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*Title:* **Comparison of H-3 Deposition in Precipitation  
to Airborne H-3 Emissions at LANL**

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## Comparison of H-3 Deposition in Precipitation to Airborne H-3 Emissions at LANL

### Introduction

As part of the ongoing review and impact evaluation of airborne emissions at Los Alamos National Laboratory (LANL), it is of interest to determine what quantities of airborne tritium (H-3) emissions are deposited on the ground in precipitation. Besides providing information on the radiological significance of H-3 in precipitation, this determination may assist in evaluating the potential impact of airborne H-3 on surface or ground water, the determination of which is beyond the scope of this document.

No tritium-in-precipitation measurements currently are being made by LANL, but a study was done in the early 1990s. During 1990-93 measurements were made of tritium in precipitation at LANL, the results of which were published in the annual LANL Environmental Surveillance Reports for those years. The entire study was published in the report, "Chemical and Isotopic Variations for Precipitation in the Los Alamos Region, New Mexico," LA-12895-MS, February 1995. Detailed information about how the study was done is provided in the report and is not restated here. This present comparison uses the H-3 deposition data from that report and compares the results to airborne H-3 emissions for the same period.

### Method, Assumptions, and Data

To determine the total H-3 deposited per year in precipitation in the LANL region,

- 1) average *gross* activities (pCi/liter) in precipitation must be determined for the measured sites and,
- 2) based on those measurement, conservative values determined and assigned to fairly large, easily defined areas out to some reasonable distance from LANL.
- 3) Conservative average annual precipitation (in inches) must also be assigned to these defined areas.
- 4) A conservative "background" activity must be determined and subtracted from the *gross* area H-3 concentrations to obtain a value for the *net* activity attributable to LANL in each area.
- 5) The total liters/year of precipitation in each defined area times the net annual average activity per liter in each area gives a conservative value for the total H-3 deposited in each area for the year.
- 6) Summing the area totals gives total H-3 deposition for the entire region of interest.
- 7) This regional annual total can be compared to the total H-3 emitted during the year to estimate the emitted H-3 fraction deposited in precipitation.

#### Average Measured Gross H-3 Activities in Precipitation

Among other data, Table 5 of the above report provides annual average H-3 concentrations in precipitation for 1990-93 in "Tritium Units" at a number of locations. According to the report, one Tritium Unit corresponds to 3.2 pCi/liter. The following table presents these annual averages converted to pCi/liter for all measured sites. See Attachment A for a copy of the original report table.

#### Annual Average H-3 in Precipitation Near LANL During 1990-93, in pCi/liter

Location	1990	1991	1992	1993	Notes
Santa Fe Airport	40.3	41.9	34.1	22.6	Regional
SF Ski Basin	37.8	36.8	34.6	31.8	Regional
VC-2B Sulph. Spgs.	22.6	31.3	24.5	23.4	Background
TA-33	129.1	110.4	120.5	66.4	LANL Site

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### Annual Average H-3 in Precipitation Near LANL During 1990-93, in pCi/liter (cont'd)

Location	1990	1991	1992	1993	Notes
TA-49	94.3	69.0	110.9	62.0	LANL Site
TA-51	171.2	95.0	149.0	81.3	LANL Site
S Site	92.4	66.8	98.3	47.5	LANL Site
"KM" (private home)	No smpl	104.3	250.6	98.2	Near LANL boundary
White Rock "Y"	248.5	83.0	100.9	73.2	Near LANL boundary
East Gate (Philom)	251.7	159.0	240.4	137.2	Near LANL boundary
Pajarito Mtn.	70.4	35.1	54.0	53.0	LANL Region
Espanola Rngr Sta.	71.4	52.0	45.1	36.1	LANL Region
Boundary Peak Area	43.6	50.9	73.6	41.5	LANL Region
W. of Guaje Mtn.	106.3	103.6	184.7	92.8	LANL Region

#### Affected Area Definition

The above measurements extend to about 25 miles from LANL and measurements at that maximum distance were *approaching* background H-3 values. Furthermore, the area within a 25-mile radius encompasses a large fraction of the area that would be expected to directly affect surface and ground water in the region. Therefore, it was decided that the analysis would be limited to the area within a radius of 25 miles of LANL. Circles centered on the highest measured location ("Philomena's," which is very close to the current "East Gate" site) were drawn on a map at 5, 10, 15, 20, and 25 miles. See Attachment B for a copy of the map.

The Jemez Mountains are just west of LANL and the meteorology of the area effectively **prevents** airborne emissions at LANL from significantly dispersing westward over those mountains. Consequently, segments of some of the 5-mile rings to the west of LANL needed to be deleted from the calculations. Realistically speaking, the mountains begin within the first 5-mile ring. However, as a conservative measure, the surface areas in the 5-mile rings were kept whole out to 10 miles. Thereafter, approximately 100 degrees (28%) of the west side of the 10 to 15-mile ring, 120 degrees (33%) of the 15 to 20-mile ring, and 150 degrees (42%) of the 20 to 25-mile ring were removed from the calculations.

The calculated areas for each ring are as follows:

#### Calculated Areas of Regional "Rings" Near LANL

Ring	Area, sqft
0-5 miles	5.47E+08
5-10 miles	1.64E+09
10-15 miles	1.97E+09
15-20 miles	3.08E+09
20-25 miles	3.74E+09

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These areas are determined by the formula for the area of a circle minus any interior ring areas. Additionally, for the last three rings, 28%, 33%, and 42%, respectively, of the total calculated area has been deleted as explained above.

#### Assignment of Activity to Affected Areas

A conservative average H-3 value for each year needs to be assigned to each 5-mile ring. The following methods were used to assign those averages:

**0 to 5 miles**—The 7 measured sites within the circle were averaged. Those sites are TA-49, TA-51, S-Site, KM (private residence), the White Rock “Y”, Philomena’s, and the Guaje Mountain site. These sites are distributed over the area and should be generally a representative to conservative estimate of the average activity.

**5 to 10 miles**—The 3 measured sites within the circle were averaged. Those sites are TA-33, Boundary Peak, and Pajarito Mountain. Because TA-33 is an actual H-3 emission site, including it in the average suggests that the result is conservative.

**10 to 15 miles**—The 1 measured site (Espanola) within the circle was used. This site is in a prevalent wind direction and should be much higher than the average activity in this ring. Thus, using it for the ring average should be conservative.

**15 to 20 miles**—Sulphur Springs, located in the excluded area to the west of LANL is within this ring but does not, at all, adequately represent the average within the ring. Sulphur Springs will be discussed further under the H-3 Background Determination section below. After Sulphur Springs, the Santa Fe Airport is the closest measurement to this ring. Espanola is the next closest. These two values could be averaged to estimate the value for this ring. An alternative would be to use the Airport value times 125%. Using the 125% value instead of the 2-site average results in a slightly lower value for 1990 and 1993 but a slightly higher value for 1991 and 1992. The 125% (of the Airport value) method was selected for this ring.

**20 to 25 miles**—The only measurement in this ring is the Santa Fe Airport. The Ski Area site is approximately the same value but located high in the Sangre De Christo Mountains, the topography of which is not remotely representative of the average geography of this ring. Therefore, the Airport value will be used for this ring.

The following table provides the selected *gross* values, in pCi/liter, used for each 5-mile ring:

**Average Gross Activity in pCi/Liter Assigned to Each Ring**

Ring	1990	1991	1992	1993
0 to 5 miles	160.7	97.2	162.1	84.6
5 to 10 miles	81.0	65.5	82.7	53.6
10 to 15 miles	71.4	52.0	45.1	36.1
15 to 20 miles	50.4	52.4	42.6	28.3
20 to 25 miles	39.1	39.4	34.4	27.2

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### Average Annual Precipitation

A map of the average annual precipitation in New Mexico is shown in Attachment C. Annual precipitation rates for the areas of interest were chosen by inspection of that map. The following table gives the annual precipitation rates, in inches, that were selected for each ring. The table also shows the total annual volume, in liters, of precipitation within the area of each ring. This value is determined by converting the inches of precipitation to feet, multiplying by the area of each ring in square feet, and converting the cubic feet of water to liters.

### Average Annual Precipitation

Ring	Precipitation, in	Volume, liters
0-5	20	2.60E+10
5-10	18	7.02E+10
10-15	16	7.48E+10
15-20	14	1.02E+11
20-25	16	1.42E+11

Although actual precipitation values for each year at a number of locations at LANL are known, actual values by year for the rest of the areas are not known. Therefore, an attempt was made to select conservative to realistic values based on the graphic in Attachment C. If the selected values were to be changed, the total deposited H-3 for the ring of interest would change by the same percentage as the change in the precipitation.

### Background H-3 Determination

The last piece of information needed to calculate total deposited H-3, attributable to LANL, is a background H-3 value that will be subtracted from the gross values. The original report stated that the background could be about 32 pCi/liter (10 TU), the average of the Sulphur Springs, Santa Fe Airport, and Ski Area for all four years. That report also stated that the natural pre-atmospheric nuclear testing background was typically 19 pCi/liter. As an aside, the report states that the highest environmental H-3 concentration in precipitation, during the height of atmospheric testing, was almost 9000 pCi/liter. A small amount, above natural background, of tritium from atmospheric testing is still detectable, worldwide, in precipitation.

It has already been stated that the area west of the Jemez Mountains is largely unaffected by LANL emissions because of meteorological boundaries. Since Sulphur Springs is located well west of those mountains **and** had the lowest measured H-3 activity three out of four years (see table on page 1 above), the results of that site were chosen as the background. Therefore, for each annual ring gross H-3 value, the corresponding annual Sulphur Springs value was subtracted to give a net value, assumed to be contributed by LANL.

### LANL H-3 Emissions

Although not part of the actual deposition determination, the LANL H-3 emissions for the applicable years are of interest and will be compared to H-3 depositions in the Analysis below. Tritium emissions at LANL are reported in each annual "NESHAP" report to the EPA. Those reports for 1990-93 provide the following LANL-wide H-3 emissions:

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### LANL 1990-93 H-3 Emissions in Curies

Emissions	1990	1991	1992	1993
Total H-3	6400	4700	1300	1400
HTO	120	130	590	250

“Total H-3” includes both the water (HTO) form of tritium, which can be part of precipitation, and the elemental form, which is normally not associated with precipitation. Thus, the HTO emissions should be compared to the total deposited H-3 in precipitation.

### Analysis

Using the method, assumptions, and data above, the following table presents the total estimated curies of LANL H-3 deposition in precipitation for the years 1990-93.

### LANL H-3, in Curies, Deposited in Precipitation During 1990-93 at Various Distances from LANL

Distance	1990	1991	1992	1993
0-25 Miles	7.44E+00	4.04E+00	5.61E+00	2.57E+00
0-20 Miles	6.39E+00	3.52E+00	4.98E+00	2.32E+00
0-15 Miles	5.11E+00	2.55E+00	4.14E+00	2.10E+00
0-10 Miles	3.46E+00	1.85E+00	3.45E+00	1.67E+00
0-5 Miles	1.62E+00	7.72E-01	1.61E+00	7.16E-01

The values for 0-25 miles are a good estimate of the total H-3 deposited regionally. The other values are provided to allow the reader to do relative comparisons as the affected area changes from 5 miles to 25 miles.

### Conclusion

When compared to emissions, the total deposition results (0-25 miles), shown in the previous section, represent a small fraction of LANL emissions each year. The table below compares those values for HTO emissions and gives the relative percents of deposited H-3 to emitted H-3 as HTO.

### Comparison of LANL H-3 Emissions to H-3 Deposited in Precipitation

Distance	1990	1991	1992	1993
HTO Emitted	120	130	590	250
Total H-3 Deposited	7.44E+00	4.04E+00	5.61E+00	2.57E+00
% Deposited	6.2%	3.1%	1.0%	1.0%

Thus, these results suggest that somewhere between 1% and about 6% of emitted HTO is re-deposited on the ground in precipitation in the region within 25 miles of LANL across the Rio Grande Valley.

To gain a better understanding of the radiological significance of this H-3 in precipitation, the EPA drinking water limit is 20,000 pCi/liter and corresponds to a radiation dose of about 4 mrem/year. The single **highest** measured annual average concentration in precipitation during 1990-93 was just

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slightly less than 252 pCi/liter (1990 at Philomena's). If water at this concentration were the only water consumed for an entire year, the annual dose would be approximately 0.05 mrem, a trivial fraction of the normal total annual environmental dose of about 350-400 mrem from all sources. The annual Environmental Surveillance Reports for LANL provide a detailed explanation of the total annual environmental dose.

#### **Attachments**

- A. Table 5 of LA-12895-MS
- B. Area Map
- C. New Mexico Precipitation Map

## Comparison of H-3 Deposition in Precipitation to Airborne H-3 Emissions at LANL

### Attachment A

#### Table 5 of LA-12895-MS

Isotopes in Precipitation in the Los Alamos Region, New Mexico  
Weighted Mean Averages by Year

	Del D	Del 180	Tritium	Comments
<b>Santa Fe Airport</b>				
1990	-44.2	-4.41	12.58	
1991	-59.5	-9.07	13.10	
1992	-74.4	-10.59	10.66	
1993	-59.9	-9.17	7.07	1 collection in 1993
Composite Weighted means 1990-1993	-60.7	-8.56		
<b>Tech Area 33</b>				
1990	-64.7	-9.60	40.35	
1991	-77.9	-11.03	34.49	
1992	-65.0	-10.57	37.64	
1993	-80.6	-11.88	20.76	
Composite weighted means 1990-1993	-73.1	-10.99		
<b>Philomena's</b>				
1990	-69.1	-9.47	78.67	
1991	-84.9	-11.89	49.68	
1992	-77.2	-10.82	75.11	
1993	-81.5	-11.85	42.86	
Composite weighted means 1990-1993	-78.6	-11.45		
<b>Pajarito Mtn.</b>				
1990	-73.5	-9.80	22.09	
1991	-66.4	-10.34	10.96	
1992	-85.1	-12.61	16.88	
1993	-87.7	-12.75	16.57	
Composite weighted means 1990-1993	-77.7	-11.21		
<b>S Site</b>				
1990	-75.3	-11.24	28.88	
1991	-76.7	-11.12	20.87	
1992	-70.1	-10.26	30.72	
1993	-82.7	-12.11	14.85	
Composite weighted means 1990-1993	-76.9	-11.26		
<b>White Rock Y</b>				
1990	-64.3	-7.81	77.64	
1991	-80.6	-11.07	25.93	
1992	-80.2	-11.48	31.54	
1993	-81.7	-11.73	22.86	
Composite weighted means 1990-1993	-74.5	-10.46		
<b>Espanola Ranger Station</b>				
1990	-70.5	-9.98	22.30	
1991	-74.2	-9.71	16.26	
1992	-83.6	-11.65	14.09	
1993	-76.4	-10.86	11.29	
Composite weighted means 1990-1993	-76.8	-10.59		
<b>Boundary Peak Area</b>				
1990	-84.1	-9.15	13.61	2 collections in 1990
1991	-69.2	-8.38	15.91	1 collection in 1991
1992	-63.3	-9.26	23.00	1 collection in 1992
1993	-88.1	-12.93	12.97	Last collection of 93 was collected 2/94
Composite weighted means 1990-1993	-77.9	-10.19		



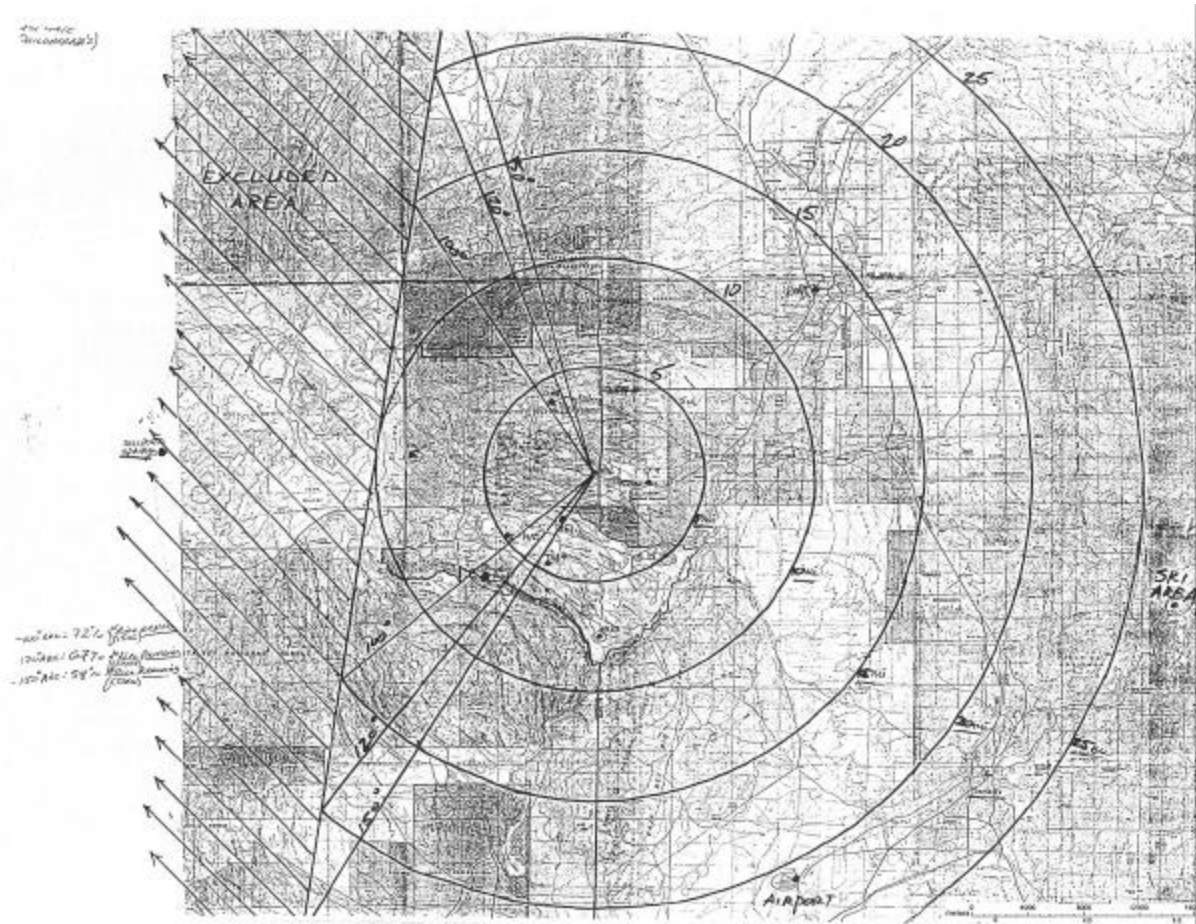
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	Del D	Del 180	Tritium	Comments
<b>West of Guaje Mtn.</b>				
1990	-63.9	-9.82	33.23	2 collections in 1990
1991	-75.8	-10.90	32.36	
1992	-85.4	-12.56	57.72	
1993	-74.5	-10.39	29.01	
Composite weighted means 1990-1993	-74.9	-11.01		
<b>Santa Fe Ski Basin</b>				
1990	-64.1	-9.69	11.82	2 collections in 1990
1991	-87.1	11.79	11.50	
1992	-85.6	-13.21	10.82	
1993	-84.6	-12.05	9.93	
Composite weighted means 1990-1993	-83.2	-12.35		
<b>VC-2B Sulphur Springs</b>				
1990	-66.1	-9.48	7.05	2 collections in 1992
1991	-87.4	-12.44	9.77	
1992	-109.1	-15.69	7.67	
1993	-82.1	-9.76	7.31	
Composite weighted means 1990-1993	-87.7	-12.85		
<b>Tech Area 49</b>				
1990	-55.9	-7.62	29.46	2 collections in 1990
1991	-77.1	-10.85	21.57	
1992	-67.1	-9.84	34.66	2 collections in 1993
1993	-86.9	-12.74	19.38	
Composite weighted means 1990-1993	-74.0	-10.59		
<b>Tech Area 51</b>				
1990	-61.9	-9.42	53.51	2 collections in 1990
1991	-78.9	-11.02	29.69	
1992	-68.8	-10.22	46.56	
1993	-82.2	-11.87	25.40	
Composite weighted means 1990-1993	-75.3	-11.03		
<b>K.M. House</b>				
1991	-72.9	-10.81	32.60	2 collections in 1991
1992	-76.4	-10.85	78.30	
1993	-75.5	-10.91	30.70	
Composite weighted means 1991-1993	-74.8	-10.82		

### Comparison of H-3 Deposition in Precipitation to Airborne H-3 Emissions at LANL

#### Attachment B

#### Area Map



**Comparison of H-3 Deposition in Precipitation to Airborne H-3 Emissions at LANL**

Attachment C

**New Mexico Precipitation Map**

**To view this graphic, please go to the following web site:**

**<http://www.wrcc.dri.edu/pcpn/nm.gif>**