth, and thus increase our knowledge about containment mechanics.

During gas sampling operations, some excess gas is produced for which disposal is required. This gas is passed through a HEPA/charcoal filter combination, and then discharged into the tunnel ventilation system. Releases associated with gas sampling operations may occur both during the drilling of the sampling hole and during the actual gas sampling operations.

3.1.8 Reentry Mining

Reentry mining is effected on many events to assess the performance of the mechanical closures and to determine the size and shape of the chimney formed by the nuclear detonation. This is accomplished by mining a reentry drift, typically from the end of stemming in the bypass drift and parallel to the LOS drift. At points of interest, crosscuts are mined from the reentry heading to the LOS drift to expose the LOS pipe and the various closures. If the rock and associated grouting materials near the LOS pipe have become contaminated, some radioactive dust may become airborne and be removed from the work area by the ventilation system.

3.1.9 Assessment of Mechanical Closure Performance

One of the goals of postshot activities and reentry mining is to assess the performance of the mechanical closures which close-off the LOS pipe. Gases (toxic, explosive, and sometimes radioactive) may be trapped in the LOS pipe between these various closures. In order to enter the LOS pipe to observe the closures, it is necessary to remove the gases from the regions of interest. After sampling and analysis of the gases so contained, this material is purged from the LOS pipe and discharged into the tunnel ventilation system.

3.1.10 Atmospheric Pumping

The only time this phenomenon is observed in the tunnels is when reentry mining has progressed to a point near the chimney region (within 50-70 feet) and probe holes are drilled into the chimney to define chimney size and shape. Current practice is to grout these holes as soon as possible after the radiation and temperature logs have been completed. If barometric pressure drops while the hole is open, the hole may breathe, releasing noble gases into the tunnel where the radioactivity is picked up by the ventilation system. This is a very insignificant source of release to the atmosphere from a tunnel test.

3.2 Test Support Compound

The Test Support Compound (TSC) is a facility within Area 12 Base Camp used by DNA-sponsored experimenters/contractors to prepare experiments before fielding, and to disassemble experiments after post-event recovery. Due to the proprietary or classified nature of some experiments, this facility is a fenced area that may have (depending on operations) round-the-clock security personnel controlling access.

Experiments are usually placed in cassettes, which are often metal boxes designed to hold shielding material to protect the experiment during the event. The cassettes are then installed in the LOS Pipe for exposure. Following the event the cassettes are taken back to the TSC where experimenters disassemble the cassettes to retrieve their experiments. Disassembly usually takes place on downdraft tables fitted with high-efficiency particulate aerosol (HEPA) filters to capture particulates.

During disassembly, some radioactive dust may become airborne and entrained in the downdraft table exhaust. This dust is the result of the deposition of the radiation energy in the experiment components and the resultant spall of the exposed surfaces (a phenomenon referred to as blowoff). This dust may be radioactive as the result of neutron activation of the materials exposed, and may also contain some particulate fission products if the device debris was not completely contained. Releases during disassembly at the TSC are composed of airborne dust which contains activation products and, occasionally, particulate daughters of the noble gases which were not contained. In the past, only radon and thoron daughters were seen.

3.3 Tunnel Ponds

Tunnel ponds are located at the portals of E, N, and T-tunnels. E and T tunnels are inactive but their ponds still receive water produced by gravity drainage of the tunnel complexes. Perched water in rock fractures exposed within the tunnel complex is the common source. N tunnel is still active and its ponds receive natural fracture water and excess water used in construction operations (e.g., drilling).

As a result of an underground nuclear detonation, any water in the vicinity of the nuclear cavity may become radioactively contaminated. Reentry mining near the cavity may allow this contaminated water to seep into the reentry drifts; it is then is drained from the tunnel into the ponds. The ponds are unlined so the water may seep into the subsurface as well as evaporate. The water may contain many radionuclides, but only tritium (as HTO) will evaporate.

4.0 RADIONUCLIDES WHICH COULD BE RELEASED DURING EACH PHASE OF THE OPERATION

4.1 Tunnel Activities

The various phases of preparation, device detonation, and post-event operations involve different probabilities of emission of radioactivity as follows:

- Preparation of the Test Bed - No releases except naturally occurring gases.
- Device Detonation - No probable releases.
- Initial Tunnel Reentries and Purging of the Tunnel - If a release into the tunnel complex occurs, purging of the tunnel may release noble gases (^{85,85m,88}Kr and ^{131m,133,133m,135}Xe) and perhaps small quantities of iodine-133 and iodine-131. Typical release scenarios may involve diffusion through the rock and/or stemming materials, which removes most iodines which may be present. A release during this phase of the operation is typically of the order of 100 curies or less of noble gases, with microcurie to millicurie quantities of the radioiodines (although the highest during the past twenty years was 36,000 curies of noble gases associated with purging of tunnel complex following the MIGHTY OAK event).
- Data Recovery - No probable releases.
- Removal of Containment Plugs - No probable releases.
- Experiment Recoveries, Instrumentation Removal and Cleanup Activities - Experiment recoveries may generate small quantities of radioactive dust which might contain activation products, and there may also be volatile fission products and some particulate fission products which are the daughters of the noble gases. Releases during this phase of the operation are typically in the millicurie and less range.
- Gas Sampling Operations - Typically a few curies of noble gases may be released during sampling operations. Some possibility exists for the release of microcurie amounts of radioiodines and rutheniums.
- Reentry Mining - Reentry mining produces dust which is removed from the reentry heading by the tunnel ventilation system. This dust may contain activation products produced by neutron activation of the LOS pipe and some particulate fission products. These releases are in the millicurie range.

- Assessment of Mechanical Closure Performance - Releases associated with purging the LOS pipe between the various LOS closure systems usually contain noble gases (0.5 to 1.0 curie), and may also include microcurie quantities of ^{131}I and the particulate, ^{137}Cs.

- Atmospheric Pumping - Reentry mining to the region of the cavity usually takes several months. Only long-lived noble gases are released by this mechanism; the other noble gases have usually decayed to insignificant amounts.

4.2 Test Support Compound

Experiment disassembly on downdraft tables may generate small quantities of radioactive dust which might contain the activation products ^{24}Na, ^{54}Mn, ^{60}Co, ^{124}Sb and ^{182}Ta. In addition, some particulate fission products, which are the daughters of the noble gases, may be released (^{89}Sr, ^{90}Sr, ^{137}Cs and $^{140}Ba/La$). Releases during the disassembly operation are typically in the millicurie and less range.

4.3 Tunnel Ponds

The ponds receive several radioisotopes in the discharge water that include ^{238}Pu, ^{239}Pu, ^{3}H, ^{137}Cs, ^{125}Sb, and ^{106}Ru. During evaporation of the pond water, tritium vapor (^{3}H) is the most likely to be released to the atmosphere.

5.0 PROCEDURES USED FOR ESTIMATING QUANTITIES OF RADIONUCLIDES RELEASED

5.1 Rationale

The following procedures used for estimating the quantities of radionuclides released are based on the historical level of releases, established performance of current and experimental measurement systems, and cost benefit considerations.

The highest potential for a release from normal tunnel operations may occur during the purging of noble gases from the tunnel complex following an event. In 1985, an array of portable noble gas samplers was placed on the mesa, in addition to the existing air sampling network at the site. Following tunnel purging operations, analysis of gas samples from this experimental array showed no significant difference in the amount of noble gases detected by the array versus current procedures for estimating quantities of radionuclides released.

5.2 Tunnel Activities

5.2.1 General

When the Remote Area Monitoring system is on line, typically for five to ten days following device detonation, radiation readings from these detectors may be used to provide either an estimate of activity within the tunnel, or an estimate of activity released through the ventilation system, or an estimate of the activity released directly to the environment in the unlikely event that this should occur. The reading of the radiation detector is utilized along with the volume of the tunnel affected, or the ventilation flow rate, or the wind speed and standard atmospheric diffusion parameters, respectively, to provide an estimate of the radioactivity involved using standard calculational models. The models used are described in the document SC-RR-68-559, "The Determination of the Quantity of Radioactivity Contained in a Gaseous Effluent at the Nevada Test Site Using Gamma Dose-Rate Measurements." The error associated with using these radiation detectors for release calculations ranges from a factor of two to about a factor of ten. The larger errors are associated with a release directly to the environment, a situation which is rarely experienced using current containment designs.

5.2.2 Purging of the Tunnel

Noble gases which seep into the tunnel complex after detonation of the nuclear device are contained within a specific volume of the tunnel as defined by the various containment plugs. Volumes of these different regions of the complex are fairly accurately known from the as-built drawings for the facility. The specific volume of tunnel affected by a particular release is defined by indications of the presence of radiation by the remote area monitors fielded for the test. Samples of the gas are taken from the tunnel using the remote gas sampling system. These samples are analyzed in the laboratory, providing the concentration of gases in the tunnel. Knowing the volume containing the radioactive gases, and the concentration of same, one can calculate the activity present in the tunnel available to be released through the ventilation system [Activity (Ci) = Volume (mL) x Concentration (Ci/mL)]. The ventilation system is equipped with HEPA and charcoal filters when purging radioactive gases.

The largest error associated with this procedure is the assumption that the gases are uniformly mixed within the volume of tunnel affected. Typical sampling locations are selected such that the noble gas concentration in the samples obtained are usually high with respect to the average concentration. Data from the remote area monitors indicate that uniform mixing has not occurred, and past experience has shown that this technique overestimates the radioactivity released, usually by a factor of approximately two.

5.2.3 Experiment Recoveries

During experiment recovery operations, air samples are taken from inside the LOS pipe and from the experiment bagging area outside the pipe. These samples are taken using Whatman 41 filter paper backed up with a 1" charcoal filter. A vacuum pump is used to pull the sample through the filter assembly, and a gas lpg meter is used to measure the total amount of air sampled. The samples are analyzed in the laboratory, and the concentration of radionuclides detected is reported.

Since the tunnel makeup air sweeps the recovery area before exiting the tunnel through the ventilation system, these air samples would represent the maximum concentration levels which could be released at the point of discharge. Additionally, the ventilation air from the recovery area is diluted by air from other branches of the ventilation system before release, further lowering the concentration at the point of discharge. Air samples taken from the ventilation line near the point of release seldom indicate the presence of any activation or fission products during recovery operations. Although these vent line samples are not taken isokinetically, they do at least confirm that the emission sources are indeed small.

Although the vent line samples are not currently used to project effluent releases during recovery operations, these samples could provide estimates that are accurate to within approximately a factor of two. Release estimates made using air samples taken in the recovery area would probably overestimate a potential release by at least a factor of ten. Either technique would assure that effluent releases during recovery operations are well within NESHAP guidelines. Isokinetic sampling is being tested to provide confirmation of these estimates.

5.2.4 Gas Sampling Operations

During gas sampling operations, gas from the cavity region is pumped through a calibrated mass flow meter before being discharged into the tunnel ventilation system. A representative sample of the gas is taken and analyzed in the laboratory. The concentration of radionuclides thus determined multiplied by the total volume of gas discharged gives an estimate of the radioactivity released. This estimate is accurate to within ten percent since the only errors are in the measurement of the volume of gas pumped into the ventilation line and the errors associated with sample analysis.

5.2.5 Reentry Mining

Air samples are taken continuously in the reentry heading using the techniques described in Section 5.2.3 above. These samples are taken as close to the end of the vent line as is possible, and are analyzed in the laboratory. Samples are also taken from the ventilation line at the point of discharge. Again, these vent line samples are not taken under isokinetic conditions, but do confirm that any releases during mineback activities are small. Drierite samples are taken in the reentry heading near the end of the ventilation line at least weekly to determine if any tritium is present as water vapor. These samples are analyzed in the laboratory, and indicate that tritium releases associated with reentry mineback operations are also quite small.

As soon as the reentry operation is complete, current practice is to construct a plug in the reentry drift. No further releases from the reentry operation can occur once the plug has been completed.

5.2.6 Assessment of Mechanical Closure Performance

During these operations, a sample of the gas inside the LOS pipe between various closure systems is taken and is analyzed in the laboratory. The volume of the LOS pipe between closures is accurately known, so the activity of the gas available to be released can be easily and accurately determined [Activity (Ci) = Volume (mL) x Concentration (Ci/mL)]. The error in this estimate should be less than ten percent.

5.2.7 Atmospheric Pumping

If a release occurs from a tunnel as a result of falling barometric pressure, a sample of the gas is taken from the drill hole in a vacutainer and sent to the laboratory for analysis. An estimate of the flow rate from the hole is made (or the flow rate is measured if the proper instrumentation is available), and the volume of gas discharged is calculated from the flow rate and the length of time the release occurred. This volume multiplied by the concentration of the sample taken gives the activity discharged.

The error of the estimate in this situation is primarily determined by how well the flow rate from the drill hole is known. Since the estimate of the flow rate could be in error by a factor of ten, the calculated effluent release as the result of atmospheric pumping is no better than a factor of ten. However, the concentration of gases in the chimney region during the time that this phenomenon might be observed is quite low so releases associated with atmospheric pumping in the tunnels are also quite low.

5.3 Test Support Compound

During experiment disassembly operations, air samples are taken from the down draft table vent stacks and at several locations in each building. These samples are taken using Whatman 41 filter paper backed up with a 1" charcoal filter. A vacuum pump is used to pull the sample through the filter assembly, and a gas lpg meter is used to measure the total amount of air sampled. The samples are analyzed in the laboratory, and the concentration of radionuclides detected is reported.

Since the air sweeps down onto the table and over the disassembled experiments before exiting through the vent stack, these air samples would represent the maximum concentration levels which could be released at the point of discharge. Air samples taken from the ventilation stack near the point of release seldom indicate the presence of any activation or fission products during experiment disassembly operations. Although these vent stack samples are not taken isokinetically, they do at least confirm that the emission sources are indeed small.

Although the vent stack samples are not currently used to project effluent releases during experiment disassembly operations, these samples could provide estimates that are accurate to within approximately a factor of two. Release estimates made using air samples taken in the disassembly area and table ventstack would probably overestimate a potential release by at least a factor of ten. Either technique would assure that effluent releases during disassembly operations are well within NESHAP guidelines.

Grab samples of discharge water and water in the ponds are taken monthly. These samples are analyzed for tritium and gross beta, and by gamma spectrometry. Every quarter the samples are analyzed for plutonium, and once each year the samples are analyzed for strontium. Tritium releases, in the form of water vapor, are estimated by assuming the entire tunnel water discharge evaporates. Currently, this is a very conservative method and probably overestimates the releases by about 50 percent. However, plans call for eliminating all discharges during 1994.

As of May 1991, a water characterization/monitoring system was installed at each of the three water-producing tunnels. This system continuously monitors the physical properties of the water (flowrate, pH, etc.). Periodically a sample is collected for chemical and radiological water quality analyses. These samples are used to calculate an air effluent by assuming total evaporation.

6.0 SUMMARY

There are a number of operations associated with weapons effects tests conducted in NTS tunnels which have the possibility of releasing some airborne radioactive effluent. This document has attempted to describe the various operations associated with a tunnel test, the radionuclides which might be released, and the procedures currently used to verify that the releases are indeed small. It is believed that all potential airborne release pathways have been identified, and that the dose to the maximally exposed individual in the offsite area is well below 0.1 mrem/year. As these small releases lead to exposures well below the guidelines for exposures to offsite people, only periodic confirmatory measurements are required to demonstrate continuing compliance with NESHAP. It is the DNA's contention that monitoring at the source of production of the potential effluent provides such confirmation.

7.0 REPORTS RELATED TO EFFLUENT MEASUREMENTS AND MONITORING

A. SC-RR-68-559; "The Determination of the Quantity of Radioactivity Contained in a Gaseous Effluent at the Nevada Test Site Using Gamma Dose Rate Measurements," P. O. Matthews, December, 1968.

B. Event Effluent Documentation Reports - Distribution: Bernard F. Eubank, REECo; P. K. Fitzsimmons, DOE/NV; J. W. LaComb, DNA; D. A. Bedsun, DNA; F. D. Ferate, REECo; SNL Division 7713 Files

C. Water Pollution Control Permit Applications & Periodic Monitoring Reports for Waste Water Discharges from E, N, & T Tunnels - Distribution: J.W. LaComb, DNA; Paul Liebendorfer, Nevada Dept. Environ. Protection; D.R. Elle, DOE/NV; W.G. Flangas, REECo.

APPENDICES 4 - 10

Appendix 4. Building 650 Health Physics Laboratory Radionuclide Inventory

Appendix 5. Containment Ponds

Appendix 6. Resuspended Plutonium from Area 3

Appendix 7. Radioactive Waste Management Site

Appendix 8. Decontamination Laundry Facility

Appendix 9. Seepage Calculation for Pahute Mesa

Appendix 10. Meteorological Data for Input to STAR Files

Appendix 4. Building 650 Laboratory Radionuclide Inventory

The following approach was used to calculate the inventory of radionuclides in the Health Physics (HP) Laboratory located in Building 650, Mercury, Nevada Test Site.

- The number of samples processed during a week was totaled and documented.
- The total activity for each radionuclide analyzed was calculated for all samples in liquid form (or in liquid form during any stage of radiochemistry). Gamma activity inventory from solid samples (soil, filters not solubilized, charcoal cartridges, etc) was orders of magnitude below liquid samples, and was therefore not included.
- When the number of samples of any type processed during the week was less than typical (in the health physicist's judgement), the number of samples was modified accordingly. In each case, the modification increased, never decreased, the documented number of samples.
- The calculated activity in the Laboratory is documented in the NTS Environmental Monitoring Plan.
- The sample throughput capability of the Laboratory cannot increase much more than two to three times its actual capacity. Therefore, an error of 300% may be applied.
- The radionuclides contained in standards, check sources, and tracer solutions were also inventoried. The activity contained in these sources was orders of magnitude above that contained in samples so they are listed in Table 4.1 below where they are compared to to possession limits.

From the inventory, only two items may become sources of air emissions. These are ^{3}H (HTO) and ^{131}I and are listed in Table 2, above. The remainder of the standards are compared to the possession limits set forth in 40CFR61, Appendix E, and all are less than 0.1% of those limits.

Table 4.1

BUILDING 650 HEALTH PHYSICS LABORATORY INVENTORY COMPARED TO NESHAP

Radionuclide	Annual Inventory (Ci/year)	NESHAP Possession Quant. (Ci/year liquid form)
^{3}H	6.5×10^{-6}	1.5×10^{4}
^{131}I	5.6×10^{-5}	6.7×10^{0}
ß (fission prod.)[1]	2.0×10^{-5}	5.2×10^{-1}
$^{239+240}Pu$	1.1×10^{-7}	2.5×10^{-3}
^{238}Pu	1.0×10^{-8}	2.7×10^{-3}
^{242}Pu	4.1×10^{-9}	2.5×10^{-3}
^{241}Pu	1.4×10^{-8}	1.3×10^{-1}
^{241}Am	0.9×10^{-6}	2.3×10^{-3}
Natural U	3.8×10^{-8}	8.6×10^{-3}
^{226}Ra	1.0×10^{-7}	5.5×10^{-3}
Gamma Emitters[2]	8.9×10^{-6}	5.0×10^{0}

[1] Beta (fission products) plus ^{14}C, ^{89}Sr, ^{129}I, and ^{99}Tc are compared to the ^{90}Sr annual possession quantity (40CFR61 App. E, Table 1).

[2] Gamma emitters is the sum of all such isotopes in the Laboratory not listed separately above. The isotope with the largest dose conversion factor is ^{109}Cd so the possession quantity for that radionuclide is used. The gamma emitters included ^{57}Co, ^{60}Co, ^{88}Y, ^{89}Sr, ^{109}Cd, ^{113}Sn, ^{137}Cs, ^{139}Ce, and ^{203}Hg.

Appendix 5. Containment Ponds

Water in the containment ponds located at the Area 12 tunnel complexes and the Area 6 Decontamination Facility (DF) is 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 in the year. The volume of water discharged from the tunnels is measured by the Desert Research Institute, University of Nevada and that from the Decontamination Facility is estimated based on the average amount of water used on previous tests multiplied by the number of tests.

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 measured in the liquid effluent during the year evaporates and becomes airborne, an airborne source term is obtained. It is unlikely that this is an accurate representation of the actual process at 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 is relatively constant[1] lends credence to this calculation.

Table 5.1, below, lists the total quantity of tritium discharged into the containment ponds (and assumed to be released as airborne effluents) as measured during CY-1992.

Table 5.1. Tritium Effluents into Containment Ponds.

Location	Area (m^2)	Total ^3H Discharged (Ci)
Area 06, Decon. Facility	2,000	0.0048
Area 12, T Tunnel*	930	2150
Area 12, N Tunnel	1120	26.4
Area 12, E Tunnel	250	67.2

* Although T and E Tunnels are currently considered inactive, there is some water discharged into the containment ponds.

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[1] - For example:

Tunnel Pond & No.	Result ($\overline{X} \pm S$)	Mo./Yr.
N #2	$8.5 \pm 1.3 \times 10^{-5}$	02/92
	$2.8 \pm 1.9 \times 10^{-4}$	12/92
T #2	$4.9 \pm 0.5 \times 10^{-2}$	02/92
	$5.6 \pm 0.4 \times 10^{-2}$	12/92

Appendix 6. Resuspended Plutonium from Area 3.

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 plutonium becomes airborne. Results from the air samplers in the area indicate that only $^{239+240}$Pu is routinely detected in concentrations slightly above the MDC.

Measurements of airborne $^{239+240}$Pu in Area 3, during CY-1992, are provided in Table 6.1. This table displays the number of samples analyzed, the arithmetic mean value and the standard deviation of the 11 or 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 around the sampler with the highest concentration (worst case assumption).

Table 6.1. Airborne $^{239+240}$Pu Detected by the Area 3 Air Samplers

(μCi/mL x 10^{-18})

Location	No. of Samples	Median	1 std dev
Area 03 Complex	12	83	160
Area 03 Complex #2	12	160	230
Area 03 Mud Plant	11	1700	1900
Area 03, U3ah/at East	11	160	160
Area 03, U3ah/at North	11	2400	2700
Area 03, U3ah/at South	11	340	440
Area 03, U3ah/at West	11	280	320

Source Term

It is estimated that 2.5 mCi 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 monitored values. The method used to calculate this quantity is described below.

The CY-1992 arithmetic mean concentration of $^{239+240}$Pu at the Area 3, U-3ah/at North perimeter sampler was reported as 2.4 x 10^{-3} pCi/m^3. This concentration was the maximum annual average for $^{239+240}$Pu in Area 3. The air sampler is located towards the northwest approximately 180 meters from the assumed center of the adjacent area. Using the dose conversion factor of 310 rem/μCi derived from ICRP EDE limits and

8400 m^3 annual average air intake per person, an EDE of 6 mrem can be calculated for a person remaining all year at that sampler location.

A trial run of CAP88-PC using a 1 μCi release at a distance of 180 m to the NW yielded an EDE of 2.4×10^{-3} mrem at that location. When the calculated EDE at each sampler is divided by the EDE/μCi from the CAP88-PC run, then an estimate of the curies released can be obtained.

The following shows a typical calculation using data for the North air sampler:

$$2.4 \times 10^{-3}\ pCi/m^3 \times 8400\ m^3/yr \times 310\ rem/\mu Ci \times \mu Ci/10^6\ pCi = 6.0\ mrem$$
$$6.0\ mrem\ /\ 2.4 \times 10^{-3}\ mrem/\mu Ci = 2500\ \mu Ci$$

Using 2500 μCi (2.5 mCi) as a conservative source term for the radionuclide as input to CAP88-PC yields 1.4×10^{-3} mrem to a person in Lathrop Wells, Nevada, 54 km to the southwest. This is the MEI for a source in Area 3 of the NTS.

Error Term

The errors in the measurements are listed in Table 6.1 as a standard deviation so the EDE is actually between 0 and 1.4×10^{-3} mrem. However, the errors in the method employed in arriving at a source term, as described above, are very difficult to assess.

Appendix 7. Area 5 Radioactive Waste Management Site

Background Information

Environmental monitoring is conducted at several locations surrounding this facility. There are 9 air samplers on the RWMS boundary and other air samplers inside the facility. The CY-1992 monitoring data indicate that gross beta and $^{239+240}$Pu concentrations are not statistically different from site-wide NTS levels. However, the annual average concentration of airborne tritium (HTO) at the RWMS appears among the upper grouping for the NTS. The monitoring results from all nine sampling stations surrounding the RWMS are provided in Table 7.1, Airborne Tritium Sampling Results during CY-1992.

Source Term

It is estimated that 0.6 Ci of ^{3}H is emitted annually from the RWMS. This source term is calculated to give an EDE of 1.0×10^{-5} mrem to an individual residing in Lathrop Wells, NV. As in Appendix 6, 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 is appropriate. However, a source term was calculated using a method similar to that described for Area 3 in Appendix 6.

The annual airborne HTO concentrations from the RWMS tritium samplers surrounding the site were compared to the DOE/EH-0071 dose conversion factors to calculate a dose at each sampler location. For example, an individual breathing 1.2×10^{-11} μCi/mL of HTO for one year, for example, receives 9.7 μrem EDE when skin absorption is included. CAP88-PC calculates that an individual 305 meters to the south from a 1 Ci release of ^{3}H at the center of the RWMS, would receive a EDE of 16 μrem per year. Therefore, 9.7 μrem at that sampler divided by 16 μrem/Ci equals an estimated annual release of 0.6 Ci. This calculation was performed for all sampler locations, as shown in Table 7.1, with 0.6 Ci being the largest calculated release. This calculated release was reported to the EIS/ODIS data bank.

Lathrop Wells, NV is located WSW of the RWMS at 44 km. CAP88PC calculates an EDE of 1.0×10^{-5} mrem to an individual residing Lathrop Wells if 0.6 curies of HTO were released from the Area 5 RWMS.

Table 7.1. Airborne Tritium Sampling Results during CY-1992

SAMPLER NO.		DIRECTION[1] FROM CENTER		AVERAGE μCi/mL	AVERAGE Bq/m^3	STD. DEV. $10^{-12}\mu$Ci/mL	RATIO TO 1 Ci EMISSION[2]
05915	#1	SE	381m	4.2×10^{-12}	0.16	4.0	0.21
05908	#2	ESE	366m	6.7×10^{-12}	0.25	13	0.34
05911	#3	E	305m	4.2×10^{-12}	0.16	6.0	0.21
05700	#4	NE	418m	6.5×10^{-12}	0.24	5.1	0.32
05707	#5	N	305m	4.0×10^{-12}	0.15	3.0	0.20
05708	#6	NW	418m	4.0×10^{-12}	0.15	2.4	0.20
05709	#7	W	305m	1.2×10^{-11}	0.44	13	0.60
05714	#8	SW	418m	5.0×10^{-12}	0.18	4.6	0.25
05716	#9	S	305m	1.2×10^{-11}	0.44	23	0.60

[1] Sampler direction and distance from center of the RWMS.

[2] This ratio = number curies emitted from RWMS that would give the sampler result.

Appendix 8. Decontamination Laundry Facility

Background Information

All potentially contaminated 'Anti-C' suits are laundered within the Area 6 Decon Facility. These suits are washed, dried, and then counted for residual activity. If any activity remains on the suit, the suit is re-laundered.

Air effluents from this facility may result from laundering then drying contaminated clothing. The potential airborne effluents discharged during drying are considered to be minimal. As a conservative estimate, it has been determined that on the average, 300 contaminated suits are laundered per each nuclear explosives test and that an average of 100 may contain measurable activity, prior to laundering, typically on the order of 400 cpm above background. Therefore, if the conservative estimate is made that all of this potential activity remains on the suit through the wash cycle to be emitted during the drying cycle, then less than 30 μCi of beta/gamma activity can be discharged from the dryers per year.

Source Term

To calculate the total potential effluent, the following data were obtained from Area 06, Health Physics:

300 suits laundered per test
100 (on average) suits contain measurable activity
400 cpm above background per contaminated suit, typical activity

Conservative Assumptions

- Typical surface area contaminated: 1 ft^2/suit
- All activity on suit survives the washing cycle and becomes airborne effluent.
- Surface area of typical pancake probe = 4 in^2
- All activity on suits assumed to be ^{131}I
- Probe efficiency is 30%

Calculations

$400 \text{ cpm} \div 0.30 \text{ cpm/dpm} \div 2.2 \times 10^{12} \text{ dpm/Ci} = 6.0 \times 10^{-10} \text{ Ci}$
$(144 \text{ in}^2) / (4 \text{ in}^2) = 36$ (this is a ratio of the contaminated area to the area of the pancake probe).

$(100 \text{ suits/test}) \times (6 \text{ tests/1992}) \times (36) \times (6.0 \times 10^{-10} \text{ Ci/suit}) =$

1.3×10^{-5} Ci/yr of beta/gamma activity.

Assume that the 13 μCi of activity is ^{131}I, then this becomes the source term that is listed in Table 2, above.

Appendix 9. 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 detected in these samples.

In 1992, additional permanent sampling locations were established as shown in Figure 9.1, to increase the number of stations to 10. 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, fewer than 52 results are obtained for each station. The 1992 results are shown below.

Table 9.1 ^{85}Kr Concentrations on the NTS (pCi/m^3

STATION LOCATION	NO.	ARITH. AVERAGE	STANDARD DEVIATION
BJY	45	25.8	5.1
GRAVEL PIT	48	26.6	11.0
GATE 200	45	26.6	6.5
AREA 12 CAMP	47	25.8	7.8
EPA FARM	36	26.3	7.3
AREA 20 CAMP	42	29.5	8.7
EMAD	45	27.7	19
PAHUTE SUB.	30	24.4	5.6
GATE 400	33	24.5	9.4
DDZ77 TRANS.	19	24.3	2.9

The results from the Area 20 Camp sampler have frequently been higher than the results from the other NTS samplers. This appears to be true for th 1992 results also. The average of the 9 stations other than Area 20 was 25.8 pCi/m^3 while the results for the Area 20 sampler were 29.5 pCi/m^3, or an annual average of 3.7 pCi/m^3 higher. Note that the new stations (last 3 in the table) have slightly lower results than the network average. One deduction from these facts is that the source of krypton for the Area 20 sampler is upwind from that sampler but not from the others. The wind roses shown on Figure 9.2 suggest that, for the Area 20 sampler, the source is to the SSE in the area between some U19 and U20 emplacement holes. This area is about 5260 m (17,250 ft) from the sampler. Using a procedure similar to that in Apendices 6 and 7, and also using a CAP88-PC run with 1 curie of ^{85}Kr, yields a result of 280 Ci emission from ground seepage on Pahute Mesa. The calculation for this emission is shown on the following page.

The dose conversion factor for ^{85}Kr is obtained from EPA Federal Guidance No. 11 that lists such factors for inhalation, ingestion and submersion. The DCF is multiplied by the krypton concentration to obtain the effective dose equivalent (EDE) at the sampler location. To determine the emission necessary to cause this EDE, an assumed emission of 1 Ci, the distance to the sampler (5260 m), and the STAR (stability array) for Pahute Mesa were entered into the CAP88-PC program. At a distance of 5260 m in the direction NNW, the CAP88-PC run with 1 Ci indicates an EDE of 2 x 10^{-7} mrem/yr. The calculations are displayed in the following three equations:

$$DCF\ for\ Kr^{85} = 1.5x10^{-5}\ mrem/yr\ per\ pCi/m^3$$

$$3.7\ pCi/m^3\ x\ 1.5x10^{-5} = 5.55\ x\ 10^{-5}\ mrem/yr$$

$$\frac{5.55\ x\ 10^{-5}\ mrem/yr}{2\ x\ 10^{-7}\ mrem/Ci} = 280\ Ci$$

APPENDIX 10

IDENTIFICATION AND JUSTIFICATION FOR THE DEVELOPMENT OF METEOROLOGICAL DATA USED AS INPUT TO CAP88PC

by

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

INTRODUCTION

The Nevada Test Site (NTS) is located in southern Nevada, approximately 50 miles northwest of Las Vegas, and encompasses an approximate rectangular area of 1500 sq mi (see Figure 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 #25) to near 7700 ft on Rainier Mesa in the northern part of the NTS (Station #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 upslope and downslope wind regimes as a function of time of day.

Meteorological support, observations, and climatological services for the NTS are provided to the DOE Nevada Field Office (DOE/NV) by the Weather Service Nuclear Support Office (WSNSO). WSNSO is a National Oceanic and Atmospheric Administration (NOAA), National Weather Service (NWS) office. WSNSO supports DOE/NV programs under the authority of an Interagency Agreement between NOAA/NWS and DOE/NV.

An arid climate exists over the NTS. Annual precipitation ranges from 4.5 inches per year at Station #25 to 6.9 inches per year in Yucca Flat (Station #6) to 7.6 inches at Desert Rock, to 9.5 inches per year on Rainier Mesa (Station #12).

METEOROLOGICAL OBSERVATIONS

WSNSO manages, operates, and maintains a meteorological monitoring program that is designed and used to support 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 NWS surface observations are collected by trained NWS 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 #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 #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 Fig. 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 (Fig. 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 WSNSO 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. 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) 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.

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 will be 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/ climatological conditions.

For sources at Mercury, the cloud observations from DRA are representative. DRA is only 3 miles from Mercury.

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

Reference: Quiring, R.F., "Precipitation Climatology for the Nevada Test Site," NOAA/WSNSO, Las Vegas, NV, WSNSO 351-88, 34 pp., 1983.

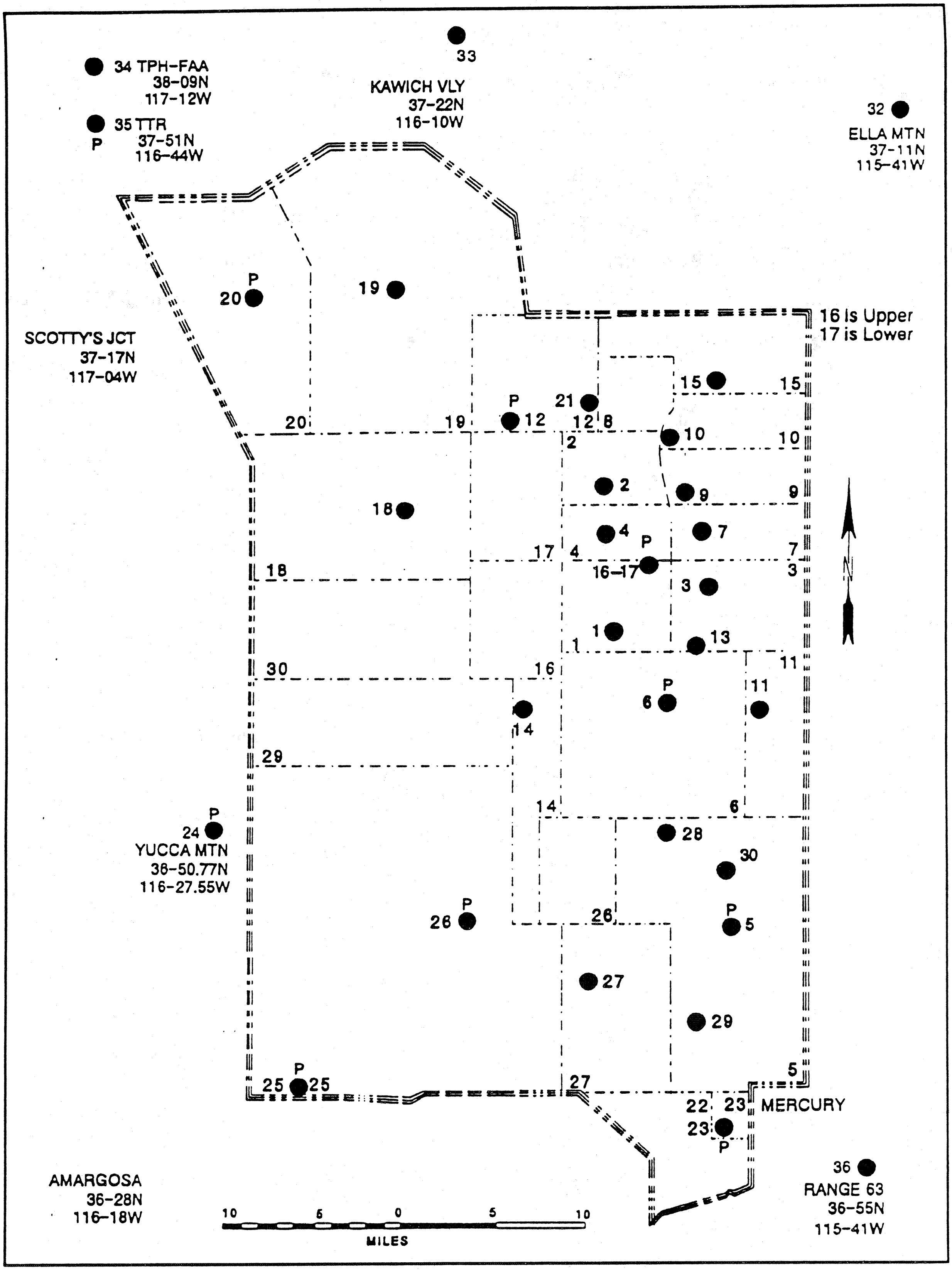

Figure 1. Location of MEDA Stations on the NTS

Supplemental Information

1. Comparison with Previous Year's Data.

Maximum Potential Individual EDE:	1992 - 1.2×10^{-2} mrem
	1991 - 8.6×10^{-3} mrem
	1990 - 5.8×10^{-3} mrem

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% increase in HTO effluents and the STAR for the tunnel area was developed that slightly changed the offsite distribution of the effluent.

2. Collective Effective Dose Equivalent.

The maximum potential collective effective dose equivalent to the 21,750 people who live within 80 km of the NTS emission sources was 0.029 person-rem in 1992 due principally to tritium exposure. This was less than last year because the Radionuclide Migration Study (tritium effluent) in Area 5 was terminated. The calculation is shown below.

The collective EDE data are based on distance and direction from each of the sources of emission on the NTS. These data are displayed in the rightmost column of Table 5. The population dose to the public within 80 km of each NTS source is 0.029 person-rem.

The population EDE based on the emission sources from each Area of the NTS is:

Max. Potential Collective EDE (person-mrem) by NTS source:		
	AREA 3	3.28
	AREA 5	0.12
	AREA 6	0.00005
	AREA 12	26.0
	AREA 19/20	0.005
	MERCURY	0.0003
		29.4 person-mrem (0.029 person-rem)

The higher potential population doses from Areas 3 and 12 are due to the conservative assumptions about resuspension of plutonium from Area 3 and about evaporation of tritium from liquid effluents from the Area 12 ponds. The extent of overestimation can be assessed as follows: calculate the concentration of ^{3}H necessary to cause the CAP88-PC estimate of EDE. The CAP88-PC effective dose equivalent was 0.012 mrem at Indian Springs due to evaporation of HTO effluent from the tunnels. Using a dose conversion factor of 6.3×10^{-5} rem/μCi (from DOE/EH-0071) and an inhalation intake of 8400 m^3 per year, divide the 0.012 mrem by 0.063 mrem/μCi to obtain an intake of 0.19 μCi. The 0.19 μCi divided by 1.5 for skin absorption and the inhalation rate of 8400 m^3 per year gives an annual average concentration of 1.98×10^{-5} μCi/m^3 or 20 pCi/m^3. The 1992 annual average concentration measured by EMSL-LV at Indian Springs was 0.54 pCi/m^3 or just 2.7% of the concentration required to deliver the EDE calculated by CAP88-PC.

3. Compliance with NESHAP.

DOE/NV was in compliance with 40 CFR 61, Subpart H, during Calendar Year 1992. Periodic confirmatory measurements and analysis of the NTS environs are provided in Appendices 1 through 9 plus periodic isokinetic confirmatory sampling at the P-tunnel ventilation duct. These measurements and analysis are the methods of determining NTS effluents presented in the April 24, 1991, meeting between Region IX and DOE/NV and documented in the 1990, 1991, and 1992 DOE/NV annual reports. However, we have not received any notification from EPA Region 9 stating that we are in compliance with NESHAP.

4. Compliance with Subparts Q and T, 40 CFR 61.

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

5. Radon Emissions from U-238 and Th-232 Sources.

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

6. Non-disposal/Non-storage Sources of Radon Emission.

None of these sources exist on the NTS.

7. NESHAP QA Program.

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

8. Status of Tiger Team Findings.

The Status of DOE/NV's responses to the 1989 Tiger Team Compliance Assessment Findings relevant to radioactive air emissions were provided in the CY 1991 annual NESHAP report.