Key Findings of CDC's LAHDRA Project: Early Airborne Plutonium Releases

Thomas Widner, Joseph Shonka, Robert Burns, Jr., Jeffrey Knutsen, James O'Brien

Pioneering Efforts at D Building During World War II

D Building in the Original Technical Area at the Manhattan Project's "Site Y" (now called Los Alamos National Laboratory, LANL) was the first site in the world in which plutonium was handled in visible quantities, purified, converted to metal, and used to fabricate atomic weapon parts. Starting in 1943, scientists and engineers in D Building (Figure 1), used equipment and procedures that are considered extremely crude by modern-day standards to process the new and largely unknown element plutonium under demanding schedules and extreme wartime pressures. Progress reports indicate that D Building and its roof became highly contaminated, and about 85 rooftop vents released contaminated air without monitoring and for the most part with no filtration. A former Los Alamos plutonium worker wrote that "During the War years, partly because of ignorance and partly because of the stress of wartime conditions, operations with plutonium in D Building were conducted with greater laxity than has ever been tolerated since" and "D Building was known to be hotter than a firecracker" (Coffinberry, 1961). There are no records or LANL estimates of airborne plutonium releases from D Building, which ceased main plutonium production functions when DP West site became operational in late 1945 but remained active until around 1953.

Fig. 1. Late-1940s photograph of D Building, the first facility in the world to handle plutonium in visible quantities, purify it, convert it to metal, and make atomic weapon parts. Approximately 85 rooftop vents were unmonitored and largely unfiltered.

DP West Site Takes Over Plutonium Production

DP West site (Figure 2) began processing plutonium and producing weapon components in late 1945. DP West Site's central effluent treatment facilities located in Building 12 (Figure 3) included precipitators and filters, but they were considerably less effective than modern-day high efficiency particulate air (HEPA) filters. Airborne radioactivity was sampled from the four Building 12 stacks and analyzed to quantify releases, but not all stacks were sampled over all periods of operation. For years, stack sampling was performed using modified "Filter Queen" vacuum cleaners like the one shown in Figure 4.

Fig. 2. DP West Site at what became known as TA-21 took over plutonium production late in 1945. Process exhaust from Buildings 2, 3, 4, and 5 was collected, treated, sampled, and released via four main stacks at Building 12.

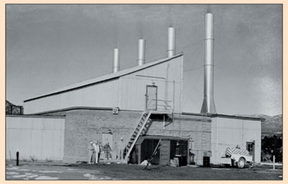


Fig. 3. Building 12 at DP West Site contained central effluent treatment components including crude precipitators and filters.

Fig. 4. A modified "Filter Queen" vacuum cleaner used for stack sampling at DP West Site at Los Alamos.

Official Release Estimates Issued in the 1970s

In its 1979 Final Environmental Impact Statement (FEIS), LANL indicated that 1.2 Ci of ^{239}Pu had been released from site activities through 1972 (USDOE, 1979). That estimate included no contribution from D Building or from DP West operations before 1948, periods during which LANL was the nation's sole manufacturer of plutonium cores for atomic weapons. In a 1975 publication, the 1.2 Ci release total was attributed to the DP West stacks alone (Maraman et al., 1975).

Addressing the Data Gaps for Plutonium Releases

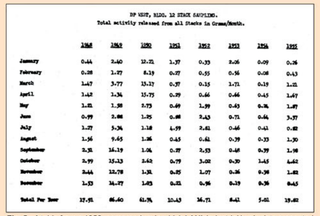
With no plutonium release estimates available for years before 1948, the LAHDRA team used several approaches to gain information about how high releases could have been during the periods when effluent monitoring was not performed or was incomplete. These approaches included:

- Evaluation of historical measurements of plutonium in soil samples collected around Los Alamos to "back calculate" how much would have to have been released to match the "environmental record" remaining in soils.
- Examination of a rarely available dataset of measurements of plutonium in human tissue samples collected at autopsy from 236 people who lived in Los Alamos. Residential histories can in most cases be determined from public records.
- Estimation of releases of plutonium from the chemical processing performed in D Building using a process adopted by the Department of Energy. Release fractions derived from relevant research are assigned to each identified release mechanism.
- Analysis of measurements of airborne radioactivity inside D Building to estimate, with knowledge of the ventilation system, quantities that could have been released to the environment.

LAHDRA Team Adjusts Release Estimates Based on Historical Information

Airborne plutonium release estimates for 1948–55 reported by LANL were adjusted upward by the LAHDRA team (by roughly a factor of 20) to agree with results of a study conducted by the LANL industrial hygiene group in 1955 and 1956 (Hyatt, 1956). In that study, improved, isokinetic stack sampling systems were operated alongside the original systems (Hyatt, 1955). After six months of sampling, results were compared and correction factors were applied to releases previously reported for 1948-55. Past that point, the improved sampling system was used. In several memoranda issued in 1956, monthly quantities of plutonium released from DP West Site's Building 12 stacks were documented for 1948–55 (Figure 5). The total release of 227 g documented in those memos corresponds (using a specific activity value of 0.063 alpha Ci g^{-1}) to the release of 14 Ci over those eight years.

All release estimate values for 1948 through 1975 were adjusted upward further by the LAHDRA team using a sample line loss correction factor equal to 5 for 1945-58 and 2 for 1959-75 based on analyses performed by LANL staff (Fuehne, 2008). That factor was reduced after 1958 because a single stage of HEPA filters was added to the combined process exhaust system at DP West in 1959 (Maraman et al., 1975), and the particle size distribution in that exhaust stream likely shifted toward smaller particles.



DP WEST, BLDG. 12 STACK EFFLUENT.
Total activity released from all Stacks in Curies/Month.

	1948	1949	1950	1951	1952	1953	1954	1955
January	0.44	2.40	12.21	1.37	0.33	2.06	0.09	0.26
February	0.28	1.77	8.13	0.77	0.53	0.56	0.08	0.43
March	1.47	3.77	13.13	0.37	0.13	1.71	0.19	1.21
April	1.42	3.34	15.73	0.39	0.46	0.46	0.43	1.47
May	1.21	1.38	3.73	0.49	1.39	0.43	0.34	1.49
June	0.99	2.86	1.75	0.88	3.43	0.71	0.44	3.37
July	1.27	3.34	1.18	1.99	2.81	0.46	0.41	0.88
August	1.36	9.45	1.86	0.43	0.81	0.39	0.33	1.30
September	3.31	14.19	1.04	0.37	3.33	0.48	0.37	1.38
October	3.99	13.13	2.63	0.79	3.08	0.30	1.45	4.42
November	3.44	13.78	1.31	0.35	1.07	0.36	0.36	1.88
December	1.33	14.77	1.83	0.31	0.96	0.29	0.36	0.45
Total Per Year	17.91	86.40	64.74	10.43	18.71	8.41	5.05	18.48

Fig. 5. A table from a 1956 memorandum in which LANL industrial hygienists presented revised airborne alpha radioactivity release estimates Building 12 stacks for 1948-55.

A filter burial correction factor of 2.33 was also applied to plutonium release totals reported by LANL for 1948-75 based on assessments performed by LANL staff (Fuehne, 2008). When the line loss and filter paper burial factors are applied, the release becomes 170 Ci over that period (8 of the 34 y of DP West site operations) from the Building 12 stacks alone.

Components of Site-Total Airborne Plutonium Releases

To evaluate the potential overall effects of airborne plutonium releases at Los Alamos, one must consider what sources have contributed to site-total plutonium releases since LANL became operational. Plutonium emission sources that could have been significant include those listed in Figure 6. Accidents have been important contributors to site total releases at a number of weapons complex sites, including the Rocky Flats Plant. Accidental releases that occurred at Los Alamos but have not been closely evaluated include burial ground fires, such as a major fire that occurred in a radioactive waste burial ground near DP West Site in 1946.

If one looks at how many of these components of the site total release are reflected in the release estimate that is based on the data from the 1956 memos, as depicted in Figure 7, one sees that most of the components of the actual site total release are not included in the 170 Ci release estimate that is based on the work of Hyatt. In fact, only one source is included— DP West Site Building 12 stacks— and even that source for only 8 of the 34 years of operations at DP West Site.

D Building Stacks 1944-53	DP Site Building 12 Stacks
DP Site Building Vents	Accidents and Incidents
CMR Building Exhausts (chemistry/metallurgy 1953+)	Burial ground fires
Waste Disposal: (burial, incinerators, etc.)	TA-55 releases (modern Pu facility, 1978+)

Fig. 6. Key components of site-total airborne plutonium releases from Los Alamos.

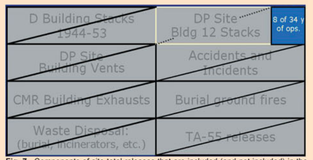


Fig. 7. Components of site-total releases that are included (and not included) in the 170-Ci release estimate based on the work by Hyatt et al.

Putting LANL Releases in Perspective

If a site total release estimate were generated for LANL that included all sources and all years of operations, the value would likely climb well above 170 Ci. If one considers the releases that have been independently reconstructed for the main DOE plants that produced or processed plutonium (Rocky Flats, Hanford, and Savannah River), one sees that releases from Los Alamos could have easily exceeded the total from the three major production plants combined. Releases from these production plants total to approximately 39 Ci; while Los Alamos, which has often said "we were not a production facility," based on their own records, released 170 Ci from one building alone, during 8 of the 34 years of operation of the DP West facility.

A Reason for Concern– Residents Lived Particularly Close to Operational Areas

One reason that releases of this magnitude have particularly caught the attention of the LAHDRA team is that they happened with people living much closer to Los Alamos operations than at any other DOE site. Figure 8 shows a portion of the Original Technical Area with Sundt Apartment residences just across the street, separated by about 200 m from D Building and as little as 50 m from other production facilities. Figure 9 shows DP West Site and several housing areas that were built nearby. Of particular importance is a trailer park (Figure 10) that was built 1 km west of the Building 12 stacks. As shown in Figure 11, residents at this trailer park could also have been exposed to effluents from the reactors operated at Omega Site in the canyon just below where they lived.

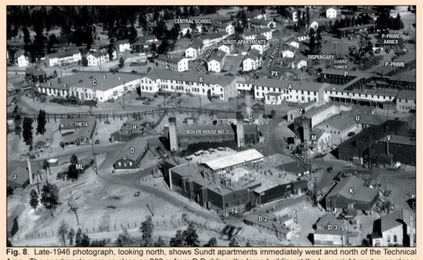


Fig. 8. Late-1946 photograph, looking north, shows Sundt apartments immediately west and north of the Technical Area. The apartments were as close as 200 m from D Building, the large building at the lower right, and even closer to C Building, which housed machine shops for uranium and other materials.

Fig. 9. Modern-day photograph of DP West Site (Technical Area 21) with overlaid drawing of a trailer park that was located 1 km to the west.

Fig. 10. The trailer park located 1 km west of the DP West Building 12.

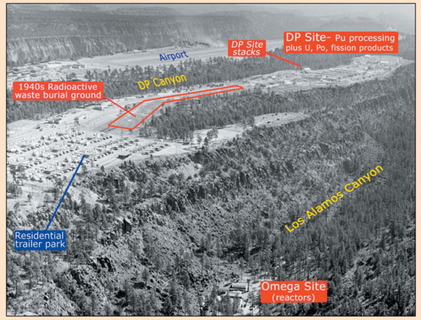


Fig. 11. View of the trailer park south of DP Road, a nearby radioactive waste burial ground, DP West Site, and Omega Site.

Preliminary Screening Performed for Building 12 Emissions in 1949

Because airborne plutonium releases from DP West Site were documented to have been significantly higher than officially reported, a screening assessment using the methodology of National Council on Radiation Protection and Measurements (NCRP) Report No. 123 (NCRP, 1996) was performed for releases from DP West Site Building 12 stacks during 1949, the apparent year of peak emissions. Methods of the three levels of screening that were performed are briefly described in Table 1. Level I screening uses the simplest approach and incorporates a high degree of conservatism to avoid underestimating doses to people. Screening values were calculated for residents at the trailer park located 1 km west of the Building 12 stacks. Level II screening more rigorously accounts for dispersion in the atmosphere and combines all significant pathways into a single screening factor. In Level III screening, which includes more definitive pathways analysis, the assessment included potential intakes from vegetable consumption based on historical documents and interviews with residents that indicated that residents were allowed to maintain vegetable gardens after World War II, including at the trailer park west of DP Site.

Results and Conclusions

The results of preliminary screening of airborne ^{239}Pu releases from DP West site Building 12 stacks during 1949 are presented in Table 1. In Level I and Level II screening, the screening value exceeded the limiting value (based on 1 in 100,000 added cancer risk) by at least four orders of magnitude, prompting application of the screening methodology at the next highest level. The results of the screening calculations are strictly for comparison with an environmental standard (limiting value), in order to determine if compliance with that standard is assured or if further investigation is warranted. The screening values are not intended to represent estimates of actual doses to individuals.

The results of Level III screening, which again exceeded the limiting value by over four orders of magnitude, indicate that airborne ^{239}Pu releases from Building 12 stacks– as represented by estimated releases during 1949– warrant further evaluation by experts in environmental radiological assessment.

Table 1. Results of Preliminary Screening of Airborne ^{239}Pu Releases from DP West Site Building 12 Stacks During 1949 Using the Methodology of NCRP Report No. 123

Level of Screening	Features of Screening Methodology	Screening Value (Sv y^{-1})	Screening Limit exceeded?	NCRP Guidance
I	Vent air, all pathways, concentration at exposure point set equal to 25% of stack concentration.	310	Yes	Proceed to Level II
II	Vent air, all pathways, Gaussian plume modeling to exposure point outside near-wake region, wind blows toward exposure point 25% of the time.	0.37	Yes	Proceed to Level III
III	Vent air, specific pathways (inhalation, external exposure, consumption of vegetables), same dispersion assumptions as Level II.	0.37	Yes	"Seek assistance from experts in environmental radiological assessment"

References

Coffinberry, A.S., 1961, Later plutonium metallurgical research at Los Alamos, *in* Coffinberry, A.S., and Miner, W.N., eds., The Metal Plutonium, University of Chicago.
Fuehne, D.P., 2008, Personal communication with David P. Fuehne of LANL Meteorology & Air Quality Group, 2008.
Hyatt, E.C., 1955, Total Activity Released from D.P. West Stacks, Los Alamos Scientific Laboratory.
—, 1956, Total alpha activity released from DP West stacks, Bldg. 12 from 1948 through 1955 (memorandum to Dean D. Meyer), Los Alamos Scientific Laboratory, p. 2.
Maraman, W.J., McNeese, W.D., and Stafford, R.G., 1975, Plutonium–health implications for man. Confinement facilities for handling plutonium: Health Phys, v. 29, p. 469-80.
NCRP, 1996, Screening Models for Releases of Radionuclides to Atmosphere, Surface Water, and Ground: Bethesda, MD, National Council on Radiation Protection and Measurements.
USDOE, 1979, Final environmental impact statement, Los Alamos Scientific Laboratory site, Los Alamos, New Mexico: Washington, DC, U.S. Department of Energy.

ChemRisk®
Shonka Research Associates
NGTS Incorporated
ENSR International