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ESTIMATES OF AMOUNTS OF SOIL REMOVAL FOR CLEAN-UP OF TRANSURANICS AT NAEG OFFSITE SAFETY-SHOT SITES

by

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ESTIMATES OF AMOUNTS OF SOIL REMOVAL FOR CLEAN-UP OF TRANSURANICS AT NAEG OFFSITE SAFETY-SHOT SITES

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ABSTRACT

Rough estimates are given for the amount of soil removal necessary to "decontaminate" five representative safety-shot areas. In order to decontaminate to levels of less than 160 pCi $^{239-240}Pu$ per gram of surface soil, it is estimated that over one-half million tons of soil would have to be removed from the five areas. This is a preliminary estimate based on summary data and concentration contour maps readily available in NAEG publications. More accurate estimates could be obtained by applying Kriging techniques to available soil data if the need arises.

The inclusion of ^{241}Am and ^{238}Pu activities do not significantly increase the soil tonnage estimates obtained for $^{239-240}Pu$ because of their relatively small contributions to total transuranic activity. The magnitude of the errors inherent in our use of summary data to obtain "rough estimates" also suggests that a revision of the tonnage estimates for $^{239-240}Pu$ to include ^{241}Am and ^{238}Pu is not warranted.

INTRODUCTION

In this paper initial or rough estimates are derived for the acreage and tons of soil removal necessary to "decontaminate" five safety-shot areas adjacent to the Nevada Test Site. These safety-shots are Project 57 (in Area 13) and Double Track (DT), Clean Slate 1 (CS1), Clean Slate 2 (CS2) and Clean Slate 3 (CS3) on the Tonopah Test Range.

We were requested by the NAEG to initially consider three definitions of decontamination: removal of surface soil (0-15 cm) containing greater than 1) 160 pCi total transuranics per gram of soil, 2) 80 pCi/g, and 3) 40 pCi/g. Examination of available summaries of the data indicated that sufficient information was available only for the 160 pCi/g level. Soil levels of 80 and 40 pCi/g usually extended beyond the range of the maps and tables published in NVO reports. In order to use these latter levels as the definition of contamination, it will be necessary to reanalyze the original data. Thus, the following discussion will assume that decontamination is achieved when all soil with a total transuranic concentration in excess of 160 pCi/g is removed.

Soil in the safety-shot areas is contaminated by all the radioisotopes in the test devices and their decay products. Decontamination efforts should be based upon total activity, that is, the sum of the picocuries per gram of soil of all the isotopes present. Most of the currently available data is for $^{239-240}$Pu and ^{241}Am. Limited data for ^{238}Pu in soil is also available (unpublished). Because of the structure of the currently available data, the estimates will be presented here first for $^{239-240}$Pu. Then additional contributions due to ^{238}Pu and ^{241}Am will be considered. We shall see that the rough estimates of soil tonnage removal for total transuranics is for all practical purposes the same as for $^{239-240}$Pu alone.

We emphasize that 160, 80 and 40 pCi/g were chosen primarily because these limits were used in the Enewetak Atoll cleanup operation recently completed. To our knowledge, no determination has been made that these limits are applicable to an actual cleanup operation at NVO safety-shot sites. Indeed the desert environment of the safety-shot sites is vastly different from the moist and humid atoll environment. Hence, accpetable residual concentrations of transuranics on the atoll could be very different from those at the safety-shot sites. Appropriate limits might be derived from transuranic transport and dose assessment models for these desert ecosystems taking into account factors such as cost, the "as low as practical" (ALAP) philosophy, and the remoteness of these sites to populated areas.

We note that Martin and Bloom (1977, p. 681) estimated an "acceptable soil concentration" of $^{239-240}$Pu for the Project 57 site to be about 2800 pCi/g in surface (0-5 cm) soil. This soil concentration was estimated to correspond to a maximum dose rate of 1.5 rems/yr to the lungs of a "standard man" living at the site. Martin and Bloom obtained the 2800 pCi/g limit by using a Pu transport and dose estimation model developed explicitly for the Project 57 site. They noted that only stratum 6 had an average $^{239-240}$Pu concentration exceeding 2800 pCi/g. Stratum 6 has an area of about 24,000 m^2 which is equivalent to about 4400 tons of soil (15 cm depth).

METHODS

The primary sources of summary information are Gilbert et al. (1975, NVO-153, FIDLER strata maps on pages 348-353, and Tables 14 and 15 on pages 393 and 394), the tables on page 425 in Gilbert (1977, NVO-181) (which is a revision of page 379 in Gilbert et al., 1975), and Figures 3, 4, and 12 in Delfiner and Gilbert (1978, pp. 368, 369, 393).

For Project 57 all of strata 6, 5, 4 and 3 and one-third of stratum 2 were considered greater than 160 pCi/g of $^{239-240}Pu$. Interpolation of the 160 pCi/g boundary within stratum 2 was done subjectively with the aid of Figures 3, 4 and 12 in Delfiner and Gilbert (1978). These figures give concentrations in $\mu Ci/m^2$. 160 pCi/g corresponds to about 9 $\mu Ci/m^2$.

For the DT and CS2 areas, all of strata 4, 3 and 2 were included along with one-third of stratum 1. For CS1 and CS3, all four strata were included. Areas, weights, etc., were calculated as for Project 57. The total area with greater than 160 pCi/g was obtained for each study site by summing the area data given by Gilbert (1977, p. 425).

It was also assumed that if an area is to be decontaminated it is impractical to remove less than 6 inches (15 cm or 0.15 meter) of soil. This is the typical minimum depth achieveable with heavy earth moving equipment if all the surface must be removed. Hence, soil volume was calculated by multiplying the area of land estimated to be greater than 160 pCi/g by the assumed average cleanup depth of 15 cm. Soil weight was calculated by multiplying this soil volume by the average soil density (g/cm^3) for the study site.

Average soil densities were taken from Martin and Bloom (1977, p. 628) and are given here in Table 1.

TABLE 1. Average density of soils at selected safety-shot sites.

Site	Average Density (g/cm^3) ± 1 Standard Deviation
Project 57	1.1 ± 0.02
DT	1.1 ± 0.03
CS1	0.92 ± 0.02
CS2	0.93 ± 0.01
CS3	0.91 ± 0.01

The metric area, volume and weights were then converted to English units of acres, cubic yards and tons using the following conversion factors:

to convert	into	multiply by
m^2	acres	2.5×10^{-4}
m^3	yd^3	1.2
Kg	tons	1.1×10^{-3}

RESULTS

Table 2 summarizes the area and tonnage results based on the $^{239-240}Pu$ data.

TABLE 2. Rough estimates of the amount of soil removal necessary to decontaminate down to 160 pCi/g of $^{239-240}Pu$. Removal of the top 15 cm of soil is assumed.

Site	Area, m	Area, acres	Volume m	Volume yd	Kg soil	Tons Soil
Project 57	10.7×10^5	269	16×10^4	21×10^4	18×10^7	200,000
DT	0.62×10^5	15	0.92×10^4	1.2×10^4	1.0×10^7	11,000
CS1	1.77×10^5	44	2.7×10^4	3.5×10^4	2.4×10^7	26,000
CS2	2.36×10^5	59	3.6×10^4	4.6×10^4	3.3×10^7	36,000
CS3	17.3×10^5	433	26×10^4	34×10^4	24×10^7	260,000
TOTAL	32.8×10^5	820	49×10^4	64×10^4	49×10^7	~530,000

We note that 820 acres is approximately 1.3 square miles. No estimates of error have been placed on the tonnage estimates due to the rough and approximate nature of the methodology.

In order to derive more accurate tonnage estimates accompanied by estimates of error, and to derive estimates for decontamination at the 80 and 40 pCi/g levels it would be necessary to include recent additions to the original data and to reanalyze the entire set with a geographical analysis computer program, such as the Kriging program BLUEPACK available at DOE-NVO and DOE-RL with program parameters set specifically for this problem. The accuracy of the resulting Kriging estimates might still be inadequate since available soil data in low level strata are sparse. Additional soil samples and in-situ surveys may be necessary to achieve desired accuracy.

Revision of the results in Table 2 to include ^{241}Am and ^{238}Pu were considered by evaluating available $^{239-240}Pu/^{241}Am$ and $^{239-240}Pu/^{238}Pu$ ratio data. The estimates of $^{239-240}Pu/^{241}Am$ ratios have changed significantly over time. Values from measurements made in 1972 for the five areas of interest are given by Gilbert et al. (1975, pp. 403-404). In 1972 the average ratio for the Project 57 site was about 9 to 1, and for the other four areas it was greater than 20 to 1. More recent data have been supplied in LFE data reports #22 and #23 dated 3/31/77 and 5/18/77, respectively, and are summarized in Table 3.

TABLE 3. Estimates of $^{239-240}Pu$ to ^{241}Am ratios from data analyzed in 1977.

Site	n	$^{239-240}Pu/^{241}Am$ Ratios			
		Minimum	Maximum	Median	Mean*
Project 57	10	5	6	5.5	6 ± 0.4
DT	12	15	30	20	20 ± 4
CS1	7	16	28	19	20 ± 4
CS2	17	15	21	17	17 ± 2
CS3	28	15	32	21	23 ± 5

*average of the ratios ± 1 standard deviaion

These 1977 data should be more representative of present conditions than the 1972 data since the new data includes americium ingrowth since 1972.

Note that the median ratios for the last four areas listed in Table 3 are 17 to 1 or greater. Hence, the inclusion of ^{241}Am will increase the total soil activity (pCi/g or $\mu Ci/m^2$) by less than approximately six percent over the activity levels obtained using only $^{239-240}Pu$ data. We feel that the accuracy inherent in using summary data to obtain "rough estimates" is much greater than six percent and thus no revision of the previously given estimates of soil tonnage is warranted for these Tonopah Test Range sites.

For Project 57 the individual $^{239-240}Pu/^{241}Am$ ratios range from 5 to 1, to 6 to 1, indicated that americium increases the total soil activity by 17 to 20 percent over the activities calculated from $^{239-240}Pu$ alone. Thus to approximate a soil stratum with a total ($^{239-240}Pu$ + ^{241}Am) activity of 160 pCi/g, a stratum with a $^{239-240}Pu$ level of around 130 pCi/g must be found on the maps of Project 57. Useful maps of this area are given by Delfiner and Gilbert (1978, pp. 368, 369). These give actual soil concentrations (10 g aliquots, 5 cm depth) in $\mu Ci/m^2$ at sampling locations. 160 pCi/g corresponds to a value of about 9 $\mu Ci/m^2$ on these maps and 130 pCi/g corresponds to a value of about 7 $\mu Ci/m^2$. It is obvious from an examination of these maps that it is subjectively impossible to accurately estimate the difference in area covered between concentrations of 160 pCi/g and 130 pCi/g $^{239-240}Pu$ in soil. Thus, even though a 20 percent increase in soil levels may be significant, it is impossible to reasonably estimate the effect of such an increase using only the summary data.

The inclusion of ^{238}Pu activities is of no significance since the average $^{239-240}Pu/^{238}Pu$ ratios for soil are about 100 to 1 at the DT and Clean Slate sites, and about 50 to 1 at the Project 57 site (samples analyzed by LASL in the period 1972-74). The available soil data is summarized in Table 4.

TABLE 4. Estimates of $^{239-240}Pu$ to ^{238}Pu ratios from data analyzed in the period 1972-1974.

		$^{239-240}Pu/^{238}Pu$ Ratios			
Site	n	Minimum	Maximum	Median	Mean*
Project 57	27	26	410	43	68 ± 87
DT	12	27	120	110	100 ± 26
CS1	14	97	120	110	110 ± 7
CS2	9	76	360	120	150 ± 93
CS3	14	83	290	120	220 ± 340

*Average of the ratios ± 1 standard deviation

CONCLUSIONS

The statistical uncertainty inherent in the data used for the tonnage estimates in Table 2 is of such a magnitude that we recommend a different approach if accurate estimates of soil amounts or area are necessary. Better estimates can be obtained from currently available data by summing the activity levels of the raw data for plutonium and americium, and then analyzing these sums with the BLUEPACK program with the program paramaters set to give cleanup boundaries at desired soil concentration levels. This computer program can also give confidence level information on the cleanup boundaries so that the area estimates can be extended to give decontamination plus, say 95%, confidence areas. Estimates of average transuranic concentrations for unit areas such as 100x100 feet can also be obtained using BLUEPACK (see e.g., Delfiner and Gilbert, 1978).

We suspect that the sparsity of the available data points will result in wide confidence intervals on the cleanup boundaries. If the decision is made to cleanup these safety-shot sites then the use of an in-situ planar intrinsic germanium detector such as used for the Enewetak Atoll radiological cleanup is a logical choice for obtaining more accurate boundary estimates (Barnes, 1978). This approach should require only a limited number of additional soil samples.

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