# NEW MEXICO ENVIRONMENT DEPARTMENT RADIONUCLIDE BACKGROUND STUDY IN NORTHERN NEW MEXICO SOILS

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In Fall 1999, the New Mexico Environment Department (NMED), Department of Energy Oversight Bureau (the Bureau) began a study to develop and compare background reference values for radionuclide concentrations in northern New Mexico soils to those developed by the Los Alamos National Laboratory's (LANL) environmental surveillance program. Background reference values for radionuclides are often used to determine whether impacts exist from past or present LANL operations.

We collected 39 soil samples and had them analyzed for strontium$^{90}$, plutonium$^{238}$, plutonium$^{239/240}$, americium$^{241}$, cesium$^{137}$, and uranium isotopes 234, 235, and 238. Reference values were determined at a 95% confidence level using multiple statistical methods and compared to the 2001 LANL Regional Statistical Reference Levels (RSRLs). We also examined the data for correlations to elevation and regions.

Both local and global fallout contribute to the radionuclide inventory in northern New Mexico. Local fallout is generated by LANL operational releases, including stack emissions, open-detonation testing, and wind re-suspension of contaminated soils. Local fallout began at LANL in the mid 1940s as part of research to produce an atomic weapon.

Global fallout originates through dispersion of radionuclides into the atmosphere from above-ground nuclear weapons testing, reactor accidents, and earth re-entry of plutonium-fueled satellites following orbit failure. The National Resources Defense Council reported that from 1945 to 1980 the U.S.A., Soviet Union, Great Britain, France, and China had conducted 528 atmospheric nuclear tests, not including two explosions over Japan that led to the end of World War II. After 1963, when the Limited Test Ban Treaty was signed, testing for the U.S., Soviet Union, and Great Britain moved underground. France continued atmospheric testing until 1974 and China did so until 1980 (http://www.nrdc.org/nuclear/nudb/datab15.asp).

Atmospheric fallout occurs within days to years of detonation. Larger particles ranging in size from 100 to 200 microns fall to the earth locally within days. Particles smaller than 100 microns are ejected to greater altitudes, distributed more widely, and take months to fall back to earth. Particles less than 10 microns take years before deposition and are distributed throughout the entire hemisphere (Graf, 1993). Between 1951 and 1962, 126 atmospheric tests were conducted at the Nevada Test Site (NTS, http://www.atomictourist.com/nts.htm). Early fallout from open air testing at NTS probably reached the San Juan Mountains and the Rio Grande watershed in northwest New Mexico and southwest Colorado, and was probably greatest in the 1960s. Tests were conducted only when westerly or southerly wind patterns existed.

Graf (1993) described fallout contaminant transport rates from soils to fluvial sediments. He pointed out that inputs to the Rio Grande surficial sediments were greatest during the late 1950s and 1960s, and probably peaked during 1954 to 1967. Once the fallout contaminants reached the surface they bound to soil particles to eventually be delivered to river systems, relatively quickly after fallout occurs and at lower rates in later years.

McLin and Lyons (2002) revised background levels for sediments in their report from those previously used by LANL. Review of their data for reservoir sediment subgroups demonstrates a much smaller plutonium contribution from fallout in the Chama watershed than the upper Rio Grande watershed. These subgroups include samples from Heron and Abiquiu Reservoirs on the Rio Chama and the Rio Grande and Lowe Reservoirs on the upper Rio Grande.

The Rio Chama and upper Rio Grande subgroups reflect regional conditions, although plutonium$^{239/240}$ values for reservoirs on the upper Rio Grande, averaging 0.017 pCi/g, are almost three times more than reservoirs on the Rio Chama, which average 0.006 pCi/g. This probably reflects a difference in global fallout rates in these two regions. The upper Rio Grande reservoir sediments originate at higher elevations in southern Colorado and are from more northerly latitudes. They receive sediments from watersheds containing the continental divide with elevations that exceed 13,000 ft, and are in a more direct down-wind path of NTS.

A river station on the Rio Chama at Chamita from the McLin and Lyons (2002) report, supports this suggestion. The average of 26 plutonium measurements in river sediments at Chamita from 1974 to 1997 is 0.001 pCi/g, similar to the 0.007 pCi/g average from 73 samples collected in reservoirs on the Chama during the same period.

To identify potential impacts from LANL above the input from nuclear atmospheric testing, radionuclide measurements in soils are compared to LANL's RSRLs. RSRLs are the upper-level background concentration (mean plus 2 standard deviations) for radionuclides calculated from soil data collected from three regional background locations away from the influence of the Laboratory over the preceding five years (Environmental Surveillance Program, 2001). If a radionuclide measurement in a soil sample exceeds its RSRL, assumptions might be made that the contaminant originated from the Laboratory.

Our objective was to assess the validity of the RSRLs developed by LANL from only three locations. The RSRL is a statistical value that includes data variability that originates from sampling, analytical measurement, and the environment. They reflect the largest probable measurements that might be measured at 95% confidence levels from an environment not impacted by Laboratory operations. Using consistent sampling methods and requiring analytical quality control methods we attempted to limit and understand the variability associated with only global fallout to the environment in northern New Mexico.

The sites selected for this study comprised three components. First, the Fall 1999 selection of sampling locations was based on Miller et al. (1993). We selected 15 sites that demonstrated similar terrestrial ecosystem properties, such as climate, soil type, geology, vegetation, topography, and sun aspect in the Jemez Mountains. By selecting sites similar in terrestrial nature, we attempted to eliminate potential data variability associated with the environment. Second, during Summer 2000 the Bureau was asked to evaluate the potential impacts to northern New Mexico farm soils from deposition of smoke particles and ash from the May 2000 Cerro Grande fire. We selected 21 sites in a northeasterly direction from LANL from undisturbed soils at farms and garden plots. Third, in December 2001 we collected three soil samples within the Jemez Mountains in conjunction with Jemez Pueblo to determine potential impacts from LANL on lands used by them.

We found that the farm soil measurements were generally lower than the Jemez data group but not statistically significant. Our assessments suggest the differences may be associated with elevation and naturally occurring uranium content. The farm soils were at lower elevations than the Jemez locations. Table 1 includes the summary statistics and their relation to RSRLs produced by LANL. While the statistical evaluation is incomplete, it appears the data are similar and the differences may be associated with natural variations in the environment such as elevation or the natural occurrence of the uranium element, except potentially cesium$^{137}$ and strontium$^{90}$. The LANL cesium$^{137}$ values are one third of those reported by NMED, while LANL strontium$^{90}$ values appear to be twice as much NMED's.

TABLE 1. Descriptive statistics of radiochemical results for combined Jemez Mountains and northern New Mexico farm soils.

| | $Pu^{238}$ | | | $Pu^{239/240}$ | | | $Am^{241}$ | | | $Sr^{90}$ | | | $Cs^{137}$ | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Reported** | **2 sigma TPU** | **MDC** | **Reported** | **2 sigma TPU** | **MDC** | **Reported** | **2 sigma TPU** | **MDC** | **Reported** | **2 sigma TPU** | **MDC** | **Reported** | **2 sigma TPU** | **MDC** |
| Count | 39 | 39 | 39 | 39 | 39 | 39 | 39 | 39 | 39 | 39 | 39 | 39 | 19 | 19 | 19 |
| Standard deviation | 0.003 | 0.002 | 0.005 | 0.012 | 0.002 | 0.003 | 0.004 | 0.003 | 0.003 | 0.17 | 0.02 | 0.05 | 0.41 | 0.08 | 0.06 |
| Mean | 0.001 | 0.003 | 0.005 | 0.016 | 0.005 | 0.003 | 0.007 | 0.005 | 0.005 | 0.17 | 0.21 | 0.35 | 0.80 | 0.19 | 0.10 |
| Median | 0.001 | 0.002 | 0.003 | 0.012 | 0.005 | 0.002 | 0.006 | 0.005 | 0.003 | 0.14 | 0.22 | 0.35 | 0.59 | 0.19 | 0.08 |
| Upper 95% confidence level of mean | 0.002 | | | 0.020 | | | 0.009 | | | 0.22 | | | 0.98 | | |
| 0.95 percentile | 0.004 | | | 0.038 | | | 0.015 | | | 0.46 | | | 1.39 | | |
| UTL (0.95, 0.95) | 0.006 | | | 0.042 | | | 0.016 | | | 0.54 | | | 1.69 | | |
| NMED (mean + 2*sd) | 0.006 | | | 0.040 | | | 0.016 | | | 0.51 | | | 1.62 | | |
| LANL 2001 RSRL (mean + 2 sd) | 0.009 | | | 0.021 | | | 0.012 | | | 0.98 | | | 0.49 | | |

| | $U^{234}$ | | | $U^{235}$ | | | $U^{238}$ | | | **Total U** | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Reported** | **2 sigma TPU** | **MDC** | **Reported** | **2 sigma TPU** | **MDC** | **Reported** | **2 sigma TPU** | **MDC** | **Reported** | **MDC** |
| Count | 39 | 39 | 39 | 39 | 39 | 39 | 39 | 39 | 39 | 39 | 39 |
| Standard deviation | 0.35 | 0.05 | 0.06 | 0.06 | 0.01 | 0.01 | 0.32 | 0.17 | 0.01 | 0.96 | 0.50 |
| Mean | 0.93 | 0.16 | 0.03 | 0.09 | 0.03 | 0.02 | 0.95 | 0.18 | 0.02 | 2.88 | 0.55 |
| Median | 0.94 | 0.15 | 0.02 | 0.08 | 0.03 | 0.02 | 0.94 | 0.15 | 0.01 | 2.81 | 0.49 |
| Upper 95% confidence level of mean | 1.04 | | | 0.11 | | | 1.05 | | | 3.18 | |
| 0.95 percentile | 1.44 | | | 0.24 | | | 1.44 | | | 4.33 | |
| UTL (0.95, 0.95) | 1.69 | | | 0.23 | | | 1.63 | | | 4.95 | |
| NMED (mean + 2*sd) | 1.63 | | | 0.22 | | | 1.58 | | | 4.80 | |
| LANL 2001 RSRL (mean + 2 sd) | 0.85 | | | 0.09 | | | 0.93 | | | 3.12 | |

TPU = Total Propagated Uncertainty
MDC = Minimum Concentration
sd = Standard Deviation

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