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ABSTRACT

From the analyses of the ^{137}Cs and $^{239+240}Pu$ content and from the plutonium mass isotopic composition of soil samples recovered in Utah, the fraction of these radionuclides that were deposited in Utah by global and by Nevada Test Site (NTS) fallout have been determined. Deposition of NTS ^{137}Cs and $^{239+240}Pu$ followed similar patterns with elevated values existing in the southwestern corner of Utah around St. George, and then decreasing rapidly with distance along a northeasterly direction from NTS. Then midway along this diagonal through Utah, NTS fallout of these radionuclides increased again and remained elevated throughout the remainder of the state. In the populated Provo and Salt Lake City valleys, the NTS ^{137}Cs deposits were about $\frac{1}{2}$ that of St. George and the NTS $^{239+240}Pu$ deposits were even greater than at St. George.

These data will serve as the basis for estimating the population exposures from NTS debris which will be addressed in a future report. Based on a preliminary but conservative estimate of 100 mrad per mCi km^{-2} of ^{137}Cs from NTS debris, the cumulative exposure to the population of southwestern Utah from external radiation is in reasonable agreement with the exposure based on postshot monitoring data. Furthermore, the population weighted exposure in man rads may prove to be significantly higher in other parts of Utah than in the southwestern section of the state.

INTRODUCTION

Considerable interest has been shown by the Department of Energy and by the scientific community in reassessing the radiological dose from nuclear tests at the Nevada Test Site (NTS) to the general population in areas surrounding the NTS. Reflecting that interest the Environmental Measurements Laboratory (EML) has conducted several experiments to estimate the cumulative free air dose and population exposure from NTS debris which was deposited throughout Nevada and Utah (Beck, 1979; Krey et al., 1980; Beck and Krey, 1980; Miller et al., 1980). These estimates will be based on current measurements and will be independent of the historic postshot radiological surveys.

In this report we present the results of the radiochemical and the plutonium mass isotopic analyses of soil samples collected in Utah and Colorado in 1979. From these measurements we calculate the global and NTS contributions to the $^{239+240}Pu$ and ^{137}Cs fallout at each site. In a future report these NTS ^{137}Cs deposition values will be converted into estimates of cumulative free air exposures and population exposures based on the relative concentrations of other fission products to NTS ^{137}Cs, arrival times of NTS fallout and gamma-ray transport calculations.

SOIL SAMPLING AND ANALYSIS

In situ gamma-ray spectrometric and high pressure ionization chamber measurements were obtained at over 150 sites and in 56 cities and towns throughout Utah in 1979 (Beck and Krey, 1980). The sites at which soil samples were taken are identified in Table 1 and all the population centers in which measurements were made are located in Figure 1. Whenever possible, each site was a flat well-kept lawn without any trees or structures within a radius of 10 m, and reportedly undisturbed since 1950. Most sites were lawns of tabernacles, schools, city offices, parks, or private homes which were heavily watered because of the arid climate. We have also identified in Table 1 some urban sites from earlier soil studies in Utah (Hardy et al., 1972a; Hardy, 1976).

The standard EML soil sampling method was used (Harley, 1972) in which eight to ten, 8.9 cm diameter cores spaced 0.5 m apart were taken to a depth of 30 cm. The sampling for each was done sequentially by first removing a 5 cm deep surface core. Usually this was then sliced into two separate 2.5 cm fractions. Then a 10 cm corer was inserted into the hole to obtain a 5 to 10 cm cut. Finally the remainder of the core was removed with an auger down to 30 cm or to a shallower depth when large rocks or stones prevented a deeper sample from being taken. Some profiles omitted the 5 to 10 cm cut and went directly from 5 to 30 cm. At other sites only surface soil samples (0 to 2.5 cm, 2.5 to

to 5.0 cm, or 0 to 5 cm) were taken. At a few sites where core samples were difficult to obtain due to terrain features or soil texture, samples were recovered from one or more areas of 400 to 900 cm^2 each as outlined by square metal templates. This technique has been used in earlier soil studies under similar conditions (Hardy, 1976; Krey and Hardy, 1970).

The soil samples are air dried, crushed, pulverized and blended according to EML standard procedures (Harley, 1972). About 100 g of the pulverized fractions were analyzed for ^{137}Cs by gamma-ray spectrometry at EML as reported earlier (Beck and Krey, 1980). Individual 100 g aliquots of selected samples were also analyzed for ^{90}Sr. These ^{90}Sr measurements were performed as a point of comparison to earlier ^{90}Sr studies in Utah (Hardy et al., 1972b). We had selected ^{137}Cs as our reference fission product for this study rather than ^{90}Sr because of its ease of measurement and because of its lesser mobility in soil. We were concerned that some of the ^{90}Sr might have percolated down below the 30 cm depth of our normal sampling methods.

One kg aliquots were removed from the pulverized fractions for ^{238}Pu and $^{239+240}Pu$ analyses. At a number of sites, the samples taken at each depth interval were analyzed independently for $^{239+240}Pu$ to indicate its distribution within the soil. At most sites we were interested in the total integrated deposit of plutonium. Therefore, we prepared a 1 kg aliquot of the entire core to a depth of 30 cm by compositing aliquots from each depth interval which reflected the fractional mass of each depth sample to the total mass in the core. Although these composite samples were homogenized, the efficiency of this homogenization is not relevant because the entire 1 kg aliquot was analyzed radiochemically.

On a selected number of these 1 kg samples, ^{241}Am analyses were also performed sequentially with the plutonium analyses. Americium-241 was selected for a limited investigation because, like ^{240}Pu, it should be deficient relative to ^{239}Pu in NTS debris as compared to global fallout. This follows because the high neutron flux in the large nuclear explosions, which were responsible for most of the global fallout, elevated the ^{241}Pu content (the ^{241}Am precursor) along with the ^{240}Pu content. Consequently, the ^{241}Am analysis should provide an independent though less precise check of our plutonium results. After the plutonium radioassays were completed, the separated plutonium fractions were analyzed for their isotopic composition by mass spectrometry.

The radiochemical analyses were performed by the Environmental Analysis Laboratories, Inc. (EAL), Richmond, CA. The samples were leached according to a version of the EML soil leaching procedure (Harley, 1972). An earlier study of soil samples recovered from Nevada, Utah and Idaho showed that acid extraction was as effective as complete dissolution in recovering the plutonium present (Hardy, 1976). The mass spectrometry was performed by the Analytical and Nuclear Research Section of the Pacific Northwest Laboratories (PNL), Battelle, Richland, WA.

ANALYTICAL RESULTS

The analyses of ^{90}Sr, ^{238}Pu, $^{239+240}Pu$, ^{241}Am and the plutonium mass isotopic composition decay corrected to 1980 at each site are presented in Table 2. In Table 2 and other tables of this report $^{239+240}Pu$ will be represented as ^{239+}Pu as a matter of convenience. The $^{242}Pu/^{239}Pu$ atom ratios are not reported because a ^{242}Pu contaminant was introduced during the chemical analyses of the sample. The total inventory of ^{137}Cs in the soil samples ($mCi\ km^{-2}$) as of 1979 previously reported by Beck and Krey (1980) are included in Table 2 for ease of reference. Recent data from several sites in the eastern United States are also included as characteristic of global fallout.

Table 3 gives the activity ratios of the nuclides measured in this study. Table 4 summarizes the precision of duplicate soil sampling and analysis from the same city or town. We have limited Table 4 to the $^{239+240}Pu$ deposition and the plutonium atom ratio because these are the critical parameters in estimating the NTS contribution at each site.

There are several sites in which duplicate collections were made that are reported upon in Table 2 but not in Table 4 because those sets of samples are not considered representative of the sampling precision achievable by the EML coring method. Jordan Park in Salt Lake City is not considered a duplicate of the two other sites in that city because it is located in the western region of the city where the rainfall is probably less than in the eastern and more elevated region where the other two sites are located. In addition a bottle cap and some bits of glass were found in the soil sample suggesting that the site may have been disturbed.

The Enterprise Reservoir samples and the samples from the Wilkens residence in Duchesne are omitted from Table 4 because they were retrieved by a variably sized template method. The core sample from the Heber Tabernacle lawn was not representative because a 5 cm asphalt layer was encountered at a depth of 15 cm. Subsequent to collection, local officials recalled the prior existence of a tennis court at the site which was removed in the mid sixties. Finally the two samples from the Scoville residence in Green River are omitted as representative duplicates in Table 4 because each consisted of only 3 cores instead of the usual 10 (an area of 186 cm^2 instead of 620 cm^2).

Table 5 gives the results of the coded blank and reference soil samples which were submitted blind to the contractor.

Quality Assurance

The quality of the estimate of the NTS ^{137}Cs at any site is related to the representivity of the soil sampling and aliquoting, and to the quality of the

analysis of ^{137}Cs, $^{239+240}Pu$ and the plutonium mass isotopic composition. We will address each of these factors separately. If the criteria for selecting a soil sampling site are satisfied, the EML sampling method has been shown to provide reasonable estimates of the local, regional, and global fallout (Hardy, 1975; Krey, 1976; Hardy et al., 1973).

Beck and Krey (1980) have shown that the prepared soil samples from this Utah study are sufficiently homogeneous that the ^{137}Cs measurements of duplicate aliquots agree to within two standard deviations of the counting rates. Table 2 corroborates that finding in that the measurements of duplicate aliquots for ^{238}Pu, $^{239+240}Pu$ and ^{241}Am also agree to within two standard deviations of the radioassay value. However, one of the two sets of ^{90}Sr analyses of duplicate aliquots does disagree by slightly more than two standard deviations of the individual measurements.

The measurements of the $^{240}Pu/^{239}Pu$ atom ratios are much more precise, usually within a few tenths of a percent for the former and two to three times as much for the latter. While the mass isotopic compositions of the duplicate aliquots usually differ by more than twice the counting error in Table 2, the standard deviations about the mean are generally $\leq \pm 1\%$. This suggests that the homogeneity of the soil sample relative to the plutonium isotopic composition is >99%, but not quite 100%. A notable exception is the 13% standard deviation of the mean $^{240}Pu/^{239}Pu$ atom ratio at Tremonton, for which we have no ready explanation.

We have assumed that, except for Salt Lake City, there is little gradient in the cumulative fallout within each city. From a series of duplicate soil collections and ^{137}Cs measurements at a number of Utah cities and towns, Beck and Krey (1980) inferred a precision of soil sampling and analysis for ^{137}Cs of ±8%. By taking the root mean square of the percent deviations between duplicate $^{239+240}Pu$ measurements given in Table 4, we arrive at a similar precision estimate of soil sampling and analyses for $^{239+240}Pu$ of ±9%. Similar calculations with the $^{240}Pu/^{239}Pu$ and $^{241}Pu/^{239}Pu$ atom ratios in Table 4 yield precision estimates of ±3.0 and ±4.1%, respectively, for the determination of these values at any given site.

The results of the coded blank samples in Table 5 indicate that any contamination of ^{90}Sr, ^{238}Pu and $^{239+240}Pu$ introduced during the preparation or analyses of the samples was insignificant compared to the activities present in the samples. The four blind analyses of the Chester reference sample for $^{239+240}Pu$ agreed with EML's assigned value within one standard deviation of the combined errors. Because of a ^{238}Pu contamination that existed at the Laboratory at the time that the Chester reference sample was analyzed, EML does not report any ^{238}Pu data for comparison. Similarly the analysis of the blank samples spiked with PNL's pure ^{239}Pu agree to within two standard deviations of the

counting errors with PNL's expected value. In addition the mass isotopic analyses of these pure ^{239}Pu samples indicate that normal sampling and analysis does not introduce sufficient ^{240}Pu or ^{241}Pu to significantly affect the plutonium atom ratios in the samples. Finally, the ^{90}Sr analyses of the reference sample agreed with the EML value within two standard deviations of the combined errors.

The Chester reference soil was blended with a small amount of Rocky Flats, CO soil which markedly decreased the $^{240}Pu/^{239}Pu$ and $^{241}Pu/^{239}Pu$ atom ratios. The individual aliquots reflected some scatter in the plutonium mass isotopic composition which might be expected for a blended composite of this kind.

The standards used to calibrate the gamma spectrometers for ^{137}Cs at EML, the beta counters for ^{90}Sr and alpha spectrometers for the Pu isotopes and ^{241}Am at EAL, and the mass spectrometers for the plutonium atom ratio measurements at PNL are all traceable to NBS. The calibration errors are <5% for ^{137}Cs, 5.8% for ^{90}Sr, 2.4% for alpha spectrometry and about 0.3% for the mass isotopic composition.

Depth Profile of Plutonium

Table 2 indicates that most of the plutonium at sites where depth profiles were analyzed resides in the lowest depth interval recovered. This was also found to be true for ^{137}Cs (Beck and Krey, 1980), and we believe it is due to the excessive watering necessary for lawn maintenance in this arid region. However, if we adjust for the varying intervals of depth sampled, it is apparent that we recovered essentially all the plutonium deposited in the soil. As a typical example, the concentration of $^{239+240}Pu$ (in units of mCi km^{-2} cm^{-1}) is plotted versus the midpoint of the sampling depth at the University of Utah in Figure 2. The area beneath the curve represents the total plutonium deposit at the site. Clearly, little plutonium penetrated below the 30 cm depth of our normal sampling procedure.

The pattern in Figure 2 is repeated at all depth profile sites except Hanksville. However, we believe that the site in Hanksville is not representative as we will discuss in greater detail in a later section.

Table 2 also shows that the $^{240}Pu/^{239}Pu$ and $^{241}Pu/^{239}Pu$ atom ratios at all depth profile sites (even including Hanksville) decreased with depth. This is reasonable because the NTS debris, which we will show later has lower plutonium atom ratios, was deposited before most of the global fallout and would have a longer period of time to percolate to greater depths.

^{90}Sr, ^{238}Pu and ^{241}Am Patterns

The ^{90}Sr results in Table 2 verify our concern that some of the ^{90}Sr might have percolated below the 30 cm depth of our sampling. This is more clearly

recognized in Figure 2 where we have also plotted the concentration of ^{90}Sr (in units of mCi km^{-2} cm^{-1}) versus the midpoint of the sampling depth at the University of Utah. The curve does not intercept the abscissa until some depth >30 cm indicating transport of ^{90}Sr below that depth.

The $^{137}Cs/^{90}Sr$ ratios in Table 3 decrease with depth at all sites, which also demonstrates the greater mobility of ^{90}Sr. The ratios for the integral activities at the Utah sites are 50 to 100% greater than those of global fallout at the eastern Pennyslvania sites in Table 3. Some part of this excess ^{137}Cs can be attributed to the loss of ^{90}Sr through the bottom of our sampling core, but we suspect that a part may also be due to an elevated ratio inherent in some NTS debris.

Little information relative to the objective of this study can be gleaned from the ^{238}Pu data because the $^{238}Pu/^{239+240}Pu$ activity ratios of weapons grade plutonium and fallout from large thermonuclear detonations are not greatly different (Krey and Krajewski, 1972; Perkins and Thomas, 1980). The ^{238}Pu results show no consistent correlation with the $^{239+240}Pu$ data and will not be discussed further in this report. There is a weak correlation between the ^{241}Am results and the $^{240}Pu/^{239}Pu$ atom ratios as seen in Figure 3. This relationship is reasonable because, as indicated earlier, the neutron flux in the production reactor or in the nuclear detonation that elevates the ^{240}Pu content relative to the ^{239}Pu content also elevates the ^{241}Pu content. Since ^{241}Am is the daughter of ^{241}Pu, it follows that its content should be elevated also. The ^{241}Am ingrowth is dependent upon the time of deposition, which tends to decouple the above correlation. It can be used, however, as a guide or cross check of the validity of a total plutonium analysis at a particular site by comparing the observed $^{241}Am/^{239+240}Pu$ activity ratio at that site with the ratio measured at other sites in the same general geographical area.

RESOLVING GLOBAL AND NTS FALLOUT

It has been shown (Hardy et al., 1972) that a mixture of two sources of $^{239+240}Pu$ in a sample each with a unique isotopic composition can be resolved by the equation

$$\frac{(Pu)_N}{(Pu)_G} = Y = \frac{(R_G - R_S)(1 + 3.73\ R_N)}{(R_S - R_N)(1 + 3.73\ R_G)} \qquad (1)$$

where

(Pu) = activity of $^{239+240}Pu$ per unit area
R = $^{240}Pu/^{239}Pu$ atom ratio

The subscripts N, G and S refer to our specific case of NTS fallout, global fallout and sample, respectively. We have increased the constant in equation (1) from its original value of 3.6 to 3.73 to reflect a more recent estimate of the half life of ^{240}Pu (6537 years). If we can assign a representative value to R_N, which will be discussed in a later section, and since R_G is known and R_S is measured, we can evaluate Y. By definition

$$(Pu)_G + (Pu)_N = (Pu)_S \tag{2}$$

Therefore,

$$(Pu)_G = \frac{1}{1 + Y} (Pu)_S \tag{3}$$

Since $(Pu)_S$ is measured in the sample, we can quantify $(Pu)_G$. Finally, if we know the activity ratio of global ^{137}Cs to Pu $(^{137}Cs/Pu)_G$, then we can calculate the NTS ^{137}Cs deposit by

$$(^{137}Cs)_N = (^{137}Cs)_S - (^{137}Cs/Pu)_G (Pu)_G \tag{4}$$

Studies conducted in 1971 showed that the ^{137}Cs to plutonium activity ratio in soil from global fallout is a constant within the northern temperate zone. Those data resulted in a value of 53±1%, decay corrected to 1979, for this ratio (Hardy, 1975). However, the 1971 soil measurements of ^{137}Cs were subsequently found to be low by about 6% due to an error in the calibration standard in use at that time. Fortuitously, the additional global fallout since 1971 compensated for this discrepancy and our corrected best estimate of this ratio from those data remains 53±1%. This result is corroborated by the values measured at the eastern United States control sites in 1979 given in Table 3.

The above mathematical approach is insensitive to variations in the $^{137}Cs/^{239+240}Pu$ activity ratio of NTS debris or even if some NTS tests were devoid of all plutonium. It is sensitive to the value and variability of R_N.

An equation similar to (1) can be derived to evaluate the $(Pu)_N/(Pu)_G$ activity ratio from the $^{241}Pu/^{239}Pu$ atom ratio

$$\frac{(Pu)_N}{(Pu)_G} = \frac{(R'_G - R'_S)(1 + 3.73\ R_N)}{(R'_S - R'_N)(1 + 3.73\ R_G)} \tag{5}$$

where

$R' = ^{241}Pu/^{239}Pu$ atom ratio

The plutonium isotopic values of global fallout referred to above (i.e., R_G and R_G') were determined from a worldwide sampling and analysis program conducted in 1970 and 1971 to be 0.180±.006 and (5.51±.33) x 10^{-3}, respectively, decay corrected to 1979 for the 30 to 60° N latitude band in the Northern Hemisphere (Krey et al., 1976). Additional plutonium fallout from atmospheric nuclear weapons testing has occurred since then, but not in sufficient quantity to change significantly the plutonium isotopic composition of the integrated deposits in soil. For example, the results of the four eastern United States sites given in Table 2 are representative of the integrated fallout at the mid-latitudes of the Northern Hemisphere. The mean $^{240}Pu/^{239}Pu$ and $^{241}Pu/^{239}Pu$ atom ratios and the standard deviations about these means for these four eastern United States sites are 0.1817±0.0023 and (5.34±0.15) x 10^{-3}, respectively. These values are not significantly different from the values based on Krey and Krajewski (1972).

ESTIMATION OF PLUTONIUM ATOM RATIOS OF NTS DEBRIS

The plutonium mass isotopic ratios at the Utah and Colorado sites given in Table 2 are all less than the expected global fallout values. Clearly NTS plutonium is present at all the western United States sites surveyed in this study. To quantify this presence according to equations (1) through (5) requires a determination of the plutonium isotopic ratios (R_n and R_n') of the NTS debris which arrived at each site.

Not all the plutonium-bearing clouds from the nuclear detonations at NTS followed the same trajectory. In addition the plutonium isotopic composition of the debris from each nuclear test was not the same. Therefore, it is probably not rigorously correct to assume that a single set of $^{240}Pu/^{239}Pu$ and $^{241}Pu/^{239}Pu$ atom ratios would be valid at all sites in Utah.

Nevertheless we believe that a single set of ratios can be demonstrated to represent the plutonium composition of NTS fallout at most sites in Utah within a reasonable range of uncertainty. While we recognize that this single set of ratios may not be strictly valid for every site, particularly for those close to the NTS which may have received most of their NTS plutonium fallout from only a few tests, we believe that most areas in Utah received plutonium fallout from a number of NTS tests. For areas receiving relatively small amounts of NTS plutonium (that is when R_S and R_S' are large), equations (1), (3) and (5) are relatively insensitive to R_N and R_N'.

Fortunately, it can be shown that R_N and R_N' for most sites in Utah can be inferred in several different ways, all of which provide approximately the same values.

Calibration Method

First, we can calibrate equations (1) to (4) at a sampling site where a completely independent estimate of the NTS fallout has been made. From a comparison of the ^{90}Sr fallout measured in precipitation versus that measured in soil as a function time at the University of Utah in Salt Lake City, Hardy et al. (1972) have estimated that by 1959 16 mCi/km^2 of ^{90}Sr from the NTS had been deposited at that site. Using Hardy et al.'s data and their own measurements in Salt Lake City in 1979, Beck and Krey (1980) have estimated that the NTS ^{137}Cs at this site in 1979 was 15 mCi/km^2. If we insert this value into equation (4) and work backwards through equations (3), (2) and (1), using the values for total Pu and ^{137}Cs measured at this site in 1979, we calculate that the value of R_N at this site must have been 0.0321. We would expect this value to reflect the summation of many small depositions from a large number of events throughout the testing period and thus be representative of the ratio at other sites receiving fallout from a large number of events.

A similar calibration treatment indicates that the mean $^{241}Pu/^{239}Pu$ ratio of debris reaching Salt Lake City must have been 4.45×10^{-4}, decay corrected to 1980.

These calibration ratios are partially confirmed by the published values for a soil sample collected at the University of Utah in 1959. Hardy et al. (1976) and Hardy (1981) report the $^{240}Pu/^{239}Pu$ and $^{241}Pu/^{239}Pu$ atom ratios for that sample are 0.05 and 5.5×10^{-4}, respectively, corrected to 1980. The values for the NTS debris must be lower than these university ratios and closer to our calibrated ratios because by 1959 Salt Lake City had already received a mixture of both NTS and global plutonium fallout. Integrated soil samples collected at the University of Utah in subsequent years exhibited a trend of increasing Pu atom ratios with time as global fallout contributed a greater fraction of the integrated plutonium deposit.

Mean Plutonium Atom Ratios of Individual Nuclear Tests

An entirely independent method of estimating R_N and R_N' is to examine the known (but classified) composition of the debris from the individual nuclear tests. First we assume that only tests of 10 kt or larger contributed significantly to the fallout as far away from the NTS as Utah. There were 35 plutonium-fueled detonations of 10 kt or larger, which represent an integrated explosive yield of 757 kt out of 1118 kt from all devices, both plutonium and uranium fueled, detonated above ground at the NTS (Perkins and Thomas, 1980).

The plutonium isotopic composition of these plutonium devices conveniently falls into two fairly narrow groups. One composition prevailed prior to Operation Plumbbob (1957) with a mean atom ratio of 0.0297 for $^{240}Pu/^{239}Pu$ and 2.9×10^{-4} for $^{241}Pu/^{239}Pu$, decay corrected to 1980. The second composition

which prevailed during Operation Plumbbob had mean values of 0.0684 and 1.7×10^{-3} for those ratios. If we weight the two sets of ratios by the relative kt yields of the devices in each set (563 kt pre-Plumbbob versus 216 kt during Plumbbob), we arrive at mean ratios of 0.040 and 6.8×10^{-4} for R and R′, respectively, decay corrected to 1980.

Very similar values are obtained when the ratios are weighted by the yields of the individual tests or if only the tower shots in each of the two groups are considered. These final estimates are admittedly crude since any given site cannot be assumed to have received fallout from each series in exactly this ratio. However, for sites fairly far downwind from the NTS the approximation should not be too unreasonable. Indeed the R_N and R_N' calculated in this manner are only 25% higher, respectively, than the values determined from the Salt Lake City calibration data. We would actually expect the proportion of pre-Plumbbob fallout to be greater than implied by the relative yields and the R_N and R_N' to be closer to the pre-Plumbbob values because some of the pre-Plumbbob tower shots had large quantities of materials surrounding the devices. As a result, larger than normal fallout particles were probably formed in the cloud, which could be expected to result in a greater than normal deposition at downwind distances relevant to this study.

We should address the subject of the relatively few nuclear clouds which traversed southwestern Utah and contributed most of the relatively high exposure rates measured in and around the St. George area. Normalizing the $^{240}Pu/^{239}Pu$ atom ratio of each of the 7 tests which according to Shleien (1981) contributed to this exposure by his estimate of their exposure rates, the weighted mean $^{240}Pu/^{239}Pu$ and $^{241}Pu/^{239}Pu$ atom ratios are 0.036 and 4.4×10^{-4}, respectively, decay corrected to 1980. These ratios are in good agreement with our other estimates, supporting the choice of a single set of ratios for use at all sites.

Consequently, we believe that the NTS atom ratios inferred from the Salt Lake City data, namely $R_N = 0.0321$ and $R_N' = 4.45 \times 10^{-4}$ decay corrected to 1980, which are supported by the individual device data, are the most appropriate to use at most sites in Utah.

Uncertainty in R_N

In order to reflect the fact that the values of R_N may vary from site to site and to account for this in our estimate of the uncertainties in our determinations of NTS $^{239+240}Pu$ and ^{137}Cs using equations (1) to (4), we have somewhat arbitrarily assigned an uncertainty estimate of 0.003 (σ or one standard deviation) to R_N. This estimate reflects our belief that it is unlikely that many sites in Utah received debris solely from tests having an atom ratio significantly less than the mean of the pre-Plumbbob tests, i.e., 0.0321 - 0.0297 = 0.0024. Similarly we would argue that, considering the likely greater fallout

from many of the early tests relative to their yields, the value of R_N for any site in Utah is unlikely to exceed 0.04 (i.e., 0.032 + 3 σ), the value inferred from the individual device ratios. We will demonstrate that this choice of σ allows reasonable and self-consistent estimates to be made of the total uncertainties in the NTS fallout calculations. In fact we shall see that the calculation of NTS fallout is not very dependent upon the value of R_N within the credible range of values at most of the sites sampled.

Because of the greater uncertainty in the correct value of R_N' at a given site, we have chosen to emphasize results based on the $^{240}Pu/^{239}Pu$ ratio. We will use the estimates from the $^{241}Pu/^{239}Pu$ ratio as supplementary information but without trying to calculate their errors.

NTS FALLOUT IN UTAH

Using R_N = 0.0321 and equations (1) to (4), we have estimated the contributions of global and NTS fallout to the measured total $^{239+240}Pu$ and ^{137}Cs inventories for each soil sample and report them in Table 6. We have also estimated the uncertainty of each of these estimates by combining the known or assumed uncertainties for each quantity in the equations using the standard method for combining independent errors (Volk, 1958). That method specifies that the variance of any function of variables is the sum of the products of each independent variable's variance and the square of its respective partial derivative. We have also included in Table 6 the results from our earlier soil samplings in populated cities and towns in Utah (Hardy et al., 1972a; Hardy, 1976), but we have applied the equations and constants derived in this work.

We have also calculated and reported in Table 6 the contributions of global plutonium fallout for each sample based on the measured $^{241}Pu/^{239}Pu$ atom ratios and an R_N' of 4.45×10^{-4}. The $(Pu)_G$ values for this calculation are almost identical to the values calculated from the $^{240}Pu/^{239}Pu$ atom ratios. The overall mean and its standard deviation of the $(Pu)_G$ calculated from the $^{240}Pu/^{239}Pu$ data divided by the corresponding $(Pu)_G$ calculated from the $^{241}Pu/^{239}Pu$ data is 1.02±0.05%.

In order to demonstrate that the results and their associated uncertainties given in Table 6 are reasonably correct and present an accurate indication of the true fallout at each site, we compared the global ^{137}Cs estimates with those expected on the basis of rainfall patterns and carefully examined the results for self-consistency. First Beck and Krey (1980) have suggested that a linear relationship exists between global ^{137}Cs deposition and precipitation in Utah. From their data we derive the equation

$$I = 2.56\ P + 15 \qquad (6)$$

where

I = the best estimate of the total inventory of global ^{137}Cs as of 1979 in mCi km^{-2}, and
P = the average annual rainfall at each site in cm.

The intercept of 15 mCi km^{-2} is the estimated average dry fallout for arid and semi-arid areas of the southwestern United States.

The global ^{137}Cs deposition values calculated from equations (1) to (4) and given in Table 6 are plotted against P in Figure 4. We have made a slight change from Beck and Krey's approach by redefining P as the mean of the average precipitation from 1962 to 1964 and the long term average annual rainfall (see column 2 of Table 8). This change was adopted because about 50% of the global fallout was deposited in the 3 year period from 1962 to 1964 with the remainder deposited more gradually over many years (Toonkel, 1980). The data in Figure 4 exhibit a linear trend, and a least square fit to the data excluding the Green River and Hanksville results gives the equation

$$I = 2.22\ P + 26 \qquad (7)$$

Equation (7) agrees very well with equation (6). By comparing the estimates of global ^{137}Cs calculated from the plutonium isotopic data to the values calculated from equation (7), we can show that on average the standard deviation of the estimate of global ^{137}Cs via equation (7) is ±13%. As additional verification of our method of ^{137}Cs resolution and selection of constants, we note that there are no geographical regions in Figure 4 where the points fall predominately on one side or the other of the expected correlation which would occur if the chosen value of R_N were inappropriate for those regions. The excluded Green River data will be discussed later.

Furthermore, if we compare each global ^{137}Cs value in Table 6 excluding Green River and Hanksville with the value estimated from the rainfall via equation (6), the mean ratio is 1.02 with a standard deviation of ±0.16 and a standard error of the mean of ±0.02. These excellent comparisons and lack of any geographical bias are strong evidence that our choices of a single value of R_N = 0.0321 for the NTS $^{240}Pu/^{239}Pu$ atom ratio and a standard deviation of 0.003 were reasonably valid.

In fact any other choice of R_N can be shown to give poorer agreement with the expected rainfall correlation. In Table 7 we compare the global ^{137}Cs deposition calculated at each site using R_N = 0.0297, 0.040 and 0.0684 with that estimated from the rainfall via equation (6) at that site. We selected equation (6) and the average rainfall from which it was derived for this comparison rather than equation (7) and its slightly modified rainfall values to

provide a totally independent test of our choice of R_N. Using these values of R_N, which are the values inferred earlier for the pre-Plumbbob, Plumbbob and weighted mean debris, provide results which we believe span the credible range of possible NTS ^{137}Cs and $^{239+240}Pu$ at each site. In fact the last value, 0.0684, could be considered to be an extremely conservative upper limit since it is unlikely that any large area in Utah and Colorado received all of its plutonium fallout only from the nuclear tests of the Plumbbob series. The mean ratios and standard errors of the global ^{137}Cs estimated from the rainfall to the global ^{137}Cs estimated from the various values of R_N for all the Utah and Colorado sites are:

R_N	Mean Ratio	Standard Error of the Mean
0.0297	1.04	±0.02
0.0321	1.02	±0.02
0.040	0.96	±0.03
0.0684	0.77	±0.04

Clearly the average agreement is best when $R_N = 0.0321$ and well outside the range of statistical uncertainty when $R_N = 0.0684$.

With regard to the calculated uncertainties given in Table 6, it is apparent from the structure of equations (1) and (3) that any uncertainty in R_N has its greatest impact upon the calculated NTS ^{137}Cs deposit when the observed $^{240}Pu/^{239}Pu$ atom ratio is low, i.e., when the proportion of NTS plutonium to total plutonium is high. This is further illustrated in Figure 5 where we have plotted the calculated difference in the NTS ^{137}Cs values when R_N is 0.05 and when R_N is 0.0321 (the calibration value) against the observed $^{240}Pu/^{239}Pu$ atom ratio. We have selected 0.05 as an upper limit of R_N in Figure 5, because the 1959 Salt Lake City soil data indicated an upper limit of 0.05 for R_N although we believe few sites are likely to have an R_N that high. For low values of the observed ratio, the difference could be as great as 36 mCi km^{-2}. For high values which make up most of the results, the difference is usually limited to 10 mCi km^{-2} or less. Thus even extreme deviations in the true R_N at a given site from our choice of 0.0321 will in most cases result in errors of about a factor of two in the estimated NTS ^{137}Cs deposition. Note that fairly large observed $^{240}Pu/^{239}Pu$ atom ratios do not necessarily imply small amounts of NTS ^{137}Cs fallout since much of the fallout at that site could have come from uranium fueled devices.

As an example of the self-consistency of the results and estimated errors given in Table 6, an inspection of Table 7 shows that about half the time ±2 standard deviations about the calculated NTS ^{137}Cs values using $R_N = 0.0321$ and $\sigma = 0.003$ covers the entire range of other calculated NTS ^{137}Cs values using other possible values of R_N, even $R_N = 0.0684$.

In those cases where 2 σ does not cover the entire range, the best agreement between the global ^{137}Cs estimates obtained from the Pu atom ratios and the rainfall via equation (6) occurs when R_N = 0.0321 or less, rather than a larger R_N value. Of the eight sites where the estimated global ^{137}Cs value would agree better with the rainfall-derived estimated if R_N were larger than 0.0321, two of these, Heber City (#127) and Green River (#142), are questionable sites as will be discussed later. For the remaining 6 sites, if a larger ratio is indeed appropriate at any of them, the NTS ^{137}Cs would be greater than the value we have estimated in Table 6.

The data in Table 6 do not include the ~7 to 8% uncertainty (1 standard deviation) which we know represents our sampling precision, i.e., the probability that a given soil sampling result is representative of the site or general area. Thus the true uncertainty in the fallout in a given town or area is slightly greater than that shown in Table 6. In most cases the uncertainty in the calculated NTS ^{137}Cs is much larger than ±8% so that this additional uncertainty is not significant.

As a final indication of the validity of our NTS ^{137}Cs estimates for Utah, we note that Krey et al. (1980) have estimated that the NTS ^{137}Cs at Enterprise Reservoir (site #AA) was <18 mCi km^{-2} in 1979 using an entirely independent method, i.e., an analysis of sections of a sediment core removed from that reservoir in 1979. Table 6 indicates that 14 mCi km^{-2} of NTS ^{137}Cs was deposited, which is in excellent agreement with the earlier result.

DISCUSSION OF ANOMALOUS RESULTS

A few of the results given in Table 6 are clearly anomalous or ambiguous. In many cases these can be attributed to the site or soil sample being non-representative. In other cases the result may reflect an undetected analysis error, a statistical anomaly, or the possibility that the chosen NTS plutonium atom ratios for a given site are not representative of the fallout composition at that site.

While we can specify the criteria for a representative soil sample, the actual selection of the site for this study depended not only on an evaluation of present conditions but also on the recollections by local officials and residents of the 30 year history of the site. The failure to remember the former tennis court under the Heber Tabernacle lawn is a good example of one of the errors in site selection which could invalidate a sample. Although we have no way of knowing, it is possible that a few other sites thought to be representative were indeed disturbed.

In some towns there were no completely representative sites, and we had to choose the best alternative available. The data from some of these choices appear anomalous. At the locations which follow, we question the validity of the data for the reasons given.

The pear orchard (site #16) at Hurricane was below the surrounding terrain, inviting runoff and pooling of fallout. This conjecture is evidenced by a greatly elevated ^{137}Cs and $^{239+240}Pu$ deposits (Table 2), and by a $^{137}Cs/^{239+240}Pu$ activity ratio (Table 3) which is not unreasonable for the area. Furthermore, the calculated ^{137}Cs from global and NTS sources are also elevated (Table 6), but in a proportion not greatly different from that at St. George. Unfortunately, the samples taken at the city park in Hurricane (site #17A) were only of the surface 5 cm of soil, and this site was also suspect because of heavy silt build-up from flood irrigation.

We can try to adjust for this buildup of NTS debris at the Hurricane pear orchard by normalizing to the global ^{137}Cs deposit estimated from the rainfall at this site. To accomplish this we multiply the elevated NTS ^{137}Cs in Table 6 by the ratio of the global ^{137}Cs estimated from rainfall via equation (7) (79±10) to the global ^{137}Cs in Table 6. The resulting NTS ^{137}Cs is 37±19 mCi/km^{-2} which is similar to the values observed at St. George.

The average total ^{137}Cs deposition from all sources weighted by the precision of each field spectral measurement in Hurricane and LaVerkin is 91±15 mCi km^{-2} (see Table 8, column 3). Subtracting the 79±10 mCi km^{-2} of global ^{137}Cs estimated from the rainfall correlation implies an NTS ^{137}Cs contribution of only 12 mCi km^{-2} with a standard deviation of ±18 mCi/km^{-2}. Further measurements may be required to obtain a better estimate of NTS fallout in this area.

We had no reason to suspect any irregularities at site #46 in Beaver. However, the NTS ^{137}Cs inferred for this site from the soil sampling result is anomalously <0. The field spectral results obtained at this site and at three other sites in Beaver (Table 8) gave a precision-weighted mean of 88±8 mCi km^{-2} of total ^{137}Cs compared to the 74±6 mCi km^{-2} found in the soil sample. This suggests that the soil sample was neither representative of the site nor of the rest of the town.

Furthermore, the $^{241}Am/^{239+240}Pu$ activity ratio measured at this site (see Table 3 and Figure 3) is low compared to other nearby sites. This suggests that perhaps the determination of the total $^{239+240}Pu$ is anomalously high, which would result in high estimates of global $^{239+240}Pu$ and ^{137}Cs, a high estimate of NTS $^{239+240}Pu$, but a low estimate of NTS ^{137}Cs. Using the rainfall correlation for global ^{137}Cs (equation (7)) and the weighted mean of the field spectral measurements of total ^{137}Cs given above, we estimate that the NTS ^{137}Cs fallout in Beaver was about 2±14 mCi km^{-2} in reasonable agreement with estimates made in nearby towns.

As mentioned previously, site #127A in Heber City was clearly disturbed, and the data from that site must be disregarded. The site at Jordan Park in Salt Lake City (#96) may also be questionable as discussed earlier. Although the NTS ^{137}Cs fallout at this site is similar to that at the other two Salt Lake City sites, the total $^{239+240}Pu$ at Jordan Park is much lower.

Site #128 in Duchesne for which a negative NTS ^{137}Cs estimate was obtained was a poorly watered lawn which purportedly had accumulated large amounts of blow sand. In addition, the soil sample from this site was recovered by the template method of sampling. The soil sample from the pasture site in Duchesne (site #129) was recovered by the standard coring method and exhibited the same $^{240}Pu/^{239}Pu$ atom ratio as the sample from site #128. The pasture sample also reflected the same total $^{239+240}Pu$ deposition and thus the same estimated global ^{137}Cs fallout as the sample from site #128. However, since the total ^{137}Cs deposition was higher at the pasture site, a positive value for the estimated NTS ^{137}Cs was obtained.

However, the field spectral measurements at the two Duchesne sites tend to confirm the total ^{137}Cs result from site #128 and suggest that the result from the pasture site (#129) is too high. Since two standard deviations about each of the reported values allow both NTS ^{137}Cs estimates to be positive, we have chosen to accept both results as being statistically valid, and to assume that the weighted average for the two sites is a reasonable estimate of the NTS ^{137}Cs fallout in Duchesne (3±4).

The northern location at the Scoville residence in Green River (sample #2675 at site #142) was suspected of having been disturbed at an earlier time and also of having silt buildup from flood irrigation. The southern location at this site was less affected. The northern location in Table 6 reflected a possibly negative or zero ^{137}Cs contribution from the NTS, but the southern location suggested a contribution of 25±7 mCi km^{-2}. This latter value agrees with the result from the normally collected sample at the Anderson residence in Green River (site #141). Since the soil samples recovered from the Scoville residence were substandard, each reflecting only 3 cores, and since the result from the more reliable one agreed with the value of the Anderson residence, we feel that the weight of evidence justifies the disregarding of the result from the northern location at the Scoville residence.

The total ^{137}Cs deposit at Green River is quite elevated relative to the amount of precipitation recorded for the town (Beck and Krey, 1980) as is the global ^{137}Cs reported in Table 6. If the water used to maintain the lawns at the two residences in Green River contained silt from the local river, the NTS ^{137}Cs deposit that we estimate would represent an upper limit. While this matter is not sufficiently resolved, our data suggests that 22±9 mCi km^{-2} of NTS ^{137}Cs was deposited in Green River.

The lawn of the Edwards residence in Monticello (site #149) appeared to satisfy our criteria for a representative site. However, we learned that at an earlier time a uranium ore processing plant had operated in Monticello, but had since been dismantled. The gamma-ray field spectrum was unusual and suggested that a layer of uranium ore such as mill tailings may have been used as fill and had been subsequently covered by overlying soil. In addition the laboratory gamma spectral measurements of the soil samples indicated a significant increase in the uranium concentrations at the lower depths relative to the surface soil. These observations challenge the reported undisturbed history of the site and support our feeling that the 42±8 mCi km^{-2} of NTS ^{137}Cs reported in Table 6 for this site is unreliable.

The field spectral measurements (Beck and Krey, 1980) at another site in Monticello (117±31 mCi km^{-2} of ^{137}Cs) and the global ^{137}Cs from the rainfall correlation (99±15 mCi km^{-2}) indicate an NTS ^{137}Cs deposit of 18±34 mCi km^{-2}. Although the uncertainty is very large, this value is much lower than that estimated from the soil sample at the Edwards residence (site #149) and is more in line with the values inferred at other sites in eastern Utah and in Grand Junction, CO.

Similarly the NTS ^{137}Cs value of 27±3 mCi km^{-2} inferred for Moab (site #152A) in Table 6 seems high. Once again the field spectral measurement of 61±10 mCi km^{-2} of total ^{137}Cs for this site (Beck and Krey, 1980) is more in line with the values measured at other sites in Moab, suggesting that the 79±6 mCi km^{-2} of total ^{137}Cs measured in the soil at site #152A is too high and the calculated NTS ^{137}Cs an overestimate. If we assume that the field spectral measurement of the total ^{137}Cs deposition (61±10 mCi km^{-2}) is correct and subtract the estimated 51±2 mCi km^{-2} of global ^{137}Cs shown in Table 6, we arrive at a reasonable 10±10 mCi km^{-2} of NTS ^{137}Cs in Moab. Neither the Monticello or Moab results were substantially affected by the choice of the $^{240}Pu/^{239}Pu$ atom ratio for NTS debris.

The town of Hanksville had no well kept grass lawns and few sites of known history. The site that we selected to sample (site #143) at an abandoned churchyard had only a 50% prairie grass cover and was located about 50 feet from a flood irrigation ditch. The analytical results corroborate that the site is nonrepresentative. For example, the total ^{137}Cs and $^{239+240}Pu$ deposition are greatly elevated compared to values at neighboring sites. Unlike any other site, the depth profile indicates that some plutonium was present below the 30 cm limit of our sampling procedure. In addition, the NTS ^{137}Cs calculated in Table 6 is an impossible -98 mCi km^{-2}. Unfortunately, none of the other sites surveyed in this town using <u>in situ</u> spectrometry provided reasonable results. Therefore, we are unable to provide an NTS ^{137}Cs estimate for Hanksville.

SUMMARY AND CONCLUSIONS

In Table 8 we report our best estimate of the NTS ^{137}Cs inventory as of 1979 in each population center in Utah surveyed in this study. The value at the time of the initial deposition at each site was approximately a factor of two higher than that given in Table 8 due to the radioactive decay in the intervening years since 1951-1957 when most of the NTS deposition occurred. These best estimates are also superimposed on a map of Utah in Figure 6.

Whenever possible, the best estimates are based on the more reliable and precise soil sample results given in Table 6 and repeated in column 4 of Table 8, using a weighted mean when multiple samples were taken in the same town. For towns where the soil analyses were anomalous or where no samples were taken, the best estimates are based on the NTS ^{137}Cs values calculated from the rainfall correlation in equation (7) and the field spectrometric estimates of total ^{137}Cs inventories reported earlier by Beck and Krey (1980). The errors of the NTS ^{137}Cs values calculated from rainfall and field spectra data are based upon the reported errors of the total ^{137}Cs deposit and a $\pm 13\%$ uncertainty on the estimate of global ^{137}Cs via equation (7). These latter NTS ^{137}Cs estimates are not as precise as the values calculated from the soil sample analyses but are provided for all samples in columns 5 of Table 8 as supporting evidence. In Figure 6 the best estimates based on the more precise soil-sample analyses are shown in large type, and the less precise best estimates from rainfall and field spectral data are shown in small type.

The results indicate a definite geographic pattern. The NTS ^{137}Cs is elevated in the southwestern corner of the state but decreases rapidly with distance along a northeasterly diagonal direction from the NTS. The sites to the east of one of the mountain ranges oriented along this diagonal (i.e., Panguitch, Richfield and Gunnison) appear to have received slightly less fallout than the cities to the west (i.e., Parawan, Filmore, Delta, etc.). Midway along the diagonal through Utah, the NTS ^{137}Cs deposits increased and remained elevated throughout the remainder of the state. In the populated Provo and Salt Lake City valleys, the deposits were about $\frac{1}{2}$ that for St. George. Relatively high levels are also present in Eastern Utah and as far east as Grand Junction, CO. Although some of the eastern Utah measurements were questionable, typical levels in the range of 10 to 20 mCi km^{-2} seem confirmed by the overall results.

A similar plot of the NTS $^{239+240}Pu$ inventories in each town is shown in Figure 7. Although we do not expect an exact correlation here with the ^{137}Cs deposition, since some fallout events were due to uranium fueled devices, we do expect the general pattern to be consistent, as indeed it is. The NTS Pu levels around Provo and Salt Lake City are in fact even higher than at St. George, while the levels in eastern Utah are comparable to these around Cedar City and Panguitch. We believe these results reflect the fact that although many clouds from nuclear

detonations at NTS took a northerly track from NTS, most eventually assumed an easterly vector toward Utah at varying distances downwind. The somewhat lower Pu levels in the east, relative to ^{137}Cs deposition, along with the generally high $^{240}Pu/^{239}Pu$ atom ratios measured in the soils from these areas, suggest a larger fraction of the fallout in this area was from uranium fueled tests, perhaps in good measure to the Smoky shot in 1957 which was known to traverse Utah from southwest to northeast.

The results obtained in this study and summarized in Table 8 and Figure 6 will be used to estimate the population exposure from direct external radiation for each town surveyed and by extrapolation to towns not surveyed. These population exposures will rely on estimates of fallout arrival time at each town, known and inferred relationships between ^{137}Cs deposition and total fission product deposition, and established relationships between external exposures rates and soil activities for each fission product. These exposure estimates and underlying assumptions will be presented and discussed in an ensuing report.

The data presented here, however, confirm the tentative conclusion made by Beck and Krey (1980). Based on a preliminary but conservative estimate of 100 mR per mCi km^{-2} of ^{137}Cs from NTS, the cumulative exposure to the population of southwestern Utah from external radiation is in reasonable agreement with the exposure based on postshot monitoring data (NOAA, 1979). It appears, however, that even after correcting for the later arrival time of the NTS debris and the corresponding lower exposure per unit ^{137}Cs deposited, the population weighted exposure in person rads, i.e., the cumulative exposure multiplied by the number of people per unit area, in other parts of Utah may prove to be significantly higher than the population weighted exposure in southwestern Utah.

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TABLE 1

SOIL SAMPLING SITES

Town	Sampling Year	Site No.	Description
Enterprise Reservoir	1979	AA	Meadow - unwatered
St. George	1979	3	City park lawn
" "	"	5	Old hospital lawn
Enterprise	1979	9A	Forest ranger station - north lawn
Hurricane	1979	16	Pear orchard
"	"	17A	City park - S.W. lawn
Kanab	1979	20A	Hamblin residence - west lawn
"	"	22	Cemetery expansion area - unwatered
Parawan	1979	26A	Adams residence - N.E. lawn
Cedar City	1979	35	Old railroad station lawn
" "	"	36	S. Utah State College - old football field
Panguitch	1979	39	Tabernacle lawn
"	"	42	Forrest ranger station
Beaver	1979	46	Visitors Center lawn
Milford	1979	51	City offices lawn
Filmore	1979	54B	High school - East lawn
Delta	1979	58B	Ludwig residence - side lawn
Richfield	1979	63	Masonic lodge lawn
Gunnison	1979	66	Old city building lawn
Nephi	1979	71	High school lawn
"	"	72	City park lawn

TABLE 1 (Cont'd)

Town	Sampling Year	Site No.	Description
Payson	1979	75	Old high school lawn - poorly watered
Provo	1971	1	Utah State Hospital lawn
"	1979	83	Memorial park lawn
"	"	85	North park lawn
Salt Lake City	1971	2	Liberty park lawn
" " "	1979	89	Liberty park lawn - W. central
Midvale	1979	90	City park lawn
Salt Lake City	1971	3	University of Utah campus lawn
" " "	1979	95	" " "
" " "	1979	96	Jordan park lawn
Magna	1979	99	Brockbank Jr. High School lawn
Tooele	1979	101	Tooele school lawn
Bountiful	1979	104	LDS Wardhouse lawn
Layton	1979	107	City park lawn
"	"	108	Van Kampen residence lawn
Ogden	1979	110	Mt. Ogden park lawn
Brigham City	1971	5	Tabernacle lawn
" "	1979	115	" "
Tremonton	1979	119	Bear River High School athletic field
Logan	1979	123	Utah State University campus
Heber City	1971	6	Tabernacle lawn
" "	1979	126	Central High School lawn
" "	1979	127A	Tabernacle lawn (disturbed)
Marion	1971	7	Cemetery

TABLE 1 (Cont'd)

Town	Sampling Year	Site No.	Description
Duchesne	1979	128	Wilkens residence lawn
"	"	129	Pasture - possibly watered
Vernal	1979	132	Central school lawn
Price	1979	135	Eastern Utah College Campus
"	"	136	Cemetery lawn
Dragerton	1979	138	Private residence lawn - Grassy Trail Rd.
Green River	1979	141	Anderson residence lawn
" "	"	142	Scoville residence lawn
Hanksville	1979	143	Stone Church yard
Blanding	1979	146	Tabernacle lawn
Monticello	1979	149	Edwards residence lawn
Moab	1979	152A	Kirk residence lawn
Grand Junction, CO	1979	155	Tope Elementary School lawn
" " "	"	157	Whitman park lawn
Middletown, PA	1979	500	Old Fellows Home lawn
West Donegal, PA	1979	501	Goods Mennonite cemetery
Conoy, PA	1979	502	Stevens Hill Church yard
N. Eastham, MA	1978	503	Grassy clearing

TABLE 2

RADIOACTIVITY CONCENTRATIONS AND PLUTONIUM ATOM RATIOS*

Town	Site No.	Sample No.	Depth (cm)	Dry Wt. (g)	Area (cm^2)	pCi kg^{-1} ± % Stnd.				mCi km^{-2} ± % Stnd. Dev.		Atom Ratios ± % Stnd. Dev.	
						^{90}Sr	^{238}Pu	^{239+}Pu	^{241}Am	^{137}Cs	^{239+}Pu	$^{240}Pu/^{239}Pu$	$^{241}Pu/^{239}Pu$ (10^{-2})§
Enterprise reservoir	AA-1	2608	0-20	19050	1200		0.60±13	15.4±6	4.22±5	120±1.1	2.44 ±6	0.14057±0.20	0.3953±0.48
" "	AA-2	2609	0-20	10300	800		0.53±11	13.1±5	3.49±5	81.4±1.8	1.69 ±5	0.13166±0.58	0.3687±1.5
St. George city park	3	2610	0-2.5	1415	620	98.6±5	0.80±5	18.0±5	2.68±7	16.0±8.8	0.411±5	0.08728±0.10	0.2324±0.43
" " " "	"	2611	2.5-5	1639	"	97.3±5	0.85±6	20.7±5	3.73±9	18.0±7.2	0.547±5	0.08331±0.17	0.2107±0.47
" " " "	"	2612	5-30	22225	"	47.3±5	0.42±91	6.71±7	0.775±9	62.7±2.9	2.41 ±7	0.07734±0.47	0.1956±2.5
" " " "	"		INTEGRATED	25279	"					96.7±2.6	3.37 ±5.1	0.07948±0.33	0.2024±1.7
St. George old hosp.	5	2613**	0-30	22531	620		0.30±10	6.90±5	1.01±12	90.8±3.4	2.51 ±5	0.07852±0.10	0.1918±0.57
" " " "	"	2623**	"	"	"		0.28±16	7.61±5	1.09±14	"	2.77 ±5	0.07748±0.18	0.1910±0.79
Enterprise ranger station	9A	2614	0-2.5	1484	620	62.6±5	0.71±7	17.0±5	3.98±6	23.2±6.0	0.407±5	0.15956±0.16	0.5023±0.42
" " "	"	2616	2.5-5	1719	"	77.9±5	0.53±11	14.0±5	3.44±5	18.0±7.8	0.388±5	0.14587±0.23	0.4124±0.46
" " "	"	2617	5-30	22150	"	52.3±6	0.16±17	2.94±5	0.590±12	36.1±8.0	1.05 ±5	0.11896±0.22	0.3077±0.75
" " "	"		INTEGRATED	25353	"					77.3±4.2	1.85 ±3.2	0.13321±0.13	0.3714±0.39
Hurricane pear orch.	16	2618	0-5	2628	496		1.48±9	37.7±6	7.48±5	91.7±2.9	2.00 ±6	0.10178±0.16	0.2706±0.37
" " "	"	2619	5-30	18100	"		0.59±11	13.8±5	2.55±10	173±2.7	5.04 ±5	0.08445±0.24	0.2024±0.79
" " "	"		INTEGRATED	20728	"					265±1.8	7.04 ±4.0	0.08937±0.17	0.2218±0.53
Hurricane city park	17A	2620	0-2.5	534	248		0.35±13	7.30±5		22.8±6.6	0.157±5	0.12336±0.28	0.3820±0.50
" " "	"	2621	2.5-5	777	"		0.41±17	8.99±6		18.2±8.8	0.281±6	0.09885±0.49	0.2529±1.0
Kanab Hamblin res.	20A	2622	0-30	25095	620		0.27±17	5.76±6	1.24±8	91.9±2.4	2.33 ±8	0.12290±0.23	0.3370±1.2
Kanab cemetery	22	2413-1	0-5	1443	248		0.33±10	5.44±4		30.3±4.1	0.317±4	0.14426±1.2	0.4602±0.63
Parawan Adams res.	26A	2624	0-30	25024	620		0.23±17	6.61±6	1.58±6	126±1.6	2.67 ±6	0.14430±0.28	0.3978±0.53
Cedar City R.R. station	35	2625	0-30	26521	620		0.21±13	4.73±5	1.04±7	94.4±4.2	2.02 ±5	0.14315±0.12	0.4098±0.61
Cedar City S. Utah State College	36	2626	0-30	27499	620		0.12±28	4.36±6		84.4±4.4	1.93 ±6	0.14225±0.17	0.4045±0.84
Panquitch Tab.	39	2627	0-30	21222	620		0.15±28	4.29±8	1.05±5	69.8±4.7	1.47 ±8	0.14927±0.31	0.4338±1.2
Panquitch ranger sta.	42	2628	0-23	13638	496		0.17±32	6.66±8		81.0±2.4	1.83 ±8	0.13970±0.21	0.3976±1.3
Beaver visitors center	46	2629	0-23	16194	496		0.27±8	8.53±5	1.53±12	74.3±3.7	2.78 ±5	0.11821±0.15	0.3345±0.72
Milford city offices	51	2630	0-24	15950	496		0.23±9	7.16±5		85.1±3.1	2.30 ±5	0.12248±0.10	0.3499±0.37
Filmore H.S.	54B	2632	0-18	12879	620		0.41±11	13.4±5		105±2.0	2.78 ±5	0.11164±0.20	0.3122±0.77
Delta Ludwig res.	58B	2633	0-25	18949	620		0.26±8	7.27±5		93.1±3.5	2.22 ±5	0.11120±0.12	0.3049±0.33

*All values are reported as of 1980 except ^{137}Cs which is reported as of 1979.

§Column heading identifies units in column, i.e., 0.3953±0.48 is equivalent to $0.3953 \times 10^{-2} \pm 0.48\%$.

**Duplicate aliquots

TABLE 2 (Cont'd)

Town	Site No.	Sample No.	Depth (cm)	Dry Wt. (g)	Area (cm^2)	pCi kg^{-1} ± % Stnd. Dev.				mCi km^{-2} ± % Stnd. Dev.		Atom Ratios ± % Stnd. Dev.	
						^{90}Sr	^{238}Pu	^{239+}Pu	^{241}Am	^{137}Cs	^{239+}Pu	$^{240}Pu/^{239}Pu$	$^{241}Pu/^{239}Pu$ (10^{-2})§
Richfield lodge	63	2634	0-27	20422	620		0.18±9	4.31±5		59.7±3.9	1.42 ±5	0.13361±0.18	0.3817±0.58
Gunnison city building	66	2635	0-28	17346	496		0.27±12	6.61±5		81.7±2.4	2.31 ±5	0.12170±0.16	0.3519±0.63
Nephi H.S.	71	2636	0-18	10570	496		0.46±12	10.5±5		88.0±2.4	2.24 ±5	0.12272±0.10	0.3503±0.46
Nephi city park	72	2637	0-30	24829	620		0.33±12	6.71±5		107±3.5	2.69 ±5	0.11863±0.10	0.3374±0.50
Payson H.S.	75	2638	0-25	21954	620		0.31±22	12.3±7		126±2.1	4.36 ±7	0.08992±0.27	0.2378±1.0
Provo Mem. park	83	2640	0-27	18233	620		0.41±10	17.3±5	2.64±5	117±3.0	5.09 ±5	0.07409±0.10	0.1894±0.32
Provo North park	85	2641	0-19	14623	620		0.41±8	18.8±5		118±1.8	4.43 ±5	0.07769±0.18	0.2015±0.45
Midvale city park	90	2642	0-30	24420	620		0.28±15	8.32±5		123±2.4	3.28 ±5	0.10693±0.14	0.2962±1.1
SLC Liberty park	89	2647	0-30	20285	620		0.54±25	15.2±10		133±2.2	4.96 ±10	0.08436±0.23	0.2289±1.7
SLC Univ. of Utah	95	2644	0-2.5	854	620	121±5	0.29±20	12.0±7	1.78±5	14.5±6.9	0.165±7	0.10702±0.13	0.3398±0.59
" " " "	"	2645	2.5-5	1733	"	134±5	1.20±11	39.9±6	6.21±5	22.9±7.4	1.12 ±6	0.08600±0.10	0.2346±0.43
" " " "	"	2646	5-10	5039	"	94.1±7	0.60±12	21.4±6	4.09±5	52.0±6.3	1.74 ±6	0.09344±0.11	0.2493±0.52
" " " "	"	2648	10-30	18475	"	69.4±11	0.23±17	7.10±5	0.955±6	54.8±3.8	2.12 ±5	0.08436±0.25	0.2183±1.4
" " " "	"		INTEGRATED	26101	"					144±3.0	5.15 ±3.2	0.08843±0.11	0.2360±0.57
SLC Jordan park	96	2649	0-30	23011	620		0.28±16	8.00±5		120±4.2	2.97 ±5	0.11740±0.11	0.3290±0.49
Magna Jr. H.S.	99	2650	0-30	28609	620		0.26±11	7.98±5		153±1.5	3.68 ±5	0.12548±0.10	0.3511±0.51
Tooele school	101	2651	0-30	25134	620		0.28±14	7.61±5		139±2.4	3.09 ±5	0.14118±0.18	0.4056±1.1
Bountiful Wardhouse	104	2652	0-30	22651	620		0.36±15	10.4±6		151±2.3	3.80 ±6	0.12360±0.30	0.3551±1.3
Layton city park	107	2653	0-30	27891	620		0.40±19	8.76±8		133±2.3	3.94 ±8	0.10254±0.28	0.2823±1.6
Layton Van Kampen res.	108	2654-1	0-30	25006	620		0.29±8	10.5±5		142±1.9	4.23 ±5	0.09900±0.10	0.2742±0.47
Ogden park	110	2656**	0-2.5	1558	620	167±5	0.84±8	15.9±5		22.9±6.6	0.400±5	0.16580±0.53	0.5765±2.2
" "	"	2745**	"	"	"	153±6							
" "	"	2657**	2.5-5	2199	"	140±5	0.58±9	15.3±5		31.2±5.8	0.542±5	0.17283±0.57	0.5542±2.4
" "	"	2746**	"	"	"	111±5							
" "	"	2658	5-10	5271	"	114±5	0.33±8	9.77±5		45.1±2.7	0.831±5	0.15890±0.12	0.4873±0.47
" "	"	2659**	10-30	17900	"	97.3±7	0 11±24	3.96±6		61.8±2.3	1.13 ±6	0.15110±0.22	0.4563±1.0
" "	"	2697**	10-30	"	"		0.13±17	4.06±5		61.8±2.3	1.17 ±5	0.14976±0.15	0.4408±0.61
	"		INTEGRATED	26928	"					161±1.9	2.92 ±2.1	0.15926±0.25	0.4972±1.1

**Duplicate aliquots

TABLE 2 (Cont'd)

Town	Site No.	Sample No.	Depth (cm)	Dry Wt. (g)	Area (cm^2)	pCi kg^{-1} ± % Stnd. Dev.				mCi km^{-2} ± % Stnd. Dev.		Atom Ratios ± % Stnd. Dev.	
						^{90}Sr	^{238}Pu	^{239+}Pu	^{241}Am	^{137}Cs	^{239+}Pu	$^{240}Pu/^{239}Pu$	$^{241}Pu/^{239}Pu$ (10^{-2}) ‡
Brigham City Tab.	115	2660	0-30	28200	620		0.35±18	9.59±7	1.68±9	177±1.7	4.36±7	0.13275±0.23	0.3814±0.73
Tremonton H.S.	119	2661**	0-30	25966	620		0.29±13	6.84±5		131±2.3	2.86±5	0.13553±0.15	0.3901±0.69
" "	"	2671**	0-30	"	"		0.26±22	5.30±8	1.55±9	"	2.22±8	0.16348±0.29	0.4885±1.5
" "	"	2662†	0-30	25969	620		0.27±14	6.20±5		137±2.2	2.60±5	0.15685±0.11	0.4550±0.48
Logan U.S.U.	123	2664	0-30	28219	620		0.36±15	7.09±6	1.01±10	133±2.3	3.23±6	0.12206±0.23	0.3450±1.1
Heber City H.S.	126	2665	0-30	25400	620		0.32±10	9.39±5		109±2.7	3.85±5	0.10011±0.17	0.2756±0.58
" " Tab.	127A	2666‡	0-30	29944	620		0.32±15	7.64±6		127±3.1	3.69±6	0.12571±0.11	0.3593±0.67
Duchesne Wilkens res.	128	2667	0-28	38966	900		0.29±12	4.97±5		79.4±3.5	2.15±5	0.13899±0.29	0.4224±0.99
" pasture	129	2668**	0-30	29900	620		0.28±13	4.56±5		107±3.3	2.20±5	0.14006±0.19	0.4110±0.73
" "	"	2530-1**	"	"	"		0.23±12	4.25±4		"	2.05±4	0.14003±0.19	0.4154±0.94
Vernal Central school	132	2669	0-30	27968	620		0.22±17	4.45±6	1.09±8	83.2±3.0	2.01±6	0.12346±0.19	0.3513±0.97
Price E. Utah Coll.	135	2670	0-30	28284	620		0.22±14	4.00±5		88.2±2.7	1.82±5	0.14419±0.15	0.4231±0.87
" cemetery	136	2672**	0-30	26412	620		0.13±18	3.68±5		73.7±3.1	1.57±5	0.15308±0.23	0.4784±0.69
" "	"	2695**	"	"	"		0.19±15	3.90±5	1.01±8	"	1.66±5	0.15480±0.10	0.4750±0.44
Dragerton private res.	138	2673	0-30	26722	620		0.20±16	4.23±5		92.2±3.6	1.82±5	0.16003±0.18	0.4654±0.69
Green River Anderson res.	141	2674	0-30	23923	620		0.38±21	6.77±8	1.43±7	119±2.3	2.61±8	0.12319±0.22	0.3406±1.2
Green River Scoville res. (North Loc.)	142	2675	0-30	7198	186		0.36±12	10.6±5		109±3.2	4.10±5	0.10093±0.16	0.2748±0.62
Green River Scoville res. (South Loc.)	"	2676	0-30	6329	186		0.36±13	8.86±5		123±2.8	3.01±5	0.10906±0.17	0.2996±0.80
Hanksville church	143	2677	0-2.5	2336	620		0.54±10	8.87±5	1.38±8	22.6±8.4	0.334±5	0.16932±0.17	0.5372±0.47
" "	"	2678	2.5-5	2066	"		0.96±8	19.1±5	5.27±7	42.0±4.0	0.636±7	0.16526±0.10	0.4980±0.28
" "	"	2680	5-10	4956	"		1.16±7	31.2±5	7.38±5	114±2.8	2.49±5	0.14534±0.10	0.4282±0.23
" "	"	2681	10-30	20500	"		0.38±13	12.4±5	1.14±5	48.3±4.1	4.10±5	0.13572±0.11	0.3880±0.34
" "	"		INTEGRATED	29858	"					227±2.0	7.56±3.2	0.14286±0.10	0.4171±0.19

**Duplicate aliquots

†Duplicate sample at site

‡Disturbed site

TABLE 2 (Cont'd)

Town	Site No.	Sample No.	Depth (cm)	Dry Wt. (g)	Area (cm^2)	pCi kg^{-1} ± % Stnd. Dev.				mCi km^{-2} ± % Stnd. Dev.		Atom Ratios ± % Stnd. Dev.	
						^{90}Sr	^{238}Pu	^{239+}Pu	^{241}Am	^{137}Cs	^{239+}Pu	$^{240}Pu/^{239}Pu$	$^{241}Pu/^{239}Pu$ (10^{-2})%
Blanding Tab.	146	2682	0-30	24450	620		0.20±13	4.27±5		69.4±3.6	1.68±5	0.13673±0.14	0.3804±0.66
Monticello Edwards res.	149	2683	0-30	27328	620		0.22±17	4.68±6	1.07±6	128±4.4	2.06±6	0.13889±0.22	0.3958±1.0
Moab Kirk res.	152A	2684	0-2.5	1129	620		0.53±7	13.1±5		34.6±4.3	0.239±5	0.15901±0.10	0.4887±0.27
" " "	"	2685	2.5-5	1785	"		0.62±10	16.2±5		18.4±6.5	0.466±5	0.12690±0.10	0.3412±0.39
" " "	"	2686	5-10	4272	"		0.13±15	3.87±5		18.1±2.2	0.267±5	0.12340±0.15	0.3240±0.62
" " "	"	2688	10-30	18300	"		0.03±42	1.13±6		7.41±18	0.334±6	0.11794±0.27	0.3133±1.4
" " "	"		INTEGRATED	29858	"					78.5±3.0	1.31±2.7	0.12937±0.10	0.3564±0.37
Grand Junction Tope school	155	2689	0-30	27508	620		0.18±15	4.73±5	0.982±7	94.5±4.0	2.10±5	0.12675±0.12	0.3477±0.55
Grand Junction park	157	2690	0-30	27128	620		0.14±17	4.78±5		87.4±3.3	2.09±5	0.12517±0.12	0.3533±0.45
Middletown Old Fell. Home	500	2691	0-5	2921	620	279±5	0.73±8	17.4±5	4.55±6	48.1±5.8	0.820±5	0.17533±0.15	0.5370±0.39
" " "	"	2692	5-10	3525	"	212±5	0.49±9	15.1±5	3.50±6	42.6±2.6	0.859±5	0.18401±0.14	0.5325±0.56
" " "	"	2693	10-15	4364	"	123±5	0.090±19	2.81±5	0.860±5	11.3±6.2	0.198±5	0.18183±0.13	0.5000±0.56
" " "	"	2694	15-30	9500	"	47.7±5	N.D.	0.29±11	0.11±20	2.3±35	0.044±11	0.17800±0.62	0.5040±3.2
" " "	"		INTEGRATED	20310	"					104±3.1	1.92±3.3	0.18004±0.10	0.5307±0.32
W. Donegal cemetery	501	2707	0-29	23444	620	132±5	0.23±9	5.79±5	1.59±5	106±2.2	2.20±5	0.18433±0.15	0.5438±0.53
Conay church	502	2711	0-24	9565	400	239±5	0.29±10	7.83±5	2.23±5	103±1.2	1.87±5	0.18281±0.13	0.5471±0.51
N. Eastham	503	2712	0-30	23016	620	116±15	0.21±17	5.97±5	1.56±5	109±6.7	2.22±5	0.17958±0.18	0.5136±0.53

N.D. = not detectable

TABLE 3

RADIONUCLIDE ACTIVITY RATIOS

Town	Site No.	Sample No.	Depth (cm)	$^{137}Cs/^{90}Sr$	$^{137}Cs/^{239+}Pu$	$^{238}Pu/^{239+}Pu$	$^{241}Am/^{239+}Pu$
Enterprise Reservoir	AA-1	2608	0-20		49	0.039	0.27
" "	AA-2	2609	0-20		48	0.040	0.27
St. George city park	3	2610	0-2.5	7.1	39	0.044	0.15
" " " "	"	2611	2.5-5	7.0	33	0.041	0.18
" " " "	"	2612	5-30	3.7	26	0.063	0.12
" " " "	"		INTEGRATED	4.5	29	0.057	0.13
St. George old hosp.	5	2613*	0-30		36	0.043	0.15
" " " "	"	2623*	"		33	0.037	0.14
Enterprise ranger station	9A	2614	0-2.5	15	57	0.042	0.23
" " "	"	2616	2.5-5	8.3	46	0.038	0.25
" " "	"	2617	5-30	1.9	34	0.054	0.20
" " "	"		INTEGRATED	3.5	42	0.048	0.22
Hurricane pear orch.	16	2618	0-5		46	0.039	0.20
" " "	"	2619	5-30		34	0.043	0.18
" " "			INTEGRATED		38	0.042	0.19
Hurricane city park	17A	2620	0-2.5		145	0.048	
" " "	"	2621	2.5-5		65	0.046	
Kanab Hamblin res.	20A	2622	0-30		39	0.047	0.22
" Cemetery	22	2413-1	0-5		96	0.061	
Parawan Adams res.	26A	2624	0-30		47	0.035	0.24
Cedar City R.R. station	35	2625	0-30		47	0.044	0.22
" " S. Utah State College	36	2626	0-30		44	0.028	
Panquitch Tab.	39	2627	0-30		47	0.035	0.24
" ranger sta.	42	2628	0-23		44	0.026	
Beaver visitors center	46	2629	0-23		27	0.032	0.18
Milford city offices	51	2630	0-24		37	0.032	
Filmore H.S.	54B	2632	0-18		38	0.031	
Delta Ludwid res.	58B	2633	0-25		42	0.036	
Richfield lodge	63	2634	0-27		42	0.042	
Gunnison city building	66	2635	0-28		35	0.041	
Nephi H.S.	71	2636	0-18		39	0.044	
" city park	72	2637	0-30		40	0.049	
Payson H.S.	75	2638	0-25		29	0.025	
Provo Mem. park	83	2640	0-27		23	0.024	0.15
" North park	85	2641	0-19		27	0.022	
Midvale city park	90	2642	0-30		38	0.034	
SLC Liberty park	89	2647	0-30		27	0.036	
" Univ. of Utah	95	2644	0-2.5	8.7	88	0.024	0.15
" " " "	"	2645	2.5-5	6.1	20	0.030	0.16
" " " "	"	2646	5-10	6.8	30	0.028	0.19
" " " "	"	2648	10-30	2.7	26	0.032	0.13
" " " "	"		INTEGRATED	4.3	28	0.030	0.16
" Jordan park	96	2649	0-30		40	0.035	
Magna Jr. H.S.	99	2650	0-30		42	0.033	
Tooele school	101	2651	0-30		45	0.037	
Bountiful Wardhouse	104	2652	0-30		40	0.035	
Layton city park	107	2653			34	0.046	

*Duplicate aliquots

TABLE 3 (Cont'd)

Town	Site No.	Sample No.	Depth (cm)	$^{137}Cs/^{90}Sr$	$^{137}Cs/^{239+}Pu$	$^{238}Pu/^{239+}Pu$	$^{241}Am/^{239+}Pu$
Layton Van Kampen res.	108	2654-1	0-30		34	0.028	
Ogden park	110	2656	0-2.5	5.4	57	0.053	
" "	"	2657	2.5-5	6.3	58	0.038	
" "	"	2658	5-10	4.6	54	0.034	
" "	"	2659*	10-30	2.2	55	0.028	
" "	"	2697*	"		53	0.032	
" "	"	INTEGRATED		3.4	55	0.035	
Brigham City Tab.	115	2660	0-30		41	0.036	0.18
Tremonton H.S.	119	2661*	0-30		46	0.042	
" "	"	2671*	"		59	0.049	0.29
" "	"	2662†	"		53	0.044	
Logan U.S.U.	123	2664	0-30		41	0.051	0.14
Heber City H.S.	126	2665	0-30		28	0.034	
" " Tab.	127A	2666‡	0-30		34	0.042	
Duchesne Wilkens res.	128	2667	0-28		37	0.058	
" pasture	129	2668*	0-30		49	0.061	
" "	"	2530-1*	"		52	0.054	
Vernal Central school	132	2669	0-30		41	0.049	0.24
Price E. Utah Coll.	135	2670	0-30		48	0.055	
" cemetery	136	2672*	0-30		47	0.035	
" "	"	2695*	"		44	0.049	0.26
Dragerton private res.	138	2673	0-30		51	0.047	
Green River Anderson res.	141	2674	0-30		46	0.056	0.21
" " Scoville res. (North Loc.)	142	2675	0-30		27	0.056	0.21
" " Scoville res. (South Loc.)	"	2676	0-30		36	0.041	
Hanksville church	143	2677	0-2.5		68	0.061	0.16
" "	"	2678	2.5-5		66	0.050	0.28
" "	"	2680	5-10		46	0.037	0.24
" "	"	2681	10-30		12	0.031	0.092
" "	"	INTEGRATED			30	0.036	0.16
Blanding Tab.	146	2682	0-30		41	0.047	
Monticello Edwards res.	149	2683	0-30		62	0.047	0.23
Moab Kirk res.	152A	2684	0-2.5		145	0.040	
" " "	"	2685	2.5-5		39	0.038	
" " "	"	2686	5-10		68	0.034	
" " "	"	2688	10-30		22	0.027	
" " "	"	INTEGRATED			60	0.035	
Grand Junction Tope school	155	2689	0-30		45	0.038	0.21
" " park	157	2690	0-30		42	0.029	
Middletown Old Fell. Home	500	2691	0-5	3.7	59	0.042	0.26
" " " "	"	2692	5-10	3.5	50	0.032	0.23
" " " "	"	2693	10-15	1.31	57	0.032	0.31
" " " "	"	2694	15-30	0.31	52	N.D.	0.38
" " " "	"	INTEGRATED		2.5	54	0.036	0.25
West Donegal cemetery	501	2707	0-29	2.1	48	0.040	0.27
Conay church	502	2711	0-24	1.8	55	0.037	0.28
N. Eastham	503	2712	0-30	2.5	49	0.035	0.26

*Duplicate aliquots

N.D. = not detectable

†Duplicate sample at site

‡Disturbed site

TABLE 4

PRECISION OF DUPLICATE SAMPLING AND ANALYSIS*

Town	Site No.	$^{239+}$Pu mCi km^{-2} Site Value	$^{239+}$Pu mCi km^{-2} Mean	^{240}Pu/^{239}Pu Atom Ratio Site Value	^{240}Pu/^{239}Pu Atom Ratio Mean	^{241}Pu/^{239}Pu Atom Ratio (10^{-2})§ Site Value	^{241}Pu/^{239}Pu Atom Ratio (10^{-2})§ Mean
St. George city park	3	3.37±5.1	3.01±17	0.07948±0.33	0.07874±1.3	0.2024±1.7	0.1969±4.0
" " old hospital	5†	2.64±7.0		0.07800±0.94		0.1914±0.21	
Cedar City R.R. station	35	2.02±5	1.98±3.2	0.14315±0.12	0.14270±0.45	0.4098±0.61	0.4072±0.92
" " S. Utah St. Coll.	36	1.93±6		0.14225±0.17		0.4045±0.84	
Panguitch tab.	39	1.47±8	1.65±15	0.14927±0.31	0.14449±4.7	0.4338±1.2	0.4157±6.2
" ranger sta.	42	1.83±8		0.13970±0.21		0.3976±1.3	
Nephi H.S.	71	2.24±5	2.47±13	0.12272±0.10	0.12068±2.4	0.3503±0.46	0.3439±2.7
" city park	72	2.69±5		0.11863±0.10		0.3374±0.50	
Provo Mem. park	83	5.09±5	4.76±9.8	0.07409±0.10	0.07589±3.4	0.1894±0.32	0.1955±4.4
" North park	85	4.43±5		0.07769±0.18		0.2015±0.45	
Salt Lake City Liberty park	89	4.96±10	5.06±2.7	0.08436±0.23	0.08640±3.3	0.2289±1.7	0.2325±2.2
" " " Univ. of Utah	95	5.15±3.2		0.08843±0.11		0.2360±0.57	
Layton city park	107	3.94±8	4.09±5.0	0.10254±0.28	0.10077±2.5	0.2823±1.6	0.2783±2.1
" Van Kampen res.	108	4.23±5		0.09900±0.10		0.2742±0.47	
Tremonton H.S.	119†	2.54±18	2.57±1.7	0.14951±13	0.15318±3.4	0.4393±16	0.4472±2.5
" "	119	2.60±5		0.15685±0.11		0.4550±0.48	
Price E. Utah Coll.	135	1.82±5	1.72±8.2	0.14419±0.15	0.14907±4.6	0.4231±0.87	0.4499±8.4
" cemetery	136†	1.62±3.9		0.15394±0.79		0.4767±0.50	
Grand Junction Tope school	155	2.10±5	2.10±0.34	0.12675±0.12	0.12596±0.89	0.3477±0.55	0.3505±1.1
" " park	157	2.09±5		0.12517±0.12		0.3533±0.45	
AVERAGE PRECISION‡			±9.4		±3.0		±4.1

*The ± values represent the % standard deviation.

†Mean of duplicate aliquots.

§Column heading identifies units in column, i.e. 0.2024 is equivalent to $0.2024 \times 10^{-2} \pm 1.7\%$.

‡Equal to $\left(\frac{\Sigma\ \%\ \text{Stnd. Dev.}^2}{n}\right)^{\frac{1}{2}}$

TABLE 5

ANALYSES OF BLANKS AND REFERENCE SAMPLES*

Sample No.	pCi kg^{-1}				Atom Ratios	
	^{238}Pu	^{239+}Pu	^{241}Am	^{90}Sr	$^{240}Pu/^{239}Pu$	$^{241}Pu/^{239}Pu$ (10^{-2})†
Blanks						
2601-1	N.D.	N.D.				
2615	N.D.	N.D.			0.11650±0.77	0.5110±4.0
2639	0.018±38	0.099±16			0.11279±0.80	0.3510±4.3
2633	0.027±50	0.027±50			0.12240±4.2	0.2010±11
2687	N.D.	0.081±21			0.13380±0.97	0.4080±3.4
2601				N.D.		
2604				2.3±26		
Reference Sample						
2631-1	0.34±24	6.28±8			0.06501±0.22	0.4050±0.77
2655	0.32±17	6.02±6			0.06941±0.43	0.4321±1.9
2679	0.24±16	6.68±5	1.52±5		0.06405±0.20	0.3821±0.52
2703	0.29±13	5.37±5	1.37±8		0.07114±0.10	0.4408±0.41
2747				459±5		
2748				509±5		
MEAN	0.30±14	6.09±9.0	1.45±7.3	484±7	0.06740±5.1	0.4150±6.4
EML VALUE		6.31±7		540±3.7		
Pure ^{239}Pu Spike						
2708	N.D.	1.00±11			0.004970±1.4	0.0200±10
EXPECTED	0	1.09±2				
% Dev.		-8				
2709	0.04±50	5.27±5			0.005900±1.2	0.0210±4.8
EXPECTED	0	5.47±0.1				
% Dev.		-3.7				
2710	0.05±50	1.23±7			0.000920±2.2	0.0032±13
EXPECTED	0	1.09±0.1				
% Dev.		+13				

*Errors are % standard deviation.
N.D. = not detectable.

†Column heading identifies units in column, i.e., 0.5110±4.0 is equivalent to $0.5110 \times 10^{-2} \pm 4.0\%$.

TABLE 6

GLOBAL AND NTS DEPOSITION AS OF 1979*

Town	Sampling Year	Site No.	From $^{240}Pu/^{239}Pu$ Ratios				From $^{241}Pu/^{239}Pu$ Ratios
			$(^{239+}Pu)_G$	$(^{239+}Pu)_N$	$(^{137}Cs)_G$	$(^{137}Cs)_N$	$(^{239+}Pu)_G$
Enterprise Res.	1979	AA-1	2.02±.13	0.42±.20	106±7	14±7	1.88
" "	"	AA-2	1.28±.07	0.41±.11	67±4	14±4	1.23
St. George city park	1979	3	1.39±.11	1.98±.20	73±6	24±6	1.36
" " old hosp.	"	5†	1.06±.09	1.58±.21	56±5	35±6	1.00
Enterprise	1979	9A	1.41±.06	0.44±.08	74±3	3±5	1.35
Hurricane	1979	16	3.42±.20	3.62±.35	180±11	85±12	3.13
Kanab	1979	20A	1.64±.11	0.69±.18	86±6	6±6	1.56
Parawan	1979	26A	2.20±.15	0.47±.22	116±8	10±8	2.07
Cedar City R.R. sta.	1979	35	1.65±.09	0.37±.14	87±5	8±6	1.60
" " S. Utah State College	"	36	1.57±.10	0.36±.15	83±6	2±7	1.52
Panguitch Tabernacle	1979	39	1.25±.11	0.22±.16	66±6	4±6	1.22
" ranger sta.	"	42	1.46±.12	0.37±.19	77±7	4±7	1.42
Beaver	1979	46	1.88±.11	0.90±.18	99±6	-25±7	1.85
Milford	1979	51	1.61±.10	0.69±.15	85±5	0±6	1.59
Filmore	1979	54B	1.76±.11	1.02±.17	93±6	13±6	1.74
Delta	1979	58B	1.40±.08	0.82±.14	74±4	19±5	1.36
Richfield	1979	63	1.09±.06	0.33±.10	57±3	2±4	1.06
Gunnison	1979	66	1.61±.09	0.70±.15	85±5	-3±5	1.61
Nephi H.S.	1979	71	1.57±.09	0.67±.14	83±5	5±5	1.55
" city park	"	72	1.82±.11	0.87±.17	96±6	11±7	1.81
Payson	1979	75	2.14±.18	2.22±.36	113±9	13±10	2.09
Provo	1971	1	2.05±.13	3.78±.14	108±7	8±10	2.08
" Mem. park	1979	83	1.89±.15	3.20±.29	99±8	18±8	1.90
" North park	"	85	1.76±.13	2.67±.26	93±7	25±7	1.78
Salt Lake City	1971	2	1.95±.11	2.15±.16	103±6	13±9	1.86
" " " Liberty park	1979	89	2.22±.24	2.74±.55	117±13	17±13	2.28
" " " Univ. of Utah	1971	3	2.37±.12	2.93±.13	125±6	8±8	2.24
" " " " " "	1979	95	2.45±.17	2.70±.23	130±9	15±10	2.45
" " " Jordan park	"	96	1.99±.12	0.98±.19	105±6	15±8	1.95
Midvale	1979	90	1.98±.12	1.30±.21	104±6	18±7	1.95
Magna	1979	99	2.64±.15	1.04±.25	139±8	14±8	2.56
Tooele	1979	101	2.49±.14	0.60±.21	131±8	8±8	2.43
Bountiful	1979	104	2.69±.18	1.11±.29	142±10	10±10	2.67
Layton city park	1979	107	2.27±.20	1.67±.38	120±10	13±10	2.24
" Van Kampen res.	"	108	2.33±.15	1.90±.27	123±8	20±8	2.34

*G designates global fallout, N designates NTS fallout, i.e.

$(^{239+}Pu)_G$ is the global $^{239}Pu + ^{240}Pu$ deposition. The ± values are one standard deviation.

†Mean values of duplicate aliquots used in calculation.

TABLE 6 (Cont'd)

Town	Sampling Year	Site No.	From $^{240}Pu/^{239}Pu$ Ratios				From $^{241}Pu/^{239}Pu$ Ratios
			$(^{239+}Pu)_G$	$(^{239+}Pu)_N$	$(^{137}Cs)_G$	$(^{137}Cs)_N$	$(^{239+}Pu)_G$
Ogden	1979	110	2.63±.09	0.29±.11	138±5	23±6	2.70
Brigham City	1971	5	2.24±.23	0.66±.37	118±12	7±13	2.03
" " Tabernacle	1979	115	3.32±.25	1.04±.40	175±13	2±14	3.26
Tremonton H.S.	1979	119†	2.16±.48	0.38±.66	114±25	17±25	2.11
" "	"	119‡	2.31±.09	0.29±.16	122±5	16±6	2.25
Logan	1979	123	2.26±.15	0.97±.24	119±8	14±9	2.21
Heber City	1971	6	1.66±.08	1.34±.12	87±4	-4±7	1.57
" " H.S.	1979	126	2.15±.13	1.70±.24	113±7	-4±8	2.14
" " Tabernacle	"	127A§	2.66±.18	1.03±.29	140±9	-13±10	2.62
Marion	1971	7	2.60±.10	2.00±.11	137±6	13±8	2.41
Duchesne Wilkens res.	1979	128	1.71±.10	0.44±.15	90±5	-11±6	1.75
" pasture	"	129†	1.71±.10	0.42±.15	90±5	17±6	1.70
Vernal	1979	132	1.42±.10	0.59±.15	75±5	9±6	1.40
Price E. Utah Coll.	1979	135	1.50±.09	0.32±.12	79±5	9±5	1.48
" cemetery	"	136†	1.42±.07	0.20±.09	75±4	-1±4	1.45
Dragerton	1979	138	1.65±.09	0.17±.13	87±5	5±6	1.60
Green River Anderson res.	1979	141	1.84±.16	0.77±.26	97±8	22±9	1.77
Green River Scoville res. (North Loc.)	"	142	2.32±.14	1.78±.25	122±8	-13±9	2.27
Green River Scoville res. (South Loc.)	"	142	1.86±.11	1.15±.19	98±6	25±7	1.81
Hanksville	1979	143	6.17±.26	1.39±.36	325±14	-98±14	6.09
Blanding	1979	146	1.32±.08	0.36±.11	70±4	0±5	1.25
Monticello	1979	149	1.64±.11	0.42±.16	86±6	42±8	1.59
Moab	1979	152A	0.97±.04	0.34±.05	51±2	27±3	0.92
Grand Junction Tope Sch.	1979	155	1.52±.09	0.58±.14	80±5	15±6	1.45
" " park	"	157	1.50±.06	0.59±.12	79±3	9±4	1.46

†Mean values of duplicate aliquots used in calculation.

‡Duplicate sample at same location.

§Disturbed site.

TABLE 7

NTS ^{137}Cs DEPOSITION FROM VARIOUS NTS PLUTONIUM ATOM RATIOS

Town	Site No.	Sample No.	$^{240}Pu/^{239}Pu$	^{137}Cs mCi km^{-2}* ± Stnd. Dev. R_N = 0.0297 Global	R_N = 0.0297 NTS	R_N = 0.0321 Global	R_N = 0.0321 NTS	R_N = 0.0399 Global	R_N = 0.0399 NTS	R_N = 0.0684 Global	R_N = 0.0684 NTS	Rain (cm)	Global from Rain
Enterprise Reservoir	AA-1	2608	0.14507	107	13	106±7	14±7	104	16	92	28	≥32	≥97
" "	AA-2	2609	0.13166	68	13	67±4	14±4	65	16	57	24	"	"
St. George city park	3	INTEGRATED	0.07948	76	21	73±6	24±6	64	32	23	74	21	69
" " old hospital	5	MEAN†	0.07800	56	35	56±5	35±6	49	42	16	75	21	69
Enterprise ranger station	9A	INTEGRATED	0.13321	75	2	74±3	3±5	72	5	63	14	32	97
Hurricane	16	INTEGRATED	0.08937	185	80	180±11	85±12	164	101	88	176	27	84
Kanab	20A	2622	0.12290	88	4	86±6	6±6	83	9	69	23	32	97
Parawan	26A	2624	0.14430	117	9	116±8	10±8	113	13	104	21	29	89
Cedar City R.R. station	35	2625	0.14315	88	6	87±5	8±6	85	9	78	16	30	92
" " S. Utah State College	36	2626	0.14225	83	1	83±6	2±7	81	4	74	11	30	92
Panguitch Tabernacle	39	2627	0.14927	66	4	66±6	4±6	65	5	60	9	24	76
" ranger sta.	42	2628	0.13970	78	3	77±7	4±7	75	6	68	13	24	76
Beaver	46	2629	0.11821	100	-26	99±6	-25±7	95	-20	76	-1.7	29	89
Milford	51	2630	0.12248	86	-1	85±5	0±6	82	3	67	18	20	66
Filmore	54B	2632	0.11164	95	10	93±6	13±6	88	17	68	37	35	105
Delta	58B	2633	0.11120	75	18	74±4	19±5	70	23	53	40	20	66
Richfield	63	2634	0.13361	58	2	57±3	2±4	56	4	49	10	20	66
Gunnison	66	2635	0.12170	86	-4	85±5	-3±5	81	0	68	14	23	74
Nephi H.S.	71	2636	0.12270	84	4	83±5	5±5	80	8	66	21	36	107
" city park	72	2637	0.11863	97	10	96±6	11±7	92	15	75	32	36	107
Payson	75	2638	0.08992	116	10	113±9	13±10	102	24	56	70	37	110
Provo Mem. park	83	2640	0.07409	104	13	99±8	18±8	85	32	18	99	33	99
" North park	85	2641	0.07769	97	21	93±7	25±7	81	37	25	93	33	99
Midvale	90	2642	0.10693	106	17	104±6	18±7	98	25	72	51	36	107

*Reported as of 1979.

†Mean of duplicate aliquots or samples.

TABLE 7 (Cont'd)

Town	Site No.	Sample No.	$^{240}Pu/^{239}Pu$	^{137}Cs mCi km^{-2}* ± Stnd. Dev. R_N = 0.0297 Global	NTS	R_N = 0.0321 Global	NTS	R_N = 0.0399 Global	NTS	R_N = 0.0684 Global	NTS	Rain (cm)	Global from Rain
SLC Liberty park	89	2647	0.08436	121	12	117±13	17±13	105	28	48	85	39	115
" Univ. of Utah	95	INTEGRATED	0.08843	134	10	130±9	15±10	118	26	61	84	"	"
" Jordan park	96	2649	0.11740	106	14	105±6	15±8	100	20	80	40	"	"
Magna	99	2650	0.12548	141	12	139±8	14±8	134	19	113	40	36	107
Tooele	101	2651	0.14118	133	6	131±8	8±8	128	11	117	23	39	115
Bountiful	104	2652	0.12360	144	7	142±10	10±10	136	15	115	37	~40	117
Layton city park	107	2653	0.10254	122	11	120±10	13±10	112	21	78	55	46	133
" Van Kampen res.	108	2654-1	0.09900	126	16	123±8	20±8	114	28	75	67	46	133
Ogden	110	INTEGRATED	0.15926	140	21	138±5	23±6	137	24	132	29	43	125
Brigham City	115	2660	0.13275	177	0	175±13	2±14	170	7	149	27	45	130
Tremonton	119	MEAN	0.15318	118	16	118±6	16±1	116	18	110	24	39	115
Logan	123	2664	0.12206	121	12	119±8	14±9	114	19	94	38	42	123
Heber City H. S.	126	2665	0.10011	116	-7	113±7	-4±8	106	3	70	39	38	112
" " Tabernacle	127A	2666‡	0.12571	142	-15	140±9	-13±10	135	-8	115	12	38	112
Duchesne Wilkens res.	128	2667	0.13899	91	-12	90±5	-11±6	88	-8	79	0	24	76
" pasture	129	MEAN	0.14005	90	17	90±5	17±6	88	19	80	27	24	76
Vernal	132	2669	0.12346	76	7	75±5	9±6	72	11	60	23	20	66
Price E. Utah college	135	2670	0.14419	80	8	79±5	9±5	77	11	71	17	23	74
" cemetery	136	MEAN	0.15394	75	-1	75±4	-1±4	74	0	69	4	23	74
Dragerton	138	2673	0.16003	87	5	87±5	5±6	86	6	83	9	22	71
Green River Anderson res.	141	2674	0.12319	98	21	97±8	22±9	93	26	78	41	15	53
Green River Scoville res. (N.)	142	2675	0.10093	125	-16	122±8	-13±9	114	-5	77	33	"	"
" " " " (S.)	"	2676	0.10906	100	23	98±6	25±7	93	30	69	54	"	"
Hanksville	143	INTEGRATED	0.14286	328	-101	325±14	-98±14	318	-91	289	-62	13	48
Blanding	146	2682	0.13673	70	0	70±4	0±5	67	2	61	9	32	97
Monticello	149	2683	0.13889	87	41	86±6	42±8	84	44	76	52	35	105
Moab	152A	INTEGRATED	0.12937	52	27	51±2	27±3	50	29	38	41	21	69
Grand Junction Tope Sch.	155	2689	0.12675	81	14	80±5	15±6	78	17	66	28	21	69
" " park	157	2690	0.12517	80	7	79±3	9±4	76	11	64	23	21	69

‡Disturbed site

TABLE 8

NTS ^{137}Cs IN POPULATION CENTERS IN UTAH

Town	Avg. Ann. Precip. (cm)[a]	Mean Total ^{137}Cs (mCi km^{-2})[b]	NTS ^{137}Cs (mCi km^{-2})[c] From Pu Ratios	From Rain	Best Estimate
St. George	18	94±4	30±4	28±9	30
Santa Clara	18	82±22		16±24	20
Washington	18	85±23		19±25	20
Enterprise	≥32	72±4	3±5	-25±13	<5
Enterprise Res.	≥32[d]	93±5	14±3	-4±14	14
Hurricane - La Verkin	24	91±15	37±19	12±18	37
Modena	21	73±17		0±19	<5
Veyo	26	135±43		51±44	50
Mt. Carmel	38[d]	85±10		-25±17	<5
Kanab	30	87±5	6±6	-6±13	6
Parawan	31	107±7	10±8	12±14	10
Karranaville	27[d]	92±19		6±22	6
Cedar City	30	84±4	5±5	-9±13	5
Hatch	21	71±15		-2±18	<5
Panguitch	23	75±3	4±5	-2±10	<5
Beaver	27	88±8[e]	-25±7	2±14	<5
Minersville	24	89±18		10±21	10
Milford	21	80±5	0±6	7±11	<5
Filmore	34	105±7	13±6	4±15	13
Delta	19	83±5	19±5	15±10	19
Richfield	20	67±4	2±4	-3±10	<5
Gunnison	23	75±5	-3±5	-2±11	<5
Manti	32	91±18		-6±22	<5
Nephi	36	93±7	7±4	-13±15	7
Payson	39[d]	124±8	13±10	11±17	13
Salem	39[d]	91±18		-22±23	<5
Spanish Fork	47	90±14		-40±22	<5
Springville	41[d]	111±30		-6±34	<5
Provo	35	125±5	19±5	21±14	19
American Fork	45[d]	113±21		-13±26	<5
Midvale	40	123±8	18±7	8±17	18
Murray	40[d]	112±30		-3±34	<5
Salt Lake City	39	130±4	15±6[f]	17±15	15
Magna	36	161±10	14±8	55±17	14
Tooele	42	136±9	8±8	17±18	8
Bountiful	40[d]	138±8	10±10	23±17	10
Layton	44[d]	130±6	17±6	6±17	17
Clearfield	44[d]	104±28		-20±32	<5

TABLE 8 (Cont'd)

Town	Avg. Ann. Precip.[a] (cm)	Mean Total ^{137}Cs[b] (mCi km^{-2})	NTS ^{137}Cs (mCi km^{-2})[c] From Pu Ratios	From Rain	Best Estimate
Ogden	44	148±9	23±6	24±18	23
Brigham City	49	150±8	5±10	15±19	5
Tremonton	41	129±7	16±6	12±17	16
Logan	44	117±7	14±9	-7±18	14
Heber City	39	111±6	-4±5	-2±16	<5
Marion	45	150±6[g]	13±8	24±17	13
Duchesne	22	85±4	3±4	10±11	<5
Vernal	17	81±5	9±6	17±10	9
Price	24	77±4	3±3	-2±11	<5
Draggerton	22	92±6	5±6	17±11	5
Green River	13	121±6	22±9	66±9	22
Hanksville	-	-	-	-	-
Blanding	28	69±5	0±5	-19±13	<5
Monticello	33	117±31[d]	42±8	18±34	20
Moab	18	74±5	27±3	8±10	10
Grand Junction, CO	21	83±4	11±3	10±10	11

[a] Equal to $\frac{1}{2}$ of the mean annual precipitation plus $\frac{1}{2}$ of the average rainfall during the period 1962-1964 (see text, pg. 12).

[b] Best estimate for town from Beck and Krey (1980)

[c] Decay corrected to 1979.

[d] Precipitation estimated from nearby measuring sites.

[e] Soil data excluded (see text, pg. 15).

[f] The calibration value from the mean of the 1979 study.

[g] From Hardy (1976).

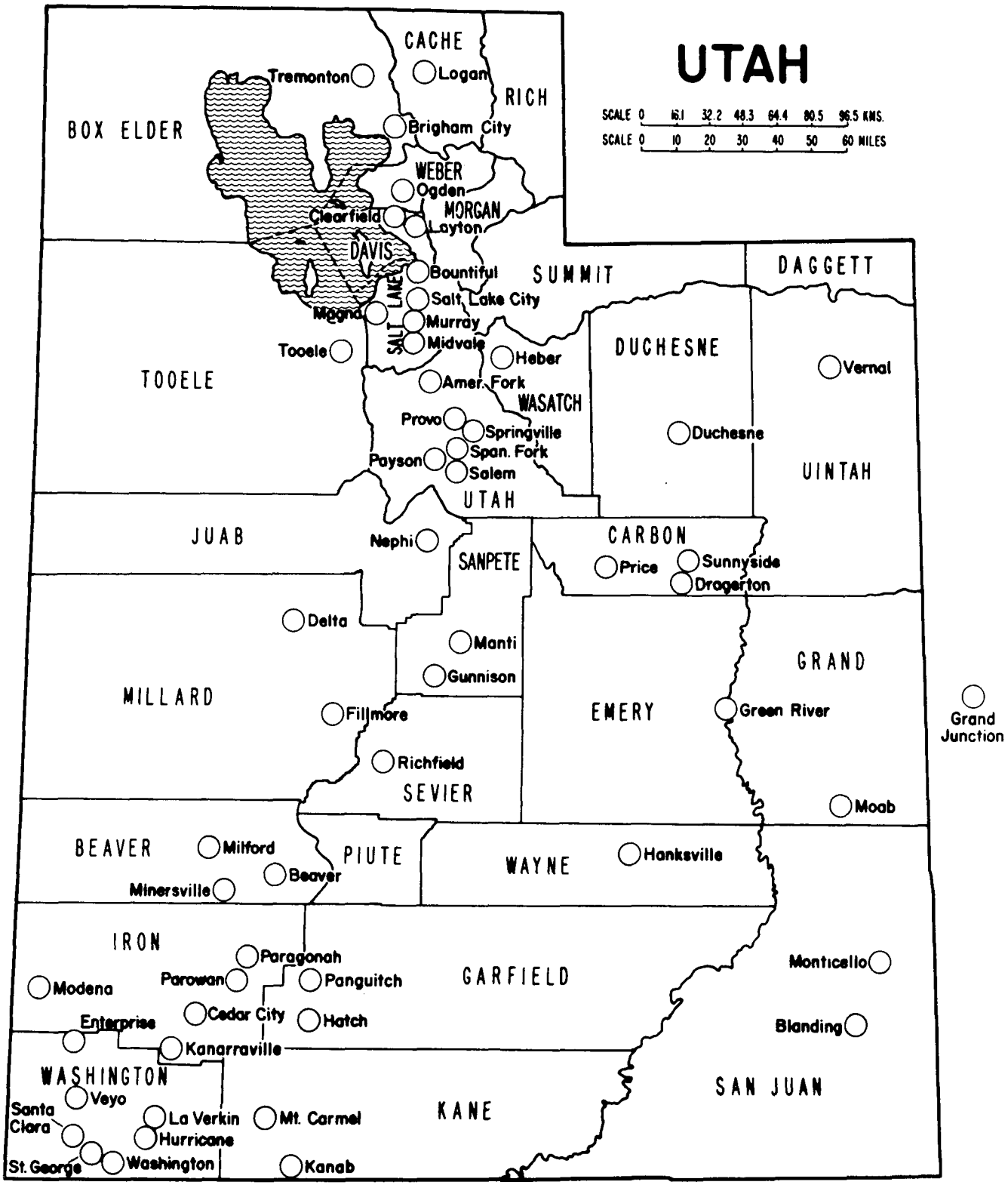

Figure 1. Population centers in which measurements were made

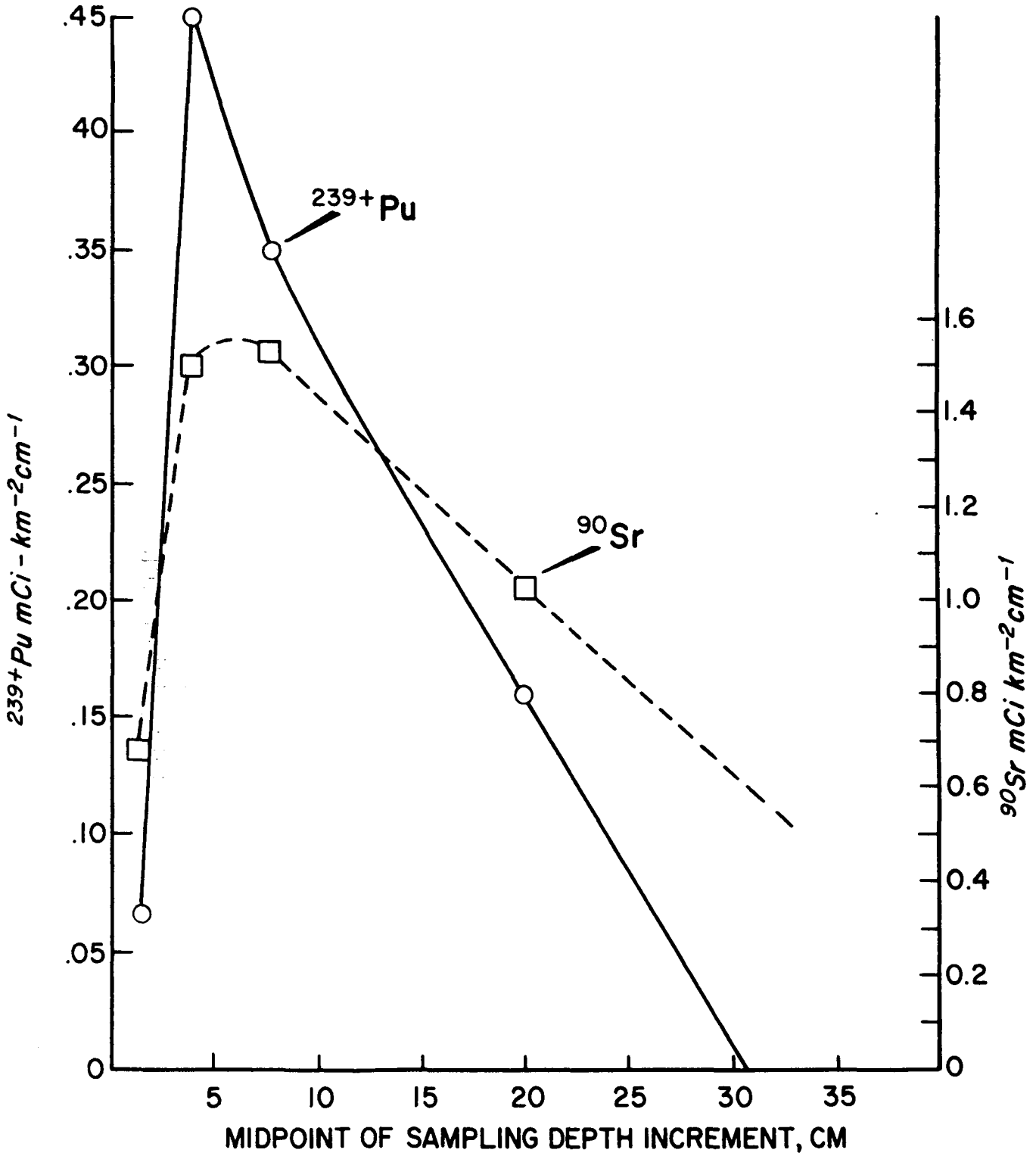

Figure 2. Profile of ^{90}Sr and ^{239+}Pu concentrations with depth in soil at the University of Utah, Salt Lake City.

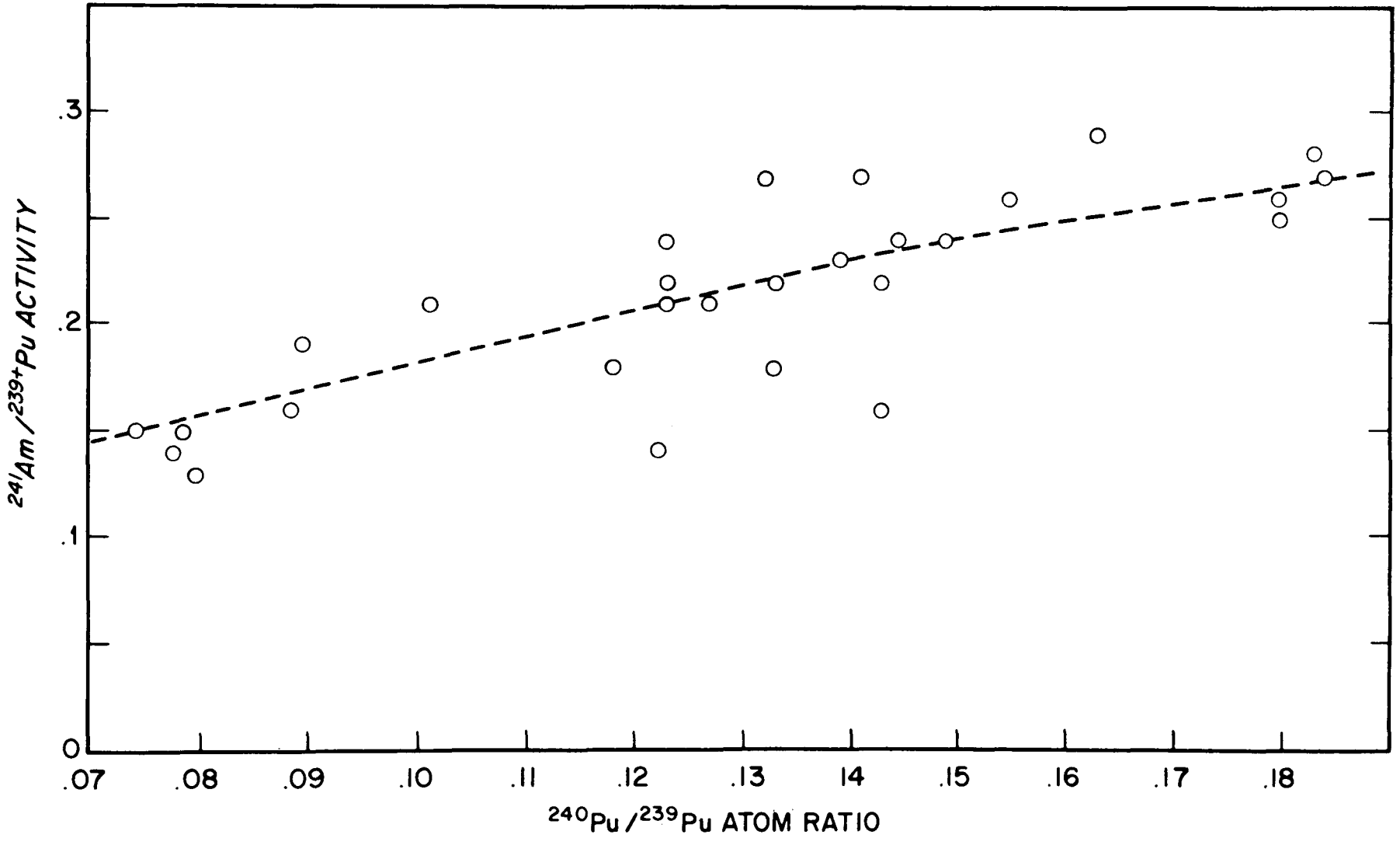

Figure 3. Correlation of $^{241}Am/^{239+}Pu$ activity ratio with $^{240}Pu/^{239}Pu$ atom ratio.

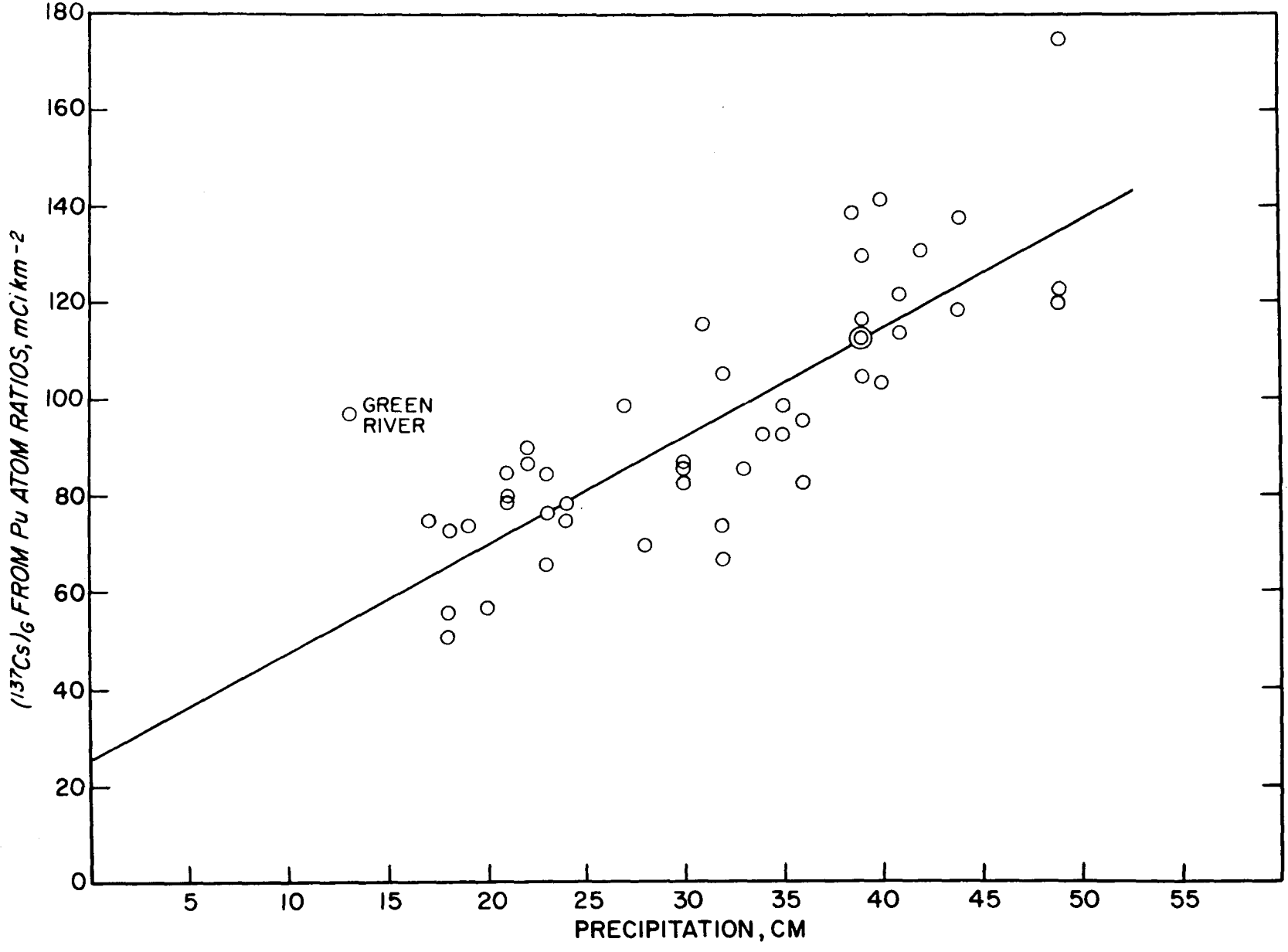

Figure 4. Correlation of global ^{137}Cs deposition from plutonium atom ratios with precipitation.

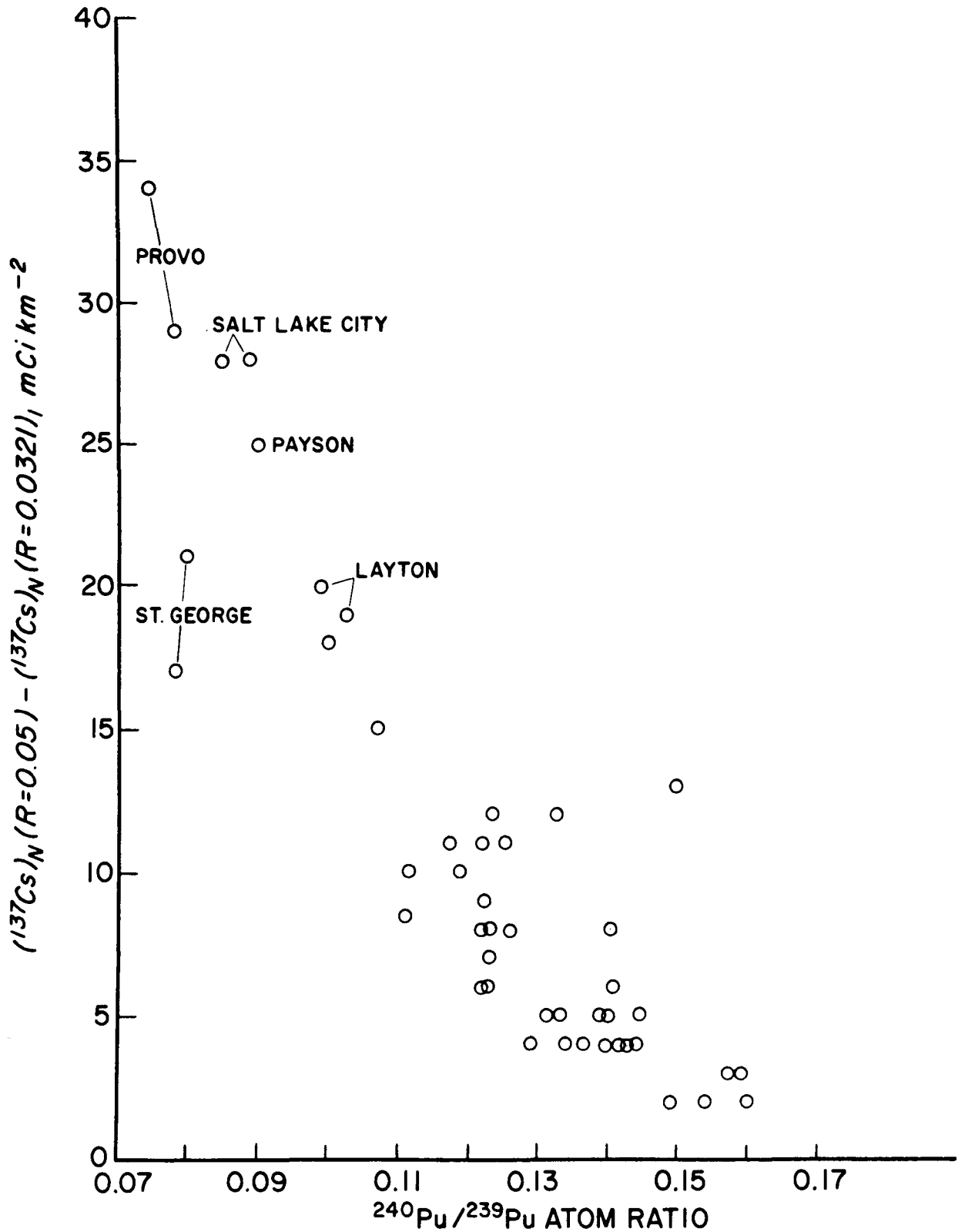

Figure 5. Correlation of differences in NTS ^{137}Cs estimates (when R_N = 0.0299 and 0.050) with $^{240}Pu/^{239}Pu$ atom ratios.

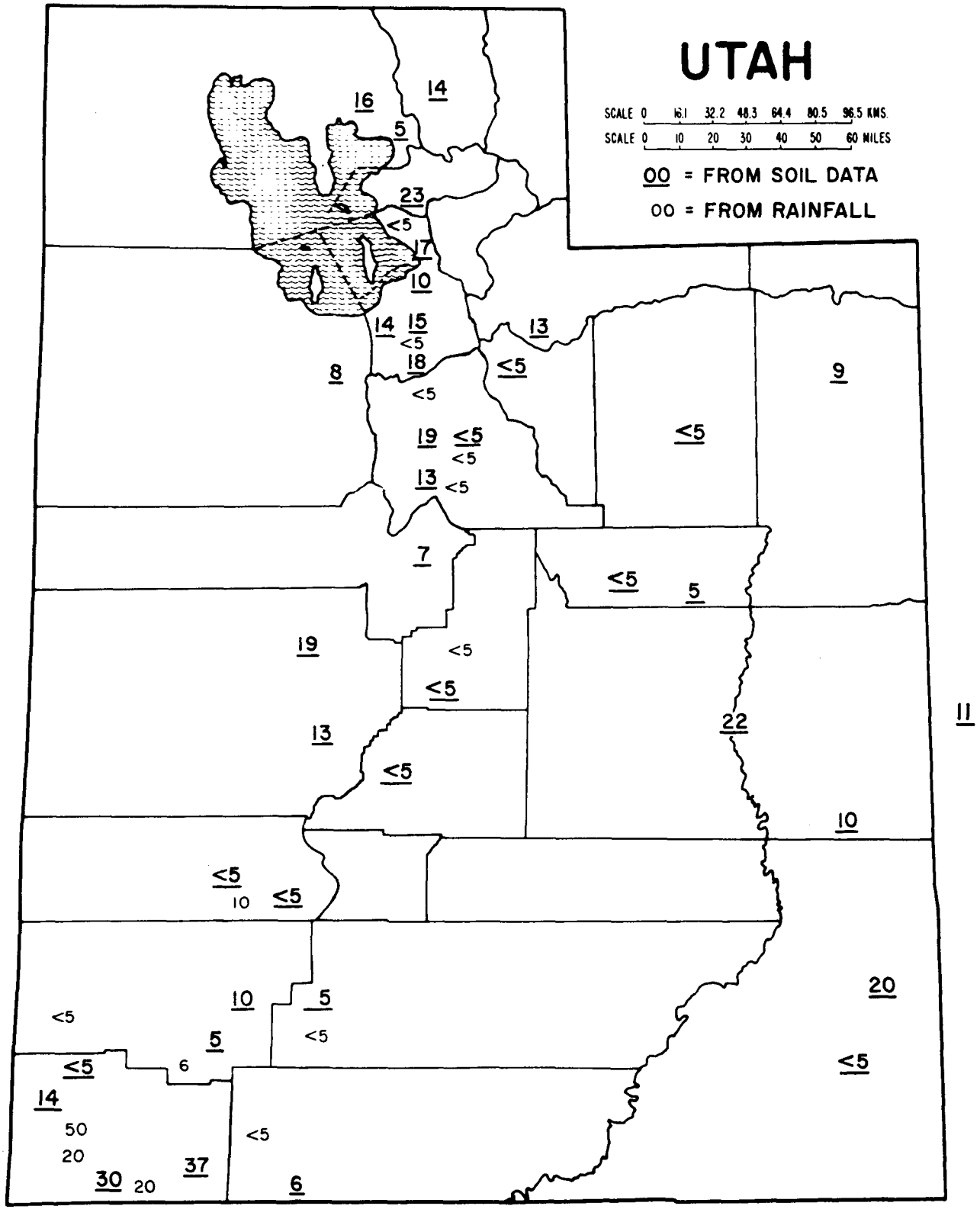

Figure 6. Best estimates of NTS ^{137}Cs deposition in population centers in Utah, mCi km^{-2} decay corrected to 1979.

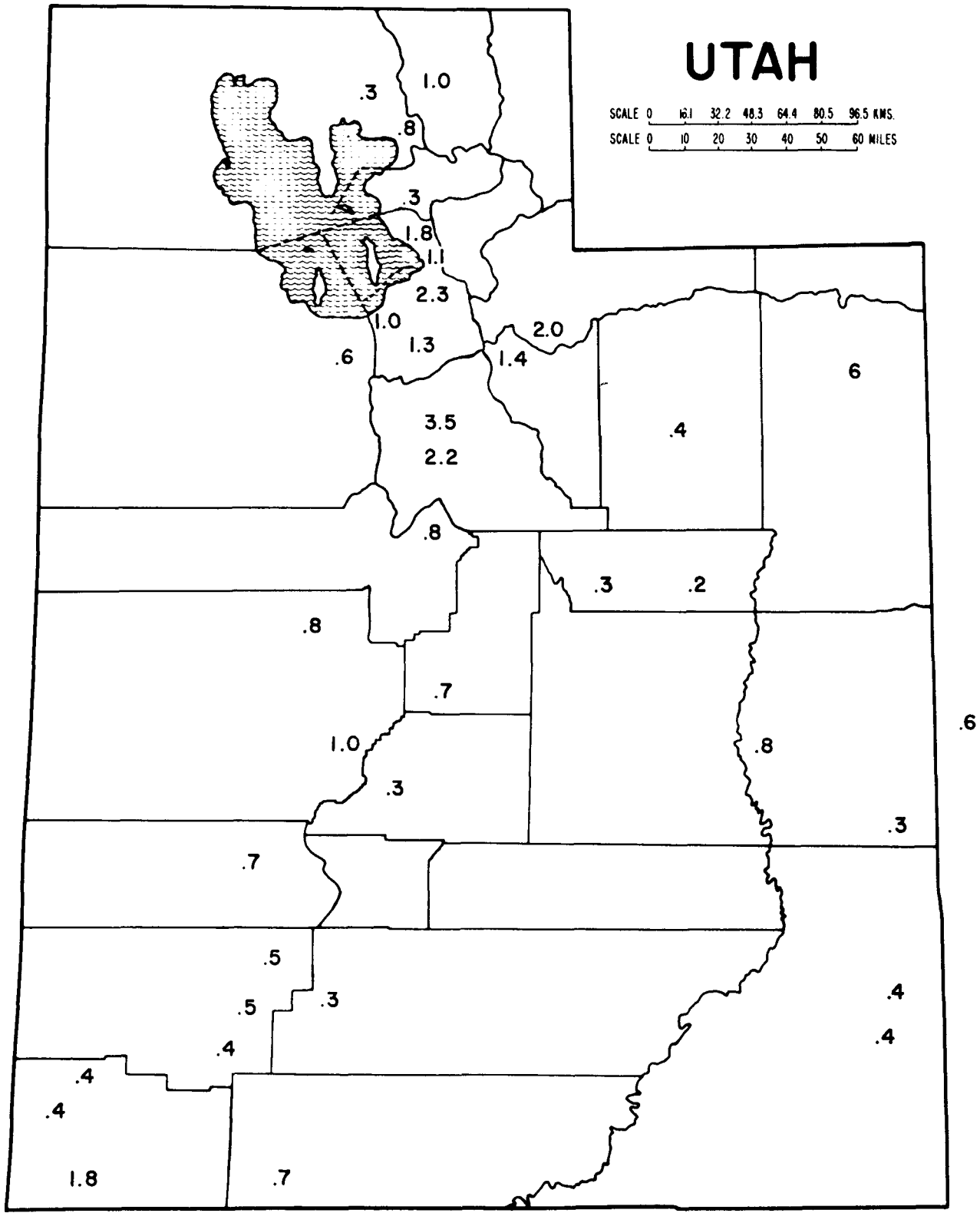

Figure 7. Estimates of NTS $^{239+}$Pu deposition in population centers in Utah, mCi km^{-2}.