 EMSL-LV-0539-13

# FRUIT AND VEGETABLE RADIOACTIVITY SURVEY, NEVADA TEST SITE ENVIRONS

by
Monitoring Operations Division
Environmental Monitoring and Support Laboratory

U.S. ENVIRONMENTAL PROTECTION AGENCY
Las Vegas, Nevada 89114

Published April 1978

This surveillance performed under a Memorandum of
Understanding No. EY-76-A-08-0539
for the
U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

## DISCLAIMER

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Energy Research and Development Administration, nor any of their employees, nor any of their contractors, subcontractors, or their employees, make any warranty, express or implied, or assume any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product or process disclosed, or represent that its use would not infringe privately-owned rights.

This document is available to the public through the National Technical Information Service, U.S. Department of Commerce, Springfield, Virginia 22161.

PRICE: PAPER COPY $4.00 MICROFICHE $3.00

 EMSL-LV-0539-13

# FRUIT AND VEGETABLE RADIOACTIVITY SURVEY, NEVADA TEST SITE ENVIRONS

by
Vernon E. Andrews and Jack C. Vandervort
Monitoring Operations Division
Environmental Monitoring and Support Laboratory

U. S. ENVIRONMENTAL PROTECTION AGENCY
Las Vegas, Nevada 89114

Published April 1978

This surveillance performed under a Memorandum of
Understanding No. EY-76-A-08-0539
for the
U. S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

Effective October 1, 1977, the U.S. Energy Research and Development Administration was designated the U.S. Department of Energy. Prior to January 19, 1975, the U.S. Energy Research and Development Administration was designated as the U.S. Atomic Energy Commission.

## ABSTRACT

During the 1974 growing season, the Environmental Monitoring and Support Laboratory-Las Vegas, of the U.S. Environmental Protection Agency, collected samples of fruits and vegetables grown in the off-site area surrounding the Nevada Test Site. The objective was to estimate the potential radiological dose to off-site residents from consumption of locally grown foodstuffs. Irrigation water and soil were collected from the gardens and orchards sampled. Soil concentrations of cesium-137 and plutonium-239 reflected the effects of close-in fallout from nuclear testing at the Nevada Test Site. The only radionuclide measured in fruit and vegetable samples which might be related to such fallout was strontium-90, for which the first year estimated dose to bone marrow of an adult with an assumed rate of consumption of the food would be 0.14 millirad.

CONTENTS

## LIST OF FIGURES



## LIST OF TABLES

ACKNOWLEDGMENTS

We are indebted to, and gratefully acknowledge the support of, the many off-site residents for their enthusiastic support of this study. As anyone who has ever gardened in the desert can testify, it is not without personal sacrifice that these people have provided samples of several kilograms each of their produce. Without their participation the study would not have been possible.

## INTRODUCTION

When the decision was made in December 1950 to use the area now known as the Nevada Test Site (NTS) for relatively low yield atmospheric nuclear detonations, the most important factor considered was public safety. The low population density existing at that time has changed little in 25 years. Outside of the metropolitan Las Vegas complex southeast of the NTS, the sparse population is located in a few small towns and on widely scattered ranches.

With the NTS off-site area composed primarily of Basin Range Desert and Mojave Desert systems, truck farming is almost nonexistent and only a few small dairies are operated. The majority of the foodstuffs consumed are produced well outside the immediate off-site area and so are unaffected by close-in fallout from nuclear testing at the NTS. However, a number of families in the area maintain milk cows for family use and grow home gardens.

From January 1951 until the moratorium on nuclear weapons testing which began in October 1958, atmospheric nuclear testing resulted in the deposition of fallout radioactivity in most of the off-site area. Since nuclear testing resumed in September 1961, all detonations have been underground except for the four small atmospheric tests of Dominic II in 1962. Occasional accidental releases from underground tests have occurred and several planned small releases of radioactivity resulted from Plowshare cratering experiments. Because of pre-shot safety planning, the majority of the fallout was deposited in unpopulated or sparsely populated areas.

The off-site radiological safety program, conducted first by the U.S. Public Health Service and later by the U.S. Environmental Protection Agency (EPA) through the Environmental Monitoring and Support Laboratory in Las Vegas (EMSL-LV), has monitored public radiation exposure since 1954. Steps have been taken, when necessary, to reduce exposures to the residents. Monitoring emphasis has been on measurement of airborne radioactivity, whole-body external gamma exposure, and measurement of radionuclides in milk and water. Occasional samples of locally grown produce indicated that it contributed a negligible fraction of the radiation dose to the off-site residents.

With the success in controlling releases of radioactivity from the NTS since January 1971, it was believed that the majority of radiation exposure levels above background would be due to fallout deposited prior to that time. The possibility existed that uptake of old fallout by locally grown crops might contribute to a measurable portion of the current population dose. It was decided, therefore, to conduct a one-time intensive survey of radioactivity levels in locally grown fruits and vegetables during 1974 to assess the potential contribution of these foods to the radiation dose.

The plan was to collect samples of edible root crops, leafy vegetables, grains, and fruits, plus garden soil and irrigation water. Prior to the 1974 growing season, off-site residents were contacted to determine gardening practices and arrange for collection of sufficient sample material for meaningful analyses. In some cases, additional plantings were necessary to provide enough of a given crop. In all cases, excellent cooperation was given by the off-site residents contacted, and without their assistance the project could not have been carried out.

The intent was to perform a general analysis for gamma-emitting radionuclides plus radiochemical analyses for isotopes of strontium and plutonium, iron-55 ($^{55}Fe$), and tritium on selected samples. Because of unexpected analytical problems, plutonium and $^{55}Fe$ results for fruits and vegetables are not included in this report.

This report describes the sampling and analytical procedures used, the results of sample analysis, and the conclusions reached on the basis of those results.

## SAMPLE COLLECTION

### SAMPLING METHODS

Crops from selected gardens and orchards in the off-site area were hand-picked by EPA representatives. In general, all samples were logged and tagged in the field at the time of collection. Although the actual sample sizes varied slightly, based upon availability at some locations, an attempt was made to obtain 4 kilograms (kg) of each crop sampled. Root crops were collected by removing the portion above ground with clippers or knife and removing the root and its surrounding soil with a coring tool. After separating the soil from the root, the root and soil were bagged separately. When it was not possible to collect sufficient root or leaf crop sample of one type, composites of two similar crops were collected. Sweet corn was shucked in the field. Fruit crops were picked at random from the applicable orchards. Crop irrigation water was collected at the point of distribution in 4-litre containers. Surface soil samples were also collected in gardens and orchards using a 10- by 10- by 5-centimetre (cm) deep scoop. Duplicate soil samples were collected at 10 locations to assess the variability in soil sampling. Alfalfa was collected as a reference crop at the six sampling locations where it was grown.

### SAMPLE LOCATIONS

Samples were collected from 26 home gardens and orchards representing 19 areas. Multiple sites were sampled in some areas to obtain as wide a variety of sample types as possible. In many areas represented by only a single-family ranch, prior contact with the residents made it possible to assure planting of most vegetable types of interest or planting of a sufficient quantity of each type to permit sampling. Sampling locations and types of samples collected at each location in the NTS off-site area are listed in Table 1. Azimuths and distances are measured from the NTS Control Point (CP). The CP is located near the geographic center of the atmospheric test areas. The locations are plotted in Figure 1, keyed to Table 1 by sampling location number. As shown in Figure 1, the majority of the sampling locations are in the northeast quadrant. Sampling was concentrated in that area because it had most often been downwind from nuclear tests at the NTS. Also, beyond the California border to the southwest lie Death Valley and the Panamint Range where no known gardening is practiced.

During the sample collection period in the off-site area, background vegetable and fruit samples, representing worldwide fallout, were purchased from a retail supermarket in Las Vegas. The sample types and origins are listed in Table 2. Figure 2 shows the approximate origins of the background samples.

## SAMPLE ANALYSIS

### ANALYTICAL PROCEDURES

Because the interest of the project was to assess the potential for ingestion of radionuclides in the locally grown produce, the food samples were prepared for analysis as they would have been in the kitchen. In general, samples were washed, peeled when appropriate, and allowed to dry. Corn was cut from the cob before analysis.

All samples--food, water, and soil--were initially analyzed for gamma-emitting nuclides by gamma spectroscopy using a 10.2- by 10.2-cm thallium-activated sodium iodide crystal and 400-channel pulse height analyzer.

Moisture was removed from fruit and vegetable samples by freeze drying. The recovered water from 25 off-site samples and 10 background samples was distilled and analyzed for tritium ($^{3}H$) by liquid scintillation. The dried samples were analyzed for strontium-89 and -90 ($^{89,90}Sr$) and plutonium-238 and -239 ($^{238,239}Pu$).

Soil samples were dried in air and analyzed for gamma-emitting radionuclides on a gamma spectrometer. The samples were screened to 10-mesh (2-millimetre screen opening) and oven dried. A 10-gram (g) aliquot of the fraction passing the 10-mesh screen was analyzed for $^{238,239}Pu$, a 1-g aliquot was analyzed for $^{89,90}Sr$, and eight samples were analyzed for $^{55}Fe$ using either a 1-g or 10-g aliquot. The potassium (K) content was determined from the naturally occurring $^{40}K$ by gamma spectroscopy.

After the water samples had been gamma scanned, a 200-millilitre (ml) aliquot was removed and evaporated to dryness. The residue was counted on a low-background, thin-window, gas-flow proportional counter for gross alpha and gross beta radioactivity. A 5-ml aliquot of water was distilled and counted in a liquid scintillation counter for $^{3}H$. In several cases a 250-ml aliquot was concentrated by electrolysis to enrich the sample in $^{3}H$ and counted by liquid scintillation for $^{3}H$. In the first method the detection limit was about 300 picocuries per litre (pCi/l). By the enrichment method the detection limit was about 7 pCi/l.

### ANALYTICAL RESULTS

#### SOIL SAMPLES

Results of all soil sample analyses are listed in Appendix 1. Because of unexpected analytical difficulties, only eight samples were analyzed for $^{55}Fe$. On the initial analysis using 1 g of soil, all results were below the detection limit of 4 pCi/g. Four of these samples, from Alamo (locations 1 and 2), Hiko (13), and Lathrop Wells (15), were reanalyzed using 10 g of soil. Samples 1 and 2 contained 0.7 and 0.6 pCi/g, respectively. The others were below the detectable limit of 0.5 pCi/g.

TABLE 1. SAMPLE COLLECTION SUMMARY

| NO. | LOCATION (Nevada) | AZIMUTH, DISTANCE (Deg. km)[a] | SAMPLE | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | SOIL | | PLANT | | | | |
| | | | Water | Garden | Orchard | Leaf | Root | Seed | Fruit | Alfalfa |
| 1 | Alamo | 058°, 92 | X | X | X | | X | X | | |
| 2 | Alamo | 058°, 92 | X | X | | X | | | | |
| 3 | Alamo | 058°, 92 | X | | X | | | | X | |
| 4 | Ash Springs | 052°, 95 | X | D | | X | | | | |
| 5 | Ash Springs | 052°, 95 | X | X | | | X | | | |
| 6 | Ash Springs | 052°, 95 | X | | X | | | | X | |
| 7 | Adaven | 018°, 138 | X | X | X | X | X | X | X | X |
| 8 | Beatty | 267°, 61 | X | D | X | X | X | X | X | |
| 9 | Clark Station | 340°, 138 | X | X | | | X | | | |
| 10 | Currant | 015°, 182 | X | D | X | X | X | X | X | |
| 11 | Goldfield | 307°, 137 | X | X | | X | X | X | | |
| 12 | Hiko | 045°, 105 | X | X | | X | X | X | | |
| 13 | Hiko | 045°, 105 | X | X | D | | | | X | |
| 14 | Indian Springs | 138°, 61 | X | X | X | X | X | X | X | |
| 15 | Lathrop Wells | 223°, 53 | X | X | X | X | X | | X | |
| 16 | Logandale | 106°, 145 | X | | X | | | | X | |
| 17 | Nyala | 016°, 177 | X | X | X | X | X | X | X | X |
| 18 | Nyala | 012°, 148 | X | D | X | X | X | X | X | X |
| 19 | Overton | 109°, 156 | X | X | | X | | | X | |
| 20 | Pahrump | 170°, 88 | X | D | X | X | X | X | X | |
| 21 | Pahrump | 175°, 72 | X | X | X | | X | X | X | X |
| 22 | Scotty's Jct. | 288°, 72 | X | D | | X | X | | | |
| 23 | Springdale | 280°, 60 | X | D | X | X | X | X | X | X |
| 24 | Sunnyside | 027°, 175 | X | X | | X | X | X | | X |
| 25 | Tonopah | 318°, 164 | X | D | | X | X | X | | |
| 26 | Warm Springs | 350°, 175 | X | D | X | | X | | X | |

[a] Azimuth and distance from Nevada Test Site Control Point (CP).

D = Duplicate sample collected.

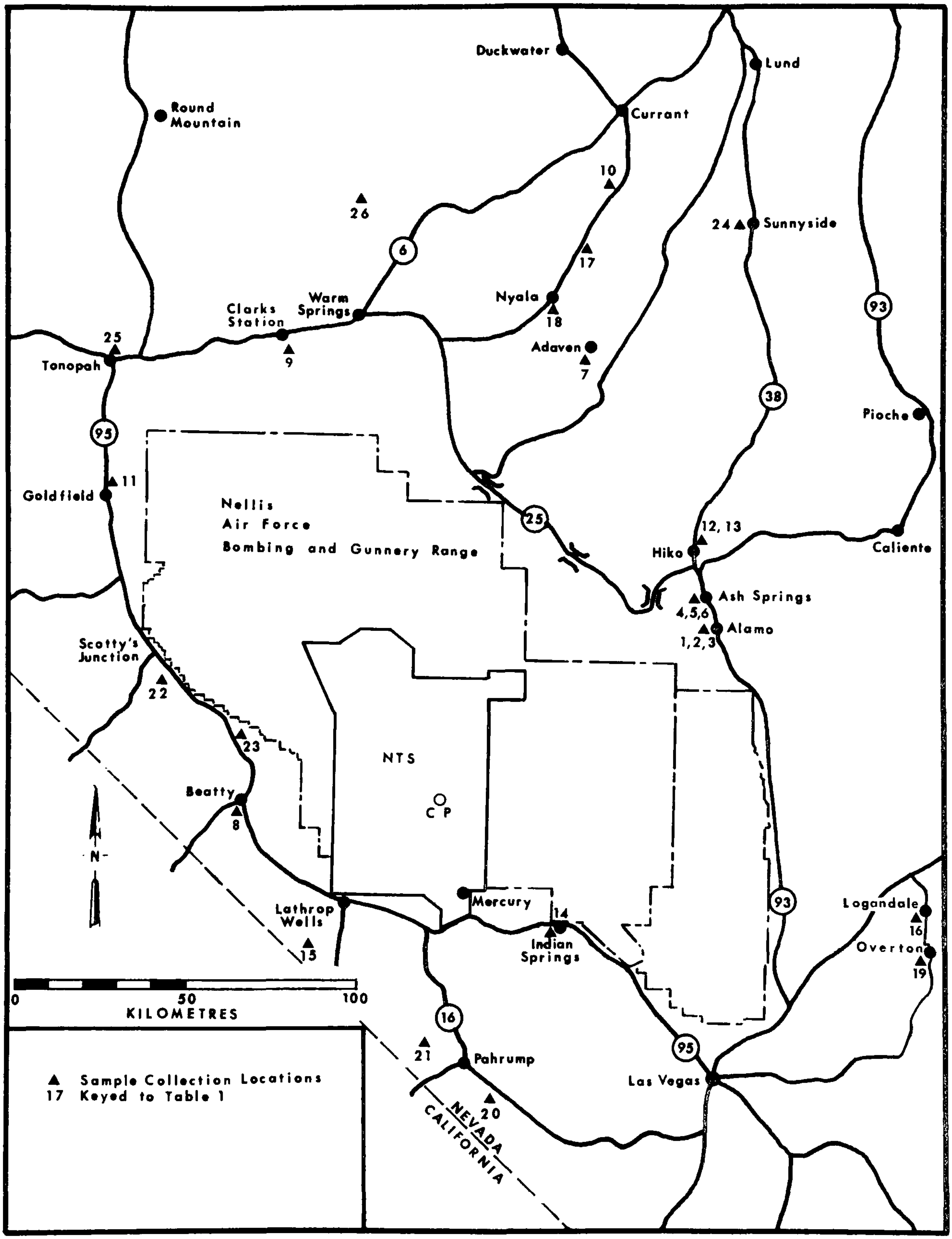


Figure 1. Sample Collection Locations

TABLE 2. BACKGROUND SAMPLE SURVEY

| DATE | ITEM | STATION NUMBER | ORIGIN |
|---|---|---|---|
| 07/08/74 | Carrots | 27 | Santa Maria, California |
| 07/08/74 | Cabbage | 27 | Santa Maria, California |
| 07/08/74 | Turnips | 28 | Salinas, California |
| 07/08/74 | Lettuce | 28 | Salinas, California |
| 07/08/74 | Turnip Greens | 28 | Salinas, California |
| 07/08/74 | Sweet Corn | 29 | Coachella, California |
| 07/08/74 | Peaches | 30 | Redding, California |
| 07/08/74 | Apricots | 31 | Banning, California |
| 07/08/74 | Plums | 32 | Santa Rosa, California |
| 10/16/74 | Plums | 32 | Santa Rosa, California |
| 10/16/74 | Lettuce | 33 | Blythe, California |
| 10/16/74 | Cabbage | 34 | Orem, Utah |

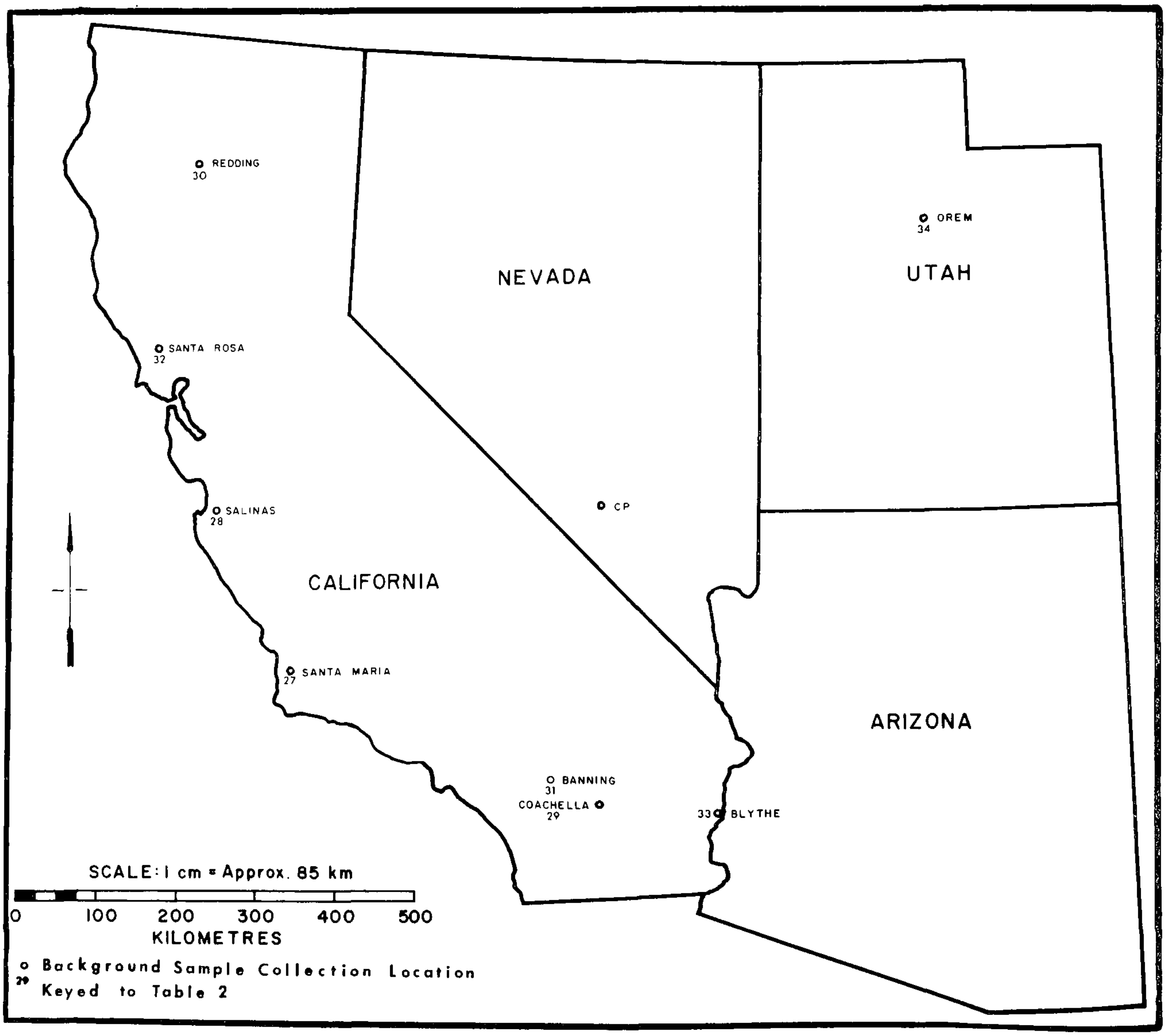


Figure 2. Background Sample Origins

Only two samples contained detectable amounts of $^{90}$Sr. The orchard sample from Alamo (1) and the garden sample from Sunnyside (24) both contained 2.6 pCi/g of soil. Strontium-89 has a relatively short half-life of 52.7 days. The last release of radioactivity from NTS which could have deposited $^{89}$Sr in the off-site area was the Baneberry Event of December 18, 1970. With at least 24 half-lives for decay since that event no $^{89}$Sr was expected to be present from NTS activities. Relatively heavy fallout activity was measured in the spring of 1974 by the EMSL-LV Air Surveillance Network (ASN), including zirconium-95 with a half-life of 65.5 days (1-5). This was believed to be the result of an atmospheric nuclear test by the People's Republic of China (PRC) on June 23, 1973. Additionally, during July of 1974, fallout radioactivity resulting from the atmospheric nuclear test by the PRC on June 17, 1974, was detected by the ASN. The one sample with detectable $^{89}$Sr, from Scotty's Junction (22), of 1.4 ± 1.1 pCi/g is believed to be a result of those two tests.

Cesium-137 in Soil

The only gamma-emitting fission-product radioactivity detected in the soil samples was $^{137}$Cs. It was initially assumed that the concentrations in orchard soil, representing relatively undisturbed soil, and in garden soil, which would be relatively well mixed, would be significantly different. A histogram and plot of cumulative frequency distribution indicated that the garden soil $^{137}$Cs concentrations belonged to three distributions which were fairly well grouped by geographical location. The sampling points were regrouped into three sets to correspond approximately to the cumulative fallout patterns in the NTS environs. These groups were from (1) the arc from 315° to 025° from the NTS CP, except for Warm Springs (Hot Creek), (2) the remainder of the northern half of the off-site area [(270° to 315°) + (025° to 090°) plus Warm Springs], and (3) the arc from 090° to 270°. The first group was from the area most affected by close-in fallout from the NTS, while the last group was from the area least affected.

Groups 2 and 3 contained samples with less than detectable concentrations of $^{137}$Cs. A graphical technique described by Denham and Waite (6), which permits the inclusion of non-detectable results, was used to derive the statistical parameters for those groups. The $^{137}$Cs data from groups 1 and 2 were found to follow a log-normal distribution, as shown in Figure 3. The few positive results from group 3 more closely followed a normal distribution. Results of the statistical analysis of $^{137}$Cs concentrations in soil are summarized in Table 3. Group 1 samples were found to have a geometric mean concentration of 0.89 pCi/g. For the second group the geometric mean of the concentrations was 0.33 pCi/g. Of the eight samples collected from group 3, four were less than detectable. The four positive results in group 3 provide a relatively poor basis for statistical analysis, but the distribution appeared to be normal, with a mean of about 0.05 pCi/g.

Because of the smaller number of orchard samples collected and the nonrandom nature of the collection it was more difficult to determine satisfactory distributions. Seven of the 16 orchard soil samples were collected from the second area. The cumulative frequency distribution of those seven was approximately log-normal with a geometric mean of 0.37 and a standard geometric deviation of 1.36; not significantly different from the garden soil distribution

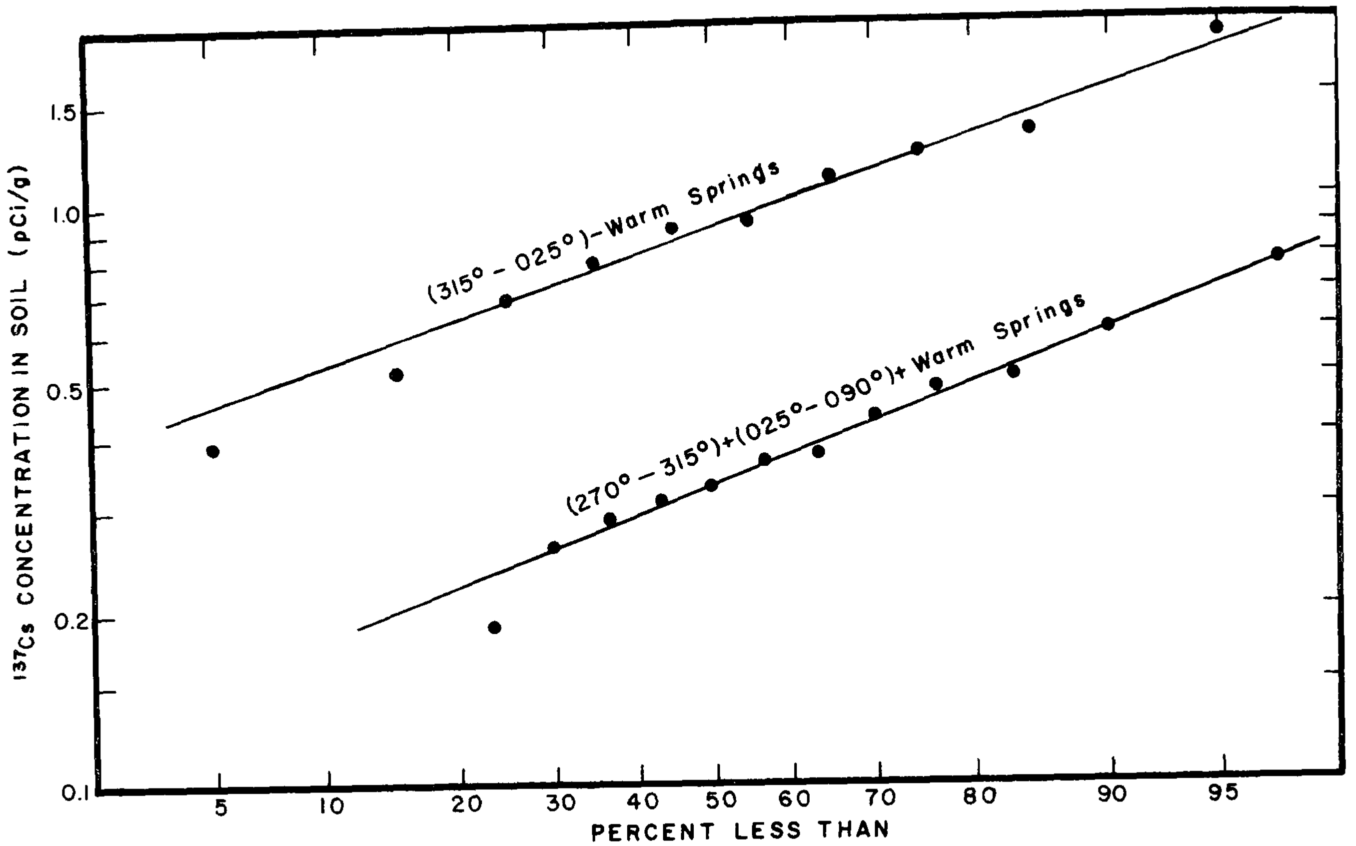


Figure 3. Cs-137 in Soil, Cumulative Frequency Distributions

in that area. When the orchard samples were grouped with the three garden soil groups no significant changes were observed. Therefore, it was deduced that no significant difference occurs for $^{137}$Cs in the two types of soil samples.

Plutonium-239 in Soil

A meaningful analysis of $^{239}$Pu results in soil samples was more difficult. Half of the 16 orchard soil samples contained concentrations of $^{239}$Pu below 0.03 pCi/g, the highest value reported for those samples as the minimum detectable concentration. Three-fourths of the 33 garden soil samples contained less than 0.04 pCi/g, the highest value for minimum detectable concentration in that group. The minimum detectable concentration is defined as that value at which two standard deviations of the sample count equals the sample count (2-sigma= ± 100%). One of the plutonium counting systems was contaminated, raising the background and, therefore, the detectable limit. Although some samples are shown with measurable concentrations as low as 0.019 pCi/g of soil, those samples counted on the contaminated system had detection limits of 0.03 to 0.04 pCi/g. The graphical method of determining statistical parameters requires that all results less than the maximum value determined for the minimum detectable concentration be grouped with that maximum value. This technique permits the determination of means which are below the minimum detectable concentrations.

TABLE 3. SUMMARY OF $^{137}$CS-IN-SOIL STATISTICAL ANALYSIS

| Sample Group | Area covered (Azimuth from CP) | $^{137}$Cs Concentration in Garden Soil | | | $^{137}$Cs Concentration in Orchard Soil | | |
|---|---|---|---|---|---|---|---|
| | | Mean, pCi/g | Std. Dev. | Range, pCi/g | Mean, pCi/g | Std. Dev. | Range, pCi/g |
| 1 | 315°-025° minus Warm Springs | 0.89[a] | 1.58[a] | 0.39-1.9 | | | |
| 2 | (270°-315°)+ (025°-090°)+ Warm Springs | 0.33[a] | 1.59[a] | <MDC-0.78 | 0.37 | 1.36 | 0.16-0.56 |
| 3 | 090°-270° | 0.05 | NC | <MDC-0.68 | | | |

[a] Geometric mean and standard deviation

Std. Dev. = standard deviation

MDC = minimum detectable concentration

NC = not calculated

A preliminary graphical analysis of the $^{239}Pu$ data showed that the three highest concentrations—0.13, 0.14, and 0.17 pCi/g—did not fit in any distribution with the other samples, which had a maximum concentration of 0.070 pCi/g. Therefore, those three samples were considered separately in the succeeding statistical analyses. The results of statistical analysis of the $^{239}Pu$ in soil concentrations are shown in Table 4.

Taking the garden soil samples from the northern half of the array—north of an east-west line through the NTS CP—a good fit to a log-normal distribution was found with a geometric mean of 0.027 pCi/g. Using all garden soil samples the results were not significantly different, with a geometric mean for all garden soil samples of 0.029 pCi/g. However, the maximum concentration measured in garden soil from the southern half was 0.045 pCi/g compared to the maximum of 0.070 pCi/g for the northern half (not including the three highest). Therefore, it is likely that with more samples a difference in means would be found between those samples collected from north and south of the NTS CP.

The orchard samples, representing undisturbed soil, did not fit a good distribution in either a normal or log-normal plot, tending to be grouped at the upper levels. An approximate geometric mean of 0.048 pCi/g was determined for $^{239}Pu$ in orchard soil samples. Unlike the $^{137}Cs$, the distribution of $^{239}Pu$ in garden soil appears to differ from that in orchard soil. It is possible that Cs is more soluble and, therefore, more uniformly distributed with depth, than the $^{239}Pu$.

The finding of a small group of high concentrations is similar to findings by other investigators. Results of $^{239}Pu$ analysis of soil samples collected in the same general areas covered by this survey showed two distributions with geometric means of about 4 and 42 nanocuries per square metre ($nCi/m^2$)(7). Assuming a bulk soil density of 1.5 $g/cm^3$ and a soil sampling depth of 5 cm, the concentration of 0.048 pCi/g in orchard soil would be equivalent to an area deposition of 3.6 $nCi/m^2$. Using the same assumptions, the geometric mean 0.14 pCi/g for the three highest results gives an area deposition of 11 $nCi/m^2$. Those results agree well with the previous findings.

## WATER SAMPLES

Analytical results of individual water samples are listed in Appendix 2. All results are typical of natural background radioactivity in groundwater of the NTS area except for $^3H$. Most $^3H$ in the environment is the result of nuclear testing. Concentrations of $^3H$ in atmospheric water vapor in the NTS area during 1974 were about 500 pCi/l of water, reflecting general worldwide distribution. Most of the water sampled originated from irrigation wells, which are normally very low in $^3H$, as shown by the three low concentrations resulting from analysis by the enrichment technique. Most of the samples were actually collected, however, not at the well, but from irrigation ditches. That resulted in some samples with $^3H$ concentrations slightly above the detection limit, which were probably picked up from the soil. This $^3H$ could have been deposited there at earlier times as a result of local contamination from testing at the NTS or from rainfall bearing $^3H$ distributed worldwide. No $^3H$ above natural background has been identified in off-NTS groundwater by the routine collections of the Long-Term Hydrological Monitoring Program (8).

## TABLE 4. SUMMARY OF $^{239}$PU-IN-SOIL STATISTICAL ANALYSIS

| Area covered (Azimuth from CP) | $^{239}$Pu Concentration in Garden Soil | | | $^{239}$Pu Concentration in Orchard Soil | | |
|---|---|---|---|---|---|---|
| | Geometric Mean, pCi/g | Geometric Std. Dev. | Range, pCi/g | Geometric Mean, pCi/g | Geometric Std. Dev. | Range, pCi/g |
| 270°-090° | 0.027 | 1.72 | <MDC-0.070 | | | |
| All | 0.029 | 1.53 | <MDC-0.070 | 0.048 | 1.7 | <MDC-0.069 |

Std. Dev. = standard deviation

MDC = minimum detectable concentration

## FRUIT AND VEGETABLE SAMPLES

Analytical results for the fruit and vegetable samples are listed in Appendix 3. Tritium analyses were performed on 25 of the fruit and vegetable samples collected in the NTS off-site area. The concentrations were found to be distributed log-normally with a geometric mean of 230 pCi/l of water recovered and a standard geometric deviation of 1.93. These results agree with those observed in the irrigation water samples. Tritium analysis of the 10 background samples purchased in July resulted in a geometric mean of 670 pCi/l of water recovered with a standard geometric deviation of 1.25. As with most other radionuclides resulting from nuclear testing, $^{3}H$ concentrations may vary with location depending on altitude, latitude, rainfall, or other factors. This is reflected in the higher concentrations of $^{3}H$ observed in the background samples. The lower $^{3}H$ concentrations in fruit and vegetable samples from near the NTS as compared to the background samples may also be a result of the greater use of well water for irrigation in the NTS vicinity. The lower concentrations of $^{3}H$ in well water than in atmospheric water, including rainfall, would be reflected in the foods grown with that water.

Only two gamma-emitting radionuclides were identified in the fruit and vegetable samples by gamma spectroscopy. These were naturally occurring beryllium-7 ($^{7}Be$), found in four samples, and the fission product zirconium-95 ($^{95}Zr$), which was identified in four samples. Beryllium-7 is produced through cosmic ray interactions in the stratosphere. Since these gamma-emitting nuclides were found only on leafy vegetables and alfalfa it is believed that they occurred as fallout deposited directly on the leaves rather than through uptake from the soil. The relatively short half-lives of 53.4 days for $^{7}Be$ and 65.5 days for $^{95}Zr$ would make that mode seem most likely. As discussed in the soil results section, the finding of $^{95}Zr$ was due to atmospheric nuclear tests by the People's Republic of China in June 1973 and June 1974.

One of the 16 samples analyzed for $^{89,90}Sr$ was positive for $^{89}Sr$. This result was also due to the nuclear tests by the People's Republic of China.

Strontium-90 was measured at slightly above the detection limit in six of the samples collected around the NTS and in none of the background samples. No correlation was found between $^{90}Sr$ results and close-in fallout patterns from atmospheric testing at the NTS; however, comparing the off-site results with the background samples indicates that the $^{90}Sr$ observed resulted from close-in fallout from the NTS.

## DISCUSSION

Analysis of soil samples for both gamma-emitting radionuclides ($^{137}Cs$) and $^{239}Pu$ shows the impact of close-in fallout from atmospheric testing at the NTS. The only radionuclide identified in fruit and vegetable samples which might be related to NTS close-in fallout was $^{90}Sr$. Although $^{90}Sr$ was above the detectable concentration in only two of the soil samples analyzed, it was detected in six of the fruit and vegetable samples. For the purpose of making conservative estimates it was assumed that all of the $^{90}Sr$ in the fruit and vegetable samples was deposited as close-in fallout.

An attempt was made to evaluate these findings in terms of radiation dose to off-site residents consuming locally grown foods. Because the study was not intended to be, and could not be, a comprehensive study to calculate dose to the population, it was necessary to make certain assumptions to arrive at an estimated dose. The foods considered and the $^{90}Sr$ concentrations used were: lettuce, 12 pCi/g; chard, 32 pCi/g; onions, 14 pCi/g; corn, 9.2 pCi/g; root vegetables, 6.8 pCi/g. It was assumed that an adult would consume 400 g/week of lettuce for half the year; 200 g/week each of chard, corn, and roots throughout the year; and 50 g/week of onions throughout the year. This consumption would result in a total intake of 660 pCi/yr. The recommended intake of calcium for an adult is 0.8 g/day or 292 g/yr [9]. The radiation dose to the bone marrow of an adult, from FRC Report No. 7 [10], would be calculated from:

$$D = \frac{0.6 \text{ rad to bone marrow in first year}}{\mu\text{Ci } ^{90}\text{Sr}/100 \text{ g calcium ingested.}}$$

During the first year of such consumption the dose would be 0.14 mrad. It is estimated that an individual will reach 86% of $^{90}Sr$ equilibrium in bones in 50 years [11]. With an annual intake of 660 pCi $^{90}Sr$ and 292 g calcium, the concentration in bone calcium would be $1.94 \times 10^{-3}$ µCi/g. Using the relationship, 0.9 rem/yr per µCi $^{90}Sr$/g calcium [10], the annual dose rate to bone marrow after 50 years of intake would be 1.7 mrad. That dose is 1% of the radiation protection standard for average dose to a suitable sample of the population[12]. Applying the estimated dose to the past 20 years would yield an estimated accumulated dose of 5.8 mrad.

## CONCLUSIONS AND RECOMMENDATIONS

The calculated dose to bone marrow of an adult would be 0.14 mrad/yr for the first year of consumption of locally grown foods based on the $^{90}Sr$ content of foods collected in 1974, or less than 0.1% of the radiation protection standard for average dose to a suitable sample of the population and would reach 1.7 mrad/yr after 50 years of such exposure or 1% of the radiation protection standard. In actuality, such continuous exposure would not likely occur, even in cases of continuous residence, due to radioactive decay. In 50 years, with no additional deposition, the $^{90}Sr$ present would be reduced to 30% of its current value.

In view of the low potential for radiation dose to the off-site population, further monitoring of this nature is not recommended for the near future. However, the portion of the original study relating to $^{55}Fe$ and $^{239}Pu$ measurements should, and will, be rescheduled. Accordingly, a follow-up to this report will include the analytical results of samples collected specifically for analysis of those radionuclides.

## REFERENCES


1. U.S. Environmental Protection Agency. Radiation Data and Reports. Vol. 15, No. 8, pp. 508-510. Washington, D.C. August 1974

2. U.S. Environmental Protection Agency. Radiation Data and Reports. Vol. 15, No. 9, pp. 594-597. Washington, D.C. September 1974

3. U.S. Environmental Protection Agency. Radiation Data and Reports. Vol. 15, No. 10, pp. 674-676. Washington, D.C. October 1974

4. U.S. Environmental Protection Agency. Radiation Data and Reports. Vol. 15, No. 11, pp. 711-713. Washington, D.C. November 1974

5. U.S. Environmental Protection Agency. Radiation Data and Reports. Vol. 15, No. 12, pp. 795-798. Washington, D.C. December 1974

6. Denham, Dale H. and David A. Waite. Some practical applications of the log-normal distribution for interpreting environmental data. BNWL-SA-4840, Battelle-Pacific Northwest Laboratory, Richland, Washington. July 1975

7. Church, B. W., D. N. Brady, I. Aoki, and W. A. Bliss. "Distribution and inventory element activities on-NTS and off-NTS." The Dynamics of Plutonium in Desert Environments. NVO-142. p 311. Las Vegas, Nevada. July 1974

8. U.S. Environmental Protection Agency. Environmental monitoring report for the Nevada Test Site and other areas used for underground nuclear detonations. January through December 1974. NERC-LV-539-39. Las Vegas, Nevada. May 1975

9. Hodgman, C. D. ed. Handbook of Chemistry and Physics. Forty-third edition. The Chemical Rubber Publishing Company. Cleveland, Ohio. p 1976. 1961

10. Federal Radiation Council. Background material for the development of radiation protection standards: Protective action guides for strontium-89, strontium-90, and cesium-137. Report No. 7. 44 pp. May 1965

11. The International Commission on Radiological Protection. Report of Committee II on permissible dose for internal radiation. ICRP Publication 2. p 85. 1959

12. U.S. Energy Research and Development Administration. "Standards for radiation protection." ERDA Manual Chapter 0524. p 3. April 1975

## APPENDICES

## APPENDIX 1. SOIL SAMPLE ANALYTICAL RESULTS

| STATION NUMBER | COLLECTION DATE (1974) | SOURCE | RADIONUCLIDE CONCENTRATION (pCi/g)[a] $^{55}Fe$ | $^{89}Sr$ | $^{90}Sr$ | $^{137}Cs$ | $^{238}Pu$ | $^{239}Pu$ | K (mg/g) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 06/05 | O | 0.7 ± 0.45 | <3 | 2.6 ± 1.4 | 0.31 | <0.004 | 0.055 ± 0.013 | 22 |
| 1 | 06/05 | G | NA | <2 | <2 | 0.29 | <0.007 | 0.019 ± 0.006 | 26 |
| 2 | 06/05 | G | 0.6 ± 0.44 | <2 | <2 | 0.19 | <0.005 | 0.022 ± 0.007 | 25 |
| 3 | 08/26 | O | NA | <2 | <2 | 0.45 | <0.03 | <0.03 | 28 |
| 4 | 09/24 | G | NA | <3 | <2 | 0.19 | <0.04 | <0.03 | 44 |
| 4 | 09/24 | G[b] | NA | <3 | <3 | 0.37 | <0.04 | <0.04 | 34 |
| 5 | 06/06 | G | NA | <2 | <2 | 0.50 | <0.004 | 0.030 ± 0.009 | 22 |
| 6 | 06/06 | O | NA | <2 | <2 | 0.32 | <0.007 | 0.066 ± 0.012 | 22 |
| 7 | 07/23 | G | NA | <2 | <2 | 1.2 | <0.04 | 0.070 ± 0.032 | 28 |
| 7 | 08/24 | G | NA | <2 | <2 | 0.69 | 0.031 ± 0.025 | <0.03 | 51 |
| 8 | 07/11 | G | NA | <2 | <1 | ND | <0.03 | 0.044 ± 0.023 | 30 |
| 8 | 07/23 | O | NA | <2 | <1 | 0.41 | <0.05 | <0.03 | 31 |
| 8 | 08/15 | G | NA | <2 | <1 | ND | <0.03 | 0.029 ± 0.020 | 37 |
| 9 | 08/12 | G | NA | <2 | <2 | 1.9 | <0.03 | <0.03 | 55 |
| 10 | 07/18 | G | NA | <2 | <1 | 0.80 | <0.04 | 0.044 ± 0.035 | 9.4 |
| 10 | 08/14 | O | NA | <2 | <1 | 1.0 | <0.05 | 0.042 ± 0.038 | 16 |
| 10 | 08/27 | G | NA | <2 | <1 | 0.91 | 0.038 ± 0.031 | 0.17 ± 0.052 | 20 |
| 11 | 07/19 | G | NA | <2 | <2 | 0.48 | <0.03 | 0.054 ± 0.027 | 24 |
| 12 | 08/05 | G | NA | <2 | <2 | 0.78 | <0.03 | 0.022 ± 0.021 | 22 |
| 13 | 06/05 | G | <0.5 | <2 | <2 | 0.60 | <0.004 | 0.029 ± 0.008 | 27 |
| 13 | 06/05 | O | NA | <2 | <2 | 0.54 | 0.0054 ± 0.0049 | 0.022 ± 0.011 | 22 |
| 13 | 08/13 | O | NA | <2 | <1 | 0.32 | <0.03 | <0.03 | 27 |
| 14 | 06/13 | O | <4 | <2 | <2 | 0.29 | <0.05 | 0.065 ± 0.041 | 8.4 |
| 14 | 07/08 | G | NA | <3 | <1 | ND | <0.04 | <0.04 | 13 |
| 15 | 06/07 | O | <0.5 | <2 | <2 | 0.33 | <0.006 | 0.014 ± 0.008 | 32 |
| 15 | 07/17 | G | NA | <2 | <2 | 0.41 | <0.04 | <0.04 | 32 |
| 16 | 07/15 | O | NA | <2 | <1 | 0.31 | <0.03 | <0.03 | 23 |

APPENDIX 1. (CONTINUED)

| STATION NUMBER | COLLECTION DATE (1974) | SOURCE | RADIONUCLIDE CONCENTRATION (pCi/g)[a] $^{55}Fe$ | $^{89}Sr$ | $^{90}Sr$ | $^{137}Cs$ | $^{238}Pu$ | $^{239}Pu$ | K (mg/g) |
|---|---|---|---|---|---|---|---|---|---|
| 17 | 07/18 | G | NA | <2 | <1 | 1.1 | <0.04 | <0.04 | 24 |
| 17 | 08/21 | O | NA | <2 | <2 | 1.0 | <0.03 | 0.068 ± 0.041 | 25 |
| 18 | 06/12 | O | <4 | <3 | <1 | 0.96 | <0.04 | 0.13 ± 0.046 | 27 |
| 18 | 07/23 | G | NA | <2 | <2 | 0.39 | <0.03 | 0.031 ± 0.026 | 17 |
| 18 | 08/28 | G | NA | <1 | <0.8 | 0.52 | <0.03 | 0.033 ± 0.022 | 26 |
| 19 | 07/15 | G | NA | <2 | <1 | 0.11 | <0.04 | <0.03 | 16 |
| 20 | 06/06 | O | NA | <2 | <2 | 0.37 | <0.005 | 0.026 ± 0.005 | 17 |
| 20 | 07/12 | G | NA | <2 | <1 | 0.29 | <0.04 | <0.03 | 18 |
| 20 | 08/15 | G | NA | <2 | <2 | 0.68 | <0.04 | <0.04 | 23 |
| 21 | 06/26 | G | NA | <2 | <1 | ND | <0.05 | 0.045 ± 0.028 | 24 |
| 21 | 06/26 | O | NA | <3 | <1 | ND | <0.04 | <0.02 | 22 |
| 22 | 08/12 | G | NA | <2 | <0.9 | 0.31 | <0.03 | <0.03 | 47 |
| 22 | 09/16 | G | NA | 1.4 ± 1.1 | <0.9 | ND | <0.05 | <0.04 | 46 |
| 23 | 06/28 | O | NA | <2 | <1 | 0.16 | <0.03 | 0.14 ± 0.037 | 30 |
| 23 | 08/15 | G | <4 | <2 | <1 | ND | <0.03 | <0.03 | 43 |
| 23 | 08/15 | G | NA | <2 | <2 | 0.43 | <0.03 | 0.046 ± 0.032 | 49 |
| 24 | 08/28 | G | NA | <3 | 2.6 ± 1.4 | 0.26 | <0.03 | <0.02 | 9.6 |
| 25 | 07/19 | G | NA | <2 | <1 | 1.3 | 0.0035 ± 0.0030 | 0.034 ± 0.008 | 32 |
| 25 | 09/17 | G | NA | <2 | <1 | 0.93 | <0.04 | <0.04 | 52 |
| 26 | 06/19 | O | <4 | <2 | <0.9 | 0.56 | 0.046 ± 0.043 | 0.069 ± 0.032 | 16 |
| 26 | 08/27 | G | NA | <2 | <2 | 0.36 | <0.04 | 0.064 ± 0.037 | 16 |
| 26 | 09/17 | G | NA | <2 | <1 | 0.33 | <0.04 | <0.03 | 17 |

[a] Detectable concentrations given ± 2-sigma counting error

[b] Duplicate Sample

O = Orchard; G = Garden

NA = No Analysis

ND = Not Detected

## APPENDIX 2

## WATER SAMPLE ANALYTICAL RESULTS

| STATION NUMBER | COLLECTION DATE (1974) | RADIOACTIVITY CONCENTRATION (pCi/litre)[a] | | |
|---|---|---|---|---|
| | | Gross Alpha | Gross Beta | $^3H$ |
| 1 | 06/05 | 9.9 ± 4.7 | 6.8 ± 3.2 | <300 |
| 2 | 06/05 | 9.4 ± 4.6 | 9.3 ± 3.4 | <300 |
| 3 | 08/26 | 7.5 ± 5.3 | 13 ± 3.9 | NA |
| 4 | 09/24 | 8.5 ± 4.6 | 7.3 ± 3.3 | <300 |
| 5 | 06/06 | 5.4 ± 3.8 | 9.6 ± 3.4 | NA |
| 6 | 06/06 | 4.2 ± 4.0 | 10 ± 3.5 | 240 ± 220 |
| 7 | 06/12 | 5.6 ± 3.6 | <3 | 330 ± 220 |
| 8 | 06/11 | 9.7 ± 6.4 | 13 ± 3.8 | <300 |
| 9 | 06/06 | <2 | 7.5 ± 3.3 | 390 ± 220 |
| 10 | 07/11 | <4 | 8.1 ± 3.3 | <300 |
| 11 | 06/07 | 14 ± 6.5 | 11 ± 3.6 | <300 |
| 12 | 08/05 | 7.6 ± 4.2 | 9.8 ± 3.8 | <7 |
| 13 | 06/05 | 9.7 ± 4.6 | 8.3 ± 3.3 | <300 |
| 14 | 06/13 | <3 | <3 | <300 |
| 15 | 06/07 | <4 | 6.3 ± 3.2 | <300 |
| 16 | 07/15 | 7.5 ± 6.0 | 16 ± 4.0 | <300 |
| 17 | 07/15 | 8.0 ± 5.1 | 4.7 ± 3.1 | <300 |
| 18 | 06/05 | <3 | <3 | <300 |
| 19 | 07/15 | 7.6 ± 6.6 | 18 ± 4.2 | <300 |
| 20 | 06/06 | 3.7 ± 3.0 | <3 | <7 |
| 21 | 06/26 | 3.1 ± 2.7 | 3.5 ± 3.0 | <300 |
| 21 | 06/26 | 2.9 ± 2.7 | 5.3 ± 3.1 | <300 |
| 22 | 06/07 | 6.5 ± 5.2 | 13 ± 3.7 | <300 |
| 23 | 06/12 | 22 ± 9.0 | 15 ± 3.9 | 42 ± 3 |
| 24 | 06/11 | 12 ± 5.0 | 5.7 ± 3.1 | <300 |
| 25 | 06/06 | <4 | 5.5 ± 3.1 | <300 |
| 26 | 06/19 | <5 | 15 ± 3.8 | 250 ± 210 |

[a] Radioactivity concentrations ± 2-sigma counting error

NA = No Analysis

# APPENDIX 3. FRUIT AND VEGETABLE SAMPLE RESULTS

| STATION NUMBER | SAMPLE TYPE | COLLECTION DATE (1974) | RADIONUCLIDE CONCENTRATION (pCi/kg WET WEIGHT) $^{3}H$ | $^{7}Be$ | $^{89}Sr$ | $^{90}Sr$ | $^{95}Zr$ | K (mg/g) | ASH (%) | MOISTURE (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Mxd Rt Crt + Bt | 08/05 | | ND | | | ND | 2.4 | 1.03 | 91.7 |
| 1 | Corn | 08/05 | | ND | | | ND | 2.3 | 0.96 | 76.9 |
| 2 | Cabbage | 08/05 | | ND | | | ND | 1.9 | 0.52 | 96.2 |
| 3 | Peaches | 08/21 | | ND | | | ND | 2.9 | 1.01 | 91.6 |
| 4 | Cabbage | 09/24 | | ND | | | ND | 2.8 | 0.66 | 94.4 |
| 5 | Mxd Rt Tnp + Bt | 08/13 | | | < 9 | 6.8 (5.5)[a] | ND | 4.2 | 0.75 | 92.4 |
| 6 | Apples | 08/13 | | ND | | | ND | 1.8 | 0.58 | 85.4 |
| 7 | Turnip Greens | 07/23 | | 400 | | | 44 | 3.9 | 1.46 | 94.8 |
| 7 | Mxd Rt Tnp + Rtb | 07/23 | | ND | | | ND | 2.7 | 1.26 | 93.7 |
| 7 | Corn | 08/28 | | ND | < 9 | < 5 | ND | 2.1 | 0.80 | 91.7 |
| 7 | Alfalfa | 08/28 | | 570 | <40 | <22 | ND | 6.7 | 3.90 | 73.8 |
| 7 | Apples | 08/28 | | ND | | | ND | 2.2 | 1.37 | 86.4 |
| 8 | Turnip Roots | 07/11 | <300 | ND | | | ND | 2.4 | 0.79 | 95.7 |
| 8 | Turnip Greens | 07/11 | 380 (280)[a] | ND | | | ND | 3.9 | 2.11 | 91.9 |
| 8 | Peaches | 07/23 | | ND | | | ND | 3.1 | 1.99 | 92.7 |
| 8 | Corn | 07/23 | | ND | | | ND | 2.6 | 1.06 | 80.4 |
| 9 | Carrots | 08/12 | <300 | ND | < 8 | < 4 | ND | 3.5 | 0.71 | 74.0 |
| 10 | Turnip Roots | 07/18 | | ND | | | ND | 4.9 | 1.36 | 94.3 |
| 10 | Turnip Greens | 07/18 | | ND | <20 | <13 | ND | 3.2 | 1.30 | 90.8 |
| 10 | Plums | 08/14 | | ND | | | ND | 4.3 | 1.29 | 78.7 |
| 10 | Corn | 08/21 | | ND | | | ND | 2.4 | 1.29 | 79.7 |
| 10 | Corn | 08/27 | | ND | < 9 | < 5 | ND | 2.3 | 0.84 | 67.6 |
| 11 | Cabbage | 07/16 | | ND | | | ND | 2.3 | 0.83 | 94.5 |
| 11 | Corn | 09/16 | | ND | | | ND | 2.3 | 0.69 | 67.4 |

APPENDIX 3. (CONTINUED)

| STATION NUMBER | SAMPLE TYPE | COLLECTION DATE (1974) | RADIONUCLIDE CONCENTRATION (pCi/kg WET WEIGHT) $^{3}$H | $^{7}$Be | $^{89}$Sr | $^{90}$Sr | $^{95}$Zr | K (mg/g) | ASH (%) | MOISTURE (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| 11 | Potatoes | 09/16 | | ND | | | ND | 4.6 | 1.20 | 83.6 |
| 12 | Corn | 08/05 | <300 | ND | | | ND | 2.2 | 1.02 | 82.9 |
| 12 | Chard | 08/05 | <300 | 100 | <31 | 32 (20)[a] | 25 | 6.5 | 2.8 | 88.4 |
| 12 | Onions | 08/05 | <300 | ND | < 8 | 14 (5.2)[a] | ND | 1.9 | 0.51 | 90.0 |
| 13 | Apples | 09/09 | | ND | | | ND | 1.6 | 0.63 | 88.5 |
| 14 | Onions | 07/08 | <300 | ND | | | ND | 1.7 | 0.54 | 91.6 |
| 14 | Lettuce | 07/08 | 490 (280)[a] | ND | | | ND | 4.0 | 1.35 | 91.6 |
| 14 | Corn | 07/08 | 360 (320)[a] | ND | | | ND | 3.8 | 0.78 | 81.0 |
| 14 | Peaches | 08/15 | | ND | | | ND | 2.6 | 1.04 | 90.0 |
| 15 | Cabbage | 07/17 | | ND | | | ND | 2.6 | 1.24 | 95.5 |
| 15 | Turnip Roots | 07/17 | | ND | | | ND | 2.1 | 0.92 | 94.6 |
| 15 | Peaches | 06/07 | <300 | ND | | | ND | 2.1 | 1.01 | 93.4 |
| 16 | Plums | 07/15 | <300 | ND | | | ND | 2.5 | 0.49 | 88.9 |
| 17 | Mxd Lf Tnp + Ltc | 07/18 | | ND | 14 (11)[a] | <8 | ND | 3.9 | 1.00 | 92.0 |
| 17 | Turnip Roots | 07/18 | | ND | | | ND | 3.2 | 1.18 | 95.4 |
| 17 | Plums | 08/21 | | ND | | | ND | 4.5 | 2.25 | 87.0 |
| 17 | Corn | 08/21 | | ND | <12 | < 7 | ND | 2.7 | 1.40 | 62.7 |
| 17 | Alfalfa | 08/27 | | 910 | | | 63 | 4.7 | 4.01 | 66.6 |
| 18 | Apricots | 07/11 | <300 | ND | | | ND | 4.1 | 0.90 | 92.4 |
| 18 | Mxd Rt Crt + On | 07/23 | <300 | ND | | | ND | 2.6 | 0.89 | 91.5 |
| 18 | Mxd Lf Cbg + Ltc | 07/23 | <300 | ND | < 9 | < 6 | ND | 2.3 | 0.72 | 93.8 |
| 18 | Corn | 08/28 | | ND | | | ND | 2.4 | 0.50 | 64.6 |

APPENDIX 3. (CONTINUED)

| STATION NUMBER | SAMPLE TYPE | COLLECTION DATE (1974) | RADIONUCLIDE CONCENTRATION (pCi/kg WET WEIGHT) $^{3}H$ | $^{7}Be$ | $^{89}Sr$ | $^{90}Sr$ | $^{95}Zr$ | K (mg/g) | ASH (%) | MOISTURE (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| 18 | Alfalfa (Hay) | 08/28 | | 720 | <95 | 75 (54)[a] | ND | 27 | 8.50 | No Analysis |
| 19 | Beets | 07/15 | <300 | ND | | | ND | 2.8 | 1.07 | 91.9 |
| 19 | Lettuce | 07/15 | 640 (280)[a] | ND | | | ND | 3.5 | 0.94 | 95.8 |
| 20 | Lettuce | 06/06 | | ND | | | ND | 3.4 | 1.04 | No Analysis |
| 20 | Apricots | 07/03 | 650 (290)[a] | ND | | | ND | 2.6 | 0.74 | 92.0 |
| 20 | Turnip Roots | 07/12 | 330 (270)[a] | ND | | | ND | 2.5 | 0.68 | 95.8 |
| 20 | Corn | 07/15 | 480 (400)[a] | ND | <11 | 9.2 (7.4)[a] | ND | 3.0 | 0.87 | 65.6 |
| 21 | Radish | 06/26 | <300 | ND | | | ND | 2.6 | 0.85 | 94.3 |
| 21 | Plums | 06/26 | <300 | ND | | | ND | 3.8 | 0.87 | 88.9 |
| 21 | Corn | 07/24 | | ND | | | ND | 2.8 | 0.82 | 78.2 |
| 21 | Alfalfa | 09/12 | | ND | | | ND | 4.6 | 2.94 | 73.1 |
| 22 | Lettuce | 07/15 | | ND | | | ND | 4.8 | 1.32 | 92.2 |
| 22 | Mxd Rt Crt + Tnp | 08/12 | | ND | | | ND | 2.7 | 0.98 | 94.3 |
| 23 | Chard | 06/28 | | ND | | | ND | 3.3 | 1.84 | |
| 23 | Turnip Roots | 08/15 | <300 | ND | | | ND | 2.5 | 0.63 | 95.3 |
| 23 | Alfalfa | 08/15 | <300 | ND | | | 110 | 22 | 9.06 | 87.0 |
| 23 | Pears | 09/11 | <300 | ND | | | ND | 1.6 | 1.09 | 86.9 |
| 23 | Corn | 09/11 | 500 (290)[a] | ND | | | ND | 2.7 | 0.87 | 86.2 |
| 24 | Cabbage | 08/28 | | ND | | | ND | 2.6 | 0.52 | 98.2 |
| 24 | Corn | 08/28 | | ND | <12 | < 7 | ND | 2.0 | 1.20 | 53.0 |
| 24 | Alfalfa | 08/28 | | ND | | | ND | 5.7 | 2.97 | |
| 24 | Carrots | 08/28 | | ND | | | ND | 2.6 | 0.78 | |

## APPENDIX 3. (CONTINUED)

| STATION NUMBER | SAMPLE TYPE | COLLECTION DATE (1974) | RADIONUCLIDE CONCENTRATION (pCi/kg WET WEIGHT) $^{3}H$ | $^{7}Be$ | $^{89}Sr$ | $^{90}Sr$ | $^{95}Zr$ | K (mg/g) | ASH (%) | MOISTURE (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| 25 | Cabbage | 07/12 | | ND | | | ND | 2.1 | 1.76 | |
| 25 | Lettuce | 07/19 | | ND | <16 | 12 (11)[a] | ND | 4.6 | 1.40 | 96.8 |
| 25 | Carrots | 08/14 | | ND | | | ND | 2.4 | 1.09 | 90.7 |
| 25 | Corn | 08/14 | | ND | < 5 | < 3 | ND | 3.0 | 0.51 | 72.5 |
| 26 | Pears | 08/27 | | ND | | | ND | 1.1 | 0.58 | 84.6 |
| 26 | Potatoes | 08/27 | | ND | | | ND | 5.0 | 1.55 | |
| 27 Bkg | Carrots | 07/08 | 820 (300)[a] | ND | < 5 | < 3 | ND | 2.6 | 0.57 | 95.4 |
| 27 Bkg | Cabbage | 07/08 | 450 (270)[a] | ND | < 5 | < 3 | ND | 2.3 | 0.57 | 93.2 |
| 28 Bkg | Turnip Roots | 07/08 | 650 (280)[a] | ND | < 6 | < 4 | ND | 1.3 | 0.64 | 93.6 |
| 28 Bkg | Turnip Roots | 07/08 | 760 (250)[a] | ND | <10 | < 7 | ND | 4.3 | 1.10 | 90.3 |
| 28 Bkg | Turnip Greens | 07/08 | 1300 (290)[a] | ND | <17 | < 9 | ND | 4.5 | 1.40 | 92.3 |
| 28 Bkg | Lettuce | 07/08 | 750 (280)[a] | ND | < 3 | < 2 | ND | 1.9 | 0.33 | 97.0 |
| 29 Bkg | Corn | 07/08 | 640 (310)[a] | ND | < 8 | < 5 | ND | 2.9 | 0.97 | 73.2 |
| 30 Bkg | Peaches | 07/08 | 670 (280)[a] | ND | < 5 | < 5 | ND | 2.5 | 0.53 | 93.1 |
| 31 Bkg | Apricots | 07/08 | 640 (280)[a] | ND | < 6 | < 5 | ND | 3.3 | 1.00 | 93.1 |
| 32 Bkg | Plums | 07/08 | 560 (280)[a] | ND | < 3 | < 2 | ND | 1.7 | 0.34 | 91.2 |
| 32 Bkg | Plums | 10/16 | | ND | | | ND | 2.3 | 1.40 | 88.8 |
| 33 Bkg | Lettuce | 10/16 | | ND | | | ND | 1.4 | 0.42 | 97.0 |

## APPENDIX 3. (CONTINUED)

| STATION NUMBER | SAMPLE TYPE | COLLECTION DATE (1974) | RADIONUCLIDE CONCENTRATION (pCi/kg WET WEIGHT) | | | | | K (mg/g) | ASH (%) | MOISTURE (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | $^{3}H$ | $^{7}Be$ | $^{89}Sr$ | $^{90}Sr$ | $^{95}Zr$ | | | |
| 34 Bkg | Cabbage | 10/16 | | ND | | | ND | 2.0 | 0.56 | 92.2 |

a - Values shown in parentheses are the 2-sigma counting error term.

Mxd Rt = Mixed Roots; Crt = Carrot; Bt = Beet; Tnp = Turnip; Rtb = Rutabaga; On = Onion; Mxd Lf = Mixed Leaf;
Ltc = Lettuce; Cbg = Cabbage
ND = Not Detected

## DISTRIBUTION

1 - 40 Environmental Monitoring and Support Laboratory - Las Vegas, NV
41 Mahlon E. Gates, Manager, DOE/NV, Las Vegas, NV
42 Troy E. Wade, DOE/NV, Las Vegas, NV
43 David G. Jackson, DOE/NV, Las Vegas, NV
44 Paul J. Mudra, DOE/NV, Las Vegas, NV
45 Elwood M. Douthett, DOE/NV, Las Vegas, NV
46 - 47 Ernest D. Campbell, DOE/NV, Las Vegas, NV
48 - 49 Paul B. Dunaway, DOE/NV, Las Vegas, NV
50 Roger Ray, DOE/NV, Las Vegas, NV
51 Robert W. Taft, DOE/NV, Las Vegas, NV
52 Leon Silverstrom, DOE/NV, Las Vegas, NV
53 Robert W. Newman, DOE/NV, Las Vegas, NV
54 Bruce W. Church, DOE/NV, Las Vegas, NV
55 Peter K. Fitzsimmons, DOE/NV, Las Vegas, NV
56 - 57 Technical Library, DOE/NV, Las Vegas, NV
58 Chief, NOB/DNA, DOE/NV, Las Vegas, NV
59 Hal Hollister, DOES, DOE/HQ, Washington, DC
60 Tommy F. McCraw, DOS, DOE/HQ, Washington, DC
61 L. Joe Deal, DOS, DOE/HQ, Washington, DC
62 - 66 Maj. Gen. Joseph K. Bratton, DMA, DOE/HQ, Washington, DC
67 Gordon F. Facer, DMA, DOE/HQ, Washington, DC
68 James L. Liverman, Director, DBER, DOE/HQ, Washington, DC
69 Robert L. Watters, DBER, DOE/HQ, Washington, DC
70 John S. Kirby-Smith, DBER, DOE/HQ, Washington, DC
71 Jeff Swinebroad, DBER, DOE/HQ, Washington, DC
72 Robert W. Wood, DBER, DOE/HQ, Washington, DC
73 William S. Osburn, Jr., DBER, DOE/HQ, Washington, DC
74 Marcy Williamson, HSL/INEL, DOE/ID, Idaho Falls, ID
75 Steven V. Kaye, Oak Ridge National Laboratory, Oak Ridge, TN
76 Helen Pfuderer, Ecological Science Information Center, Oak Ridge National Laboratory, Oak Ridge, TN

77 Library Systems Branch (PM-213), EPA/HQ, Washington, DC

78 Albert Printz, Director, Office of Technical Analysis (EN-329), EPA/HQ, Washington, DC

79 Stephen J. Gage, Asst. Admin. for Research and Development (RD-672), EPA/HQ, Washington, DC

80 William D. Rowe, Deputy Asst. Admin. for Radiation Programs (AW-458), EPA/HQ, Washington, DC

81 William A. Mills, Director, Criteria and Standards Division (AW-460), EPA/HQ, Washington, DC

82 Floyd L. Galpin, Director, Environmental Analysis Division (AW-461), EPA/HQ, Washington, DC

83 David S. Smith, Director, Technology Assessment Division (AW-459), EPA/HQ, Washington, DC

84 Paul DeFalco, Jr., Regional Administrator, Region IX, EPA, San Francisco, CA

85 James K. Channell, Regional Radiation Representative, Region IX, EPA, San Francisco, CA

86 Richard L. Blanchard, Director, Radiochemistry and Nuclear Engineering Branch, EPA, Cincinnati, OH

87 Charles R. Porter, Director, Eastern Environmental Radiation Facility, EPA, Montgomery, AL

88 Peter Halpin, Chief, APTIC, EPA, Research Triangle Park, NC

89 Harold F. Mueller, NOAA/WSNSO, Las Vegas, NV

90 Gilbert J. Ferber, ARL/NOAA, Silver Spring, MD

91 Kenneth M. Oswald, Manager, Health and Safety, LLL, Mercury, NV

92 Bernard W. Shore, LLL, Livermore, CA

93 Richard L. Wagner, LLL, Livermore, CA

94 Howard W. Tewes, LLL, Livermore, CA

95 Paul L. Phelps, LLL, Livermore, CA

96 Mortimer L. Mendelsohn, LLL, Livermore, CA

97 John C. Hopkins, LASL, Los Alamos, NM

98 Harry S. Jordan, LASL, Los Alamos, NM

99 Lamar J. Johnson, LASL, Los Alamos, NM

100 George E. Tucker, Sandia Laboratories, Albuquerque, NM

101 Carter D. Broyles, Sandia Laboratories, Albuquerque, NM

102 Melvin L. Merritt, Sandia Laboratories, Albuquerque, NM

103 Richard S. Davidson, Battelle Memorial Institute, Columbus, OH

104 Arden E. Bicker, REECo, Mercury, NV

105 Savino W. Cavender, REECo, Mercury, NV

106 Auda F. Morrow, RE/CETO, NTS, Mercury, NV

107 Billy Moore, NTSSO, DOE/NTS, Mercury, NV

108 Lloyd P. Smith, President, Desert Research Institute, University of Nevada, Reno, NV

109 Paul R. Fenske, Desert Research Institute, University of Nevada, Reno, NV

110 Thomas P. O'Farrell, Director, Applied Ecology and Physiology Center, Desert Research Institute, Boulder City, NV

111 Library, University of Nevada, Las Vegas, NV

112 Lester L. Skolil, San Diego State University, San Diego, CA

113 William Horton, Bureau of Environmental Health, State of Nevada, Carson City, NV

114 Deward W. Efurd, McClellan Central Laboratory, McClellan Air Force Base, CA

115 - 141 Technical Information Center, DOE, Oak Ridge, TN (for public availability)