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PRELIMINARY REASSESSMENT OF THE POTENTIAL RADIOLOGICAL DOSES FOR RESIDENTS RESETTLING ENEWETAK ATOLL

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INTRODUCTION

The Enewetak people were relocated to Ujelang Atoll in 1948 so that the United States could conduct part of its nuclear testing program at Enewetak Atoll. In 1972, at the request of the Enewetak Council, the U.S. Government began the process of returning Enewetak Atoll to the Enewetak people. A part of the U.S. Government's responsibility was to determine the radiological status of the atoll and to estimate the radiological doses as a consequence of resettlement. Therefore, a preliminary survey was conducted from October 1972 through February 7, 1973. The results of this survey and the associated assessment were published in late 1973.[1]

The general conclusions from that survey were: (1) the terrestrial food chain presented the greatest source of potential dose to a returning population, (2) ^{137}Cs and ^{90}Sr were the most significant radionuclides over the next few decades, (3) living patterns involving the northern half of the atoll would result in radiation exposure that would exceed U.S. Federal Guidelines--the southern half of the atoll presented no problem for either residence or agriculture, and (4) the transuranic isotopes presented a long term source of exposure in the northern and eastern regions of the atoll.

Since that initial radiological survey more data were accumulated concerning the concentration and uptake of the radionuclides into the terrestrial and marine food chains. In addition, new data were developed for external gamma exposures and soil radionuclide

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concentrations subsequent to those cleanup efforts directed toward scrap removal and soil removal from areas of highest transuranic soil concentrations begun in 1977.

The purpose of this report, as a result of now having more data available, is to refine the dose predictions for alternate living patterns proposed for the resettlement of Enewetak Atoll.

For many reasons the time frame for developing the assessment of the alternate living patterns based on all of these new data were quite short. Initial requests for the assessment by May 1979 were impossible to meet because time to collect and analyze the samples and evaluate the data exceeded the time allotted. Extension to July 1979, made a new assessment possible but required some compromises to meet the deadline.

For example, the programs to develop better concentration and uptake data in subsistence foods were began on Enewetak Atoll in August 1975 and on Bikini Atoll in August 1977. Samples from these projects which involved planting and harvesting the subsistence food crops, have only become available in the past year and a half, and the data base for each subsistence crop is not as complete as it will be within the next year or two. Studies of the marine environment and ground water have been continuing since 1974.

The program to determine the concentration of ^{137}Cs and ^{90}Sr in the soil and the external gamma exposure was begun in February 1979, at the conclusion of the cleanup activities at the atoll. Starting in February 1979, soil samples were collected in a 50-m grid on all of the northern islands at Enewetak Atoll. However because of time and budget restrictions, only samples on a 100-m grid were analyzed for ^{90}Sr and

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^{137}Cs; these samples form the basis for evaluating the terrestrial food chain. We would prefer that the entire potential data base were available, but as a result of the time constraints we are basing the assessment on the 100-m grid data. We are currently evaluating the data on the distribution and ranges of the soil radionuclide concentration for each of the islands to determine whether analysis of the other samples will be necessary.

In addition, only external gamma data are available for the islands in the northwest quadrant of the atoll, i.e., Bokoluo (Alice), Bokambako (Belle), Kiruna (Clara), Louj (Daisy), Bokinwotme (Edna), and Boken (Irene) and Runit (Yvonne) Island on the eastern side of the atoll (Fig. 1). Soil samples are now being analyzed for these islands, but evaluating the data and subsequent assessments will be done later. However, these islands are not included as residence or agriculture islands in any of the resettlement options described in the rehabilitation plans.

Data are still unavailable for the ^{241}Pu concentration in the soil on the islands. We, therefore, used ^{241}Pu soil data collected in our test plot on Enjebi (Janet) Island to determine the "grow-in" of ^{241}Am, the daughter product of ^{241}Pu. We extrapolated the observed ^{241}Pu/^{241}Am ratio from Enjebi (Janet) Island to the rest of the islands at the atoll to develop an initial evaluation of the impact of ^{241}Am "grow-in" from ^{241}Pu. However, we know the ratio will vary at the atoll and this analysis only serves to indicate the relative magnitude of ^{241}Pu in the dose assessment.

In addition there has been insufficient time to adequately evaluate the diet survey and to develop an evaluation of the distribution and uncertainty of the final dose estimates.

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DATA BASES

The exposure pathways for persons resettling Enewetak Atoll consist of two major categories: (1) external exposure and (2) internal exposure.

The specific pathways in each of these categories are:

(1) External Exposure

- a. Natural background
- b. Man-made gamma and beta

(2) Internal Exposure

- a. Radionuclides in terrestrial foods
- b. Radionuclides in marine foods
- c. Radionuclides in drinking water
- d. Radionuclides inholed

The natural background at the atoll is 3.5 r per hour and results primarily from cosmic radiation. The natural background is not included in the doses presented in this paper.

External Exposure - *In Situ* Measurements

External exposure rates for ^{137}Cs and ^{60}Co, as well as the surface (0 to 3 cm) concentration values for ^{241}Am, were obtained from *in situ* measurements performed by EG&G, Inc., as part of the Enewetak Cleanup Project and can be found in Reference 2. A draft copy of the detailed description of the systems and procedures employed in the *in situ* measurements is included with this report (Appendix A). These measurements were obtained utilizing a planar, high purity, germanium

(HPGe) detector having a surface area of 19 cm^2 and a thickness of 1.6 cm. The detector was suspended from a retractable pneumatic boom 740 cm above ground. The boom was mounted to the rear of the Thiokol IMP - a small, lightweight, tracked vehicle--modified and equipped to be a fully self-contained, mobile, data-acquisition and reduction system.

Quantitative data can be obtained from in situ measurement by combining a theoretical calculation of the flux at the detector as a function of source and source distribution with an experimental calibration of the detector response to a given incident flux. The unscattered flux of gamma rays of energy E at a height h above a smooth air-ground interface resulting from an emitter distributed in the soil (Fig. 2) is given by:

$$\phi = \int_0^\infty \int_0^\infty \frac{S_v \exp \left[-(\mu_a h \sec \theta + \mu_s z \sec \theta)\right]}{4\pi (h \sec \theta + z \sec \theta)^2} 2\pi r dr dz, \qquad (1)$$

where

S_v = the source activity per unit volume $(\frac{\text{photons}}{\text{Cm}^3 \text{ Sec}})$, and

μ_a, μ_s = the air and soil total linear attenuation coefficients (cm^{-1}).

This expression assumes a source distribution that varies only with depth. For fallout activity the distribution after a period of time can be reasonably approximated by an exponential distribution given by

$$S_v = S_v^o e^{-\alpha z}, \qquad (2)$$

where

S_v^o = the activity per unit volume at the surface $\left(\frac{\text{photons}}{\text{cm}^3\ \text{sec}}\right)$, and

α = the reciprocal of the relaxation length (cm^{-1}).

The detector response to a given flux of gamma rays of energy E, incident at an angle , can be given in terms of an effective detector area, A, defined by

$$A = \frac{N_p}{\Theta} . \tag{3}$$

The effective area, in general, varies as a function of the gamma ray angle of incidence and is normally written as

$$A = A_o R(\Theta), \tag{4}$$

where

A_o = the detector photopeak-count-rate for a unit flux incident perpendicular to the detector face $\left(\frac{\text{cps}}{\gamma\ /\text{cm}^2 - \text{sec}}\right)$, and

$R(\Theta)$ = the ratio of the detector response at an angle to that at $\Theta = 0^o$.

Both A_o and $R(\Theta)$ are determined experimentally as a function of energy; calibrated reference sources are used with the detector mounted in its standard field configuration.

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If Eqs. 1, 2, and 4 are combined into the form of Eq. 3, a relationship between the net photopeak count rate and the source activity within the soil will result. In addition, if the appropriate detector calibration results are inserted with the appropriate parameters for a given source distribution and the required numerical integration is performed, the desired conversion factor is produced. The conversion factor, S_v^o/Np, as determined above is in units of $\frac{\gamma/cm^3\text{-sec}}{cps}$. For a specific radionuclide the results can also be given in terms of total activity per unit area, S_Z, using

$$S_Z = \int_o^\infty S_v^o\, e^{-\alpha z}\, dz = \frac{S_v^o}{\alpha}\,, \tag{5}$$

Another useful conversion factor relates the net photopeak count rate to the average concentration in a given layer of soil. The average concentration per unit volume in the top z centimeters, $S_v{}^z$, is given by

$$S_v^z = \frac{1}{z} \int_o^z S_v^o\, e^{-\alpha z} dz \tag{6}$$

$$= \frac{S_v^o}{\alpha z}\,(1-e^{-\alpha z})$$

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Once the conversion factor relating the net photopeak counts, Np, to the activity per unit volume at the surface, S_v^o, is obtained for a source distribution, Eqs. 5 and 6 can be used to arrive at the corresponding conversion factor for the total activity per unit area S_A, and for the average activity per unit volume in the top Z centimeters, S^Z. By dividing the S^Z by the soil density, in g per cm^3, the results can be expressed in units of activity per unit mass.

Table 1 shows the conversion factors for ^{137}Cs obtained for the Enewetak system for several different depth distributions. Also shown in the last column are the corresponding conversion factors for total external exposure rate, in R/h, at the 1 meter level. These results were obtained directly from the total activity per unit area conversion factors using data given by Beck, et al.[3,4]

Various assumptions must be made to derive these conversion factors.[1,3] The most significant assumption is made for the depth distribution. In general, it is very desirable to perform field measurements to establish the source distribution with depth, and thus, also allow for a direct measurement of the soil density. In a situation where the depth distribution varies significantly from point to point within a given area, as on many islands at Enewetak, it is necessary to obtain, or assume, an average depth distribution. For the northern islands at Enewetak, previous data (1) indicate that the average depth distribution for ^{137}Cs has a relaxation length on the order of 10 to 15 cm. In using the data given in Table 1, a reasonable first approach would be to take the average of the values given for a 10 cm and for a 15 cm relaxation length. More precise data can be obtained for any given area if the depth distribution is better known.

Although a knowledge of the depth distribution may be critical when using in situ measurement techniques to determine concentration values, this is not the case if these techniques are used to determine external exposure for rate values. The exposure rate conversion factors (last column, Table 1) are relatively insensitive to rather large variations or uncertainties in the depth distribution. Comparisons made between exposure rate values determined using in situ techniques with those obtained with a pressurized ionization chamber are in general quite good (see, for example, Beels, et al. (4) Table 21).

The conversion factor used for ^{137}Cs was 3.6 R/h per cps. Concentration values may be obtained from the exposure rate values by multiplying the appropriate ratio of the conversion factors given in Table 1. For ^{60}Co, a conversion factor of 20.5 R/h per cps can be used with the 1173 keV peak or 22.3 R/h per cps with the 1333 keV peak. In principle, either of these peaks could be used to determine the total exposure rate resulting from ^{60}Co; both should lead to the same result. In practice, however, some measurements were slightly different in the two results. In these cases the average value was used.

The minimum detectable activity (MDA) for the in situ results was set at the 30 level where sigma equals the square root of the sum of the net photopeak counts plus twice the background counts. Because the MDA is a function of the background under a given photopeak, which varies from location to location, there is no unique number for the MDA for any given isotope. The actual value for a specific isotope varies slightly from location to location, and the values of 0.5 pCi/g for ^{241}Am, 0.2 R/h for ^{137}Cs, and 0.5 R/h for ^{60}Co used in the present report represent the worst-case situation as actually encountered at Enewetak.

In Appendix A there is a draft report by EG G on the calibration and measurement methodology for in situ determination of ^{241}Am at Enewetak Atoll. This draft report will be expanded to include ^{137}Cs and ^{60}Co, although the methodologies are very similar.

With the exceptions of Bokinwotme (Edna), Taiwel (Percy), and Lujor (Pearl), IMP measurements of ^{137}Cs, ^{60}Co, and ^{241}Am were reported by the Desert Research Institute (DRI) for the islands Bokolu (Alice) through Billae (Wilma). IMP measurements of Bokinwotme (Edna) and Taiwel (Percy) are not currently planned and those on Lujor (Pearl) are not complete. In Tables 2 and 3, the average external exposure

rates are summarized in R per h for ^{137}Cs and ^{60}Co, respectively. Average surface soil concentrations, in pCi/g, for ^{241}Am are summarized in Table 4. Two types of mean results are presented in each table--those computed with the actual measurement results and those computed by substituting the appropriate MDA value for all measurement results less than the MDA. Where no measurement results were less than the appropriate MDA, the latter type of mean is not computed. MDA values used in the mean calculations were provided to DRI by EG&G and are single valued over the entire atoll. Results for Bokaidrikdrik (Helen) appear as the Boken (Irene) sand spit entries, because the sand spit is all of Bokaidrikdrik (Helen) that remains. Mean results for the quadrants of Enjebi (Janet) reflect the following allocations of the baseline data: north baseline to the northeast quadrant, east baseline to the southeast quadrant, south baseline and benchmark (point 0,0) to the southwest quadrant, and west baseline to the

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northwest quadrant. West tip of Aomon (Sally) entries reflect results for the land mass created between Eleleron (Ruby) and Aomon (Sally) by the Pacific Area Createring Experiment (PACE) tests. Results for Lojwa (Ursula) are preliminary. With the exception of the Billae (Wilma) ^{60}Co results, the percent difference between the two types of means for a given island and isotope does not exceed 16 percent. In fact, for the most part it is less than 7 percent. The Billae (Wilma) ^{60}Co means reflect the difference expected when a significant number of the measurement results are less than the MDA and the maximum observed is not significantly higher.

In our calculations of the external dose due to ^{137}Cs and ^{60}Co, we have used the mean values based on the actual measurement results for the islands Enjebi (Janet) through Billae (Wilma). For Aomon (Sally) we have weighted the mean results for Aomon (Sally) and Aomon (Sally) west tip according to their respective areas: approximately 40 hectares for Aomon (Sally) and approximately 3.4 hectares for Aomon (Sally) west tip. In the case of the southern islands, Jinedrol (Alvin) through Kidrenen (Keith), we have used the results reported in reference 1 (pg. 501): 0.2 R/h for ^{137}Cs and 0.1 R/h for ^{60}Co. Decayed from 1973 to 1979, the external exposure rates for ^{137}Cs and ^{60}Co among the southern islands are currently estimated at 0.174 and 0.0454 R/h, respectively. To convert from exposure rates to dose rates, a factor of 6.24 mrem/y per μR/h was used.

Beta doses have been measured on Enjebi (Janet) Island and Bokombako (Belle) Island at Enewetak Atoll.[5] The measurements were made at 1 meter height using thermoluminescent Dosimeters (TLD's) with varying thickness of aluminium absorbers. The "shallow doses" calculated for Enjebi (Janet) Island are approximately 1.1 rem in 30 y and for the southern islands the dose is 0.01/rem in 30 y. This "shallow dose" is received primarily by the surface layers of skin (1 cm deep); deep doses from the external beta to organs such as gonads, bone and basal cells in the skin are less than 1 mrem in 30 y. The shallow dose contribution from the beta emitters cannot be summed with the bone and wholebody doses presented in this paper; if surface skin doses were to be considered independently then the "shallow dose" from the beta emitters should be included. Because the beta particles have a short and defined range any absorbing materials present, such as gravel buildings or clothing, will greatly reduce the external dose from beta emitters.

Inhalation Calculations

Respirable $^{293+240}$Pu and ^{241}Am are calculated using data developed in resuspension experiments conducted at Enewetak Atoll in February 1977 and Bikini Atoll in May 1978. A brief description of the methodology is given here but more detail and discussion can be found in a paper currently in press.[6]

The study conducted on Bikini Island in May 1978 provided a more complete set of data, following our preliminary studies on Enjebi (Janet) Island of Enewetak Atoll in February 1977. (Subsequent studies were conducted on Eneu Island of Bikini Atoll.) The Bikini Island study utilized extensive soil sampling and <u>in situ</u> gamma spectroscopy to determine isotope levels in soil and vegetation, various air sampling

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devices to determine particle size distribution and radioactivity, and micrometeorological techniques to determine aerosol fluxes. Four simultaneous experiments were conducted: (1) a characterization of the normal (background) suspended aerosols and the contributions from sea spray off the windward beach leeward across the island, (2) a study of resuspension of radionuclides from a field purposely laid bare by bulldozers as a worst-case condition, (3) a study of resuspension of radioactive particles by vehicular and foot traffic, and (4) a study of personal inhalation exposure using small dosimeters carried by volunteers during their daily routines. Less complete studies similar to (1) and (2) had been performed previously on Enjebi (Janet) and background studies similar to (1) were performed later on Eneu.

The "normal or background" mass loading measured by gravimetric methods for both atolls is approximately $55\ \mu g/m^3$. The Bikini experiments show that $34\ \mu g/m^3$ of this total is due to sea-salt which is present across the entire island as a result of ocean, reef, and wind actions. The mass loading due to terrestrial origins is therefore about $21\ \mu g/m^3$. The highest terrestrial mass loading observed was $136\ \mu g/m^3$ immediately after bulldozing.

Concentrations of $^{239+240}Pu$ have been determined for collected aerosols for normal ground cover and conditions, i.e. "normal conditions", in coconut groves, for areas being cleared by bulldozers and being tilled, i.e. "high activity conditions," and for stabilized bare soil, i.e., the cleared areas after a few days weathering. The plutonium concentration in the collected aerosols changes relative to the plutonium surface soil concentration for the various situations. We have defined an enhancement factor (EF) as the $^{239+240}$Pu concentration in the collected aerosol mass divided by the $^{239+240}$Pu surface soil (0-5 cm) concentration.

The EF obtained from standard Hi Vols for normal conditions is less than 1; the EF for the worst case, high activity conditions is 3.1. Table 5 gives a summary of the observed EF at Bikini and Enewetak Atolls.

The EF of less than 1 (EF<1) for Hi Vol data for the normal open air conditions is apparently the result of selective particle resuspension in which the resuspended particles have a different plutonium concentration than is observed in the total 0-5 cm soil sample; in other words the particle size and density and the corresponding radionuclide concentration is different for the normally resuspended material than for the total 0-5 cm soil sample. In addition, approximately 10 percent of the mass observed on the filter is organic which we know has a much lower Pu concentration than the soil. Similarly the enhancement factor of 3.1 for high activity conditions results from the increased resuspension of particle sizes with higher plutonium concentration than observed in the total 0-5 cm soil sample.

We have developed additional enhancement factors (PDE) from personal dosimeter data. These data are normalized to the Hi Vol data for a particular condition and represent that enhancement that occurs around an individual due to his daily activities (different from the open air measurement made with the Hi Vols). These data are also summarized in Table 5. The total enhancement used to estimate the amount of respired Pu is the combination the Hi Vol and personal

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dosimeter values. The effective enhancement used for normal conditions is = 1.54 and for high activity conditions is 2.9.

In the scenario adopted to carry out the calculations we assume that a person spends 5 h a day in high activity conditions and 19 h a day under normal conditions. Finally a breathing rate of 20 m^3 per day and the surface soil concentration (0-5 cm) for each island is used to complete the calculation for Pu and Am intake via inhalation. The Am concentrations in the surface soil were measured by high resolution gamma spectroscopy (Appendices A and B). The Pu concentrations were estimated by using the conversion ratio ($^{239+240}Pu/^{241}Am$) developed in the soil sampling program and listed in Table 6. Example calculations are provided in Appendix E.

The dose code is run assuming a pulmonary deposition of 0.3. This we feel is conservative from a dose assessment point of view at this time because preliminary analysis of the particle size distribution for both normal and high activity conditions at Bikini Atoll indicate that the pulmonary deposition would be less than 0.3 (Table 5).

The dose contribution from the inhalation pathway is a major source of exposure to the transuranic radionuclides but is a minor contribution to the total predicted doses over the next several decades.

Drinking Water

The drinking water pathway contributes a very small portion of the total dose received via all pathways.[7,8,9] However, we have included an evaluation of this pathway to demonstrate its relative contribution and to complete the assessment of all major pathways.

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The radionuclide concentration data used to evaluate the drinking water pathway are listed in Tables 7, 8 and 9. The preferred and most often used water is cistern water; however, well water is used when dought conditions exist. In addition to drinking water the Marshallese drink considerable quantities of coffee and "Kool-Aid (Malalo)" for which they again primarily use the cistern water. The total fluid intake involving the use of cistern water and well water was determined to be approximately one liter per day in the Ujelang Diet Survey (Appendix C).

Terrestrial Foods

<u>Soil Radionuclide Concentrations</u>. The soil sampling program was begun in February of 1979 at Enewetak Atoll. This program was conducted by the Department of Energy (DOE) Nevada Operations Office (NVOO) with technical direction from Lawrence Livermore Laboratory (LLL). A 50 meter grid was established on each of the islands Bokoluo (Alice) through Billae (Wilma), i.e., the northwest through the northeast and east side of the atoll. Soil profile samples were collected at each 50 m grid point.

All soil profile samples were collected over the following increments: 0-5 cm, 5-10 cm, 10-15 cm, 15-25 cm, 25-40 cm, and 40-60 cm. We have found that 40 cm depth encompasses most of the active root zone of the subsistence crops which we have observed in the northern Marshall Islands. A trench was dug at each 50 m grid point with a backhoe and samples were collected down the sidewall of the trench.

Subsequent to scraping the sidewall to avoid any possible contamination from the digging process. The 0-5 cm sample was collected from a surface area about 25 cm on a side. The area was then expanded by about 10 cm on each side and cleared to a depth of 5 cm. The upper surface (1-2 cm) of this enlarged area (35 cm x 35 cm) was then cleared to ensure that no surface soil, or soil from a preceding increment, had fallen onto the next increment to be sampled. The next sample was then taken from the entire depth of the increment (i.e., 5-10 cm) from an area about 25 cm square within the enlarged region (35 cm x 35 cm). This procedure was repeated until the final increment of 40-60 cm had been collected. A total of approximately 500-900 g of soil was collected for each profile increment.

The soil samples were dried, screened, and ball milled into a fine powder. Samples were then analyzed by gamma spectroscopy to determine the ^{137}Cs concentration and by wet chemistry procedures to determine the concentration of ^{90}Sr and in some cases $^{239+240}$Pu, ^{241}Am, and ^{241}Pu. Gamma spectroscopy of the soil samples for ^{137}Cs was accomplished using NaI Crystals and high resolution, solid state germanium diode systems. Strontium - 90, $^{239+240}$Pu, ^{241}Am, and ^{241}Pu were analyzed by current state of the art wet chemistry procedures by Eberline Corporation.

The radionuclide concentration for the profile for 0-5 cm, 0-10 cm, 0-15 cm, 0-25 cm, 0-40 cm, and 0-60 cm, were calculated using equal weights for each 5 cm increment. The island average for each depth profile (i.e., 0-5 cm, 0-25 cm, 0-40 cm, etc.) were calculated by averaging the results for each profile taken on the island. The results are summarized in Appendix G.

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Concentration Ratios. Very few locally grown crops are avail- able at Enewetak Atoll. The test plots established on Enjebi (Janet) Island have provided data for that island; other than these test plots, the available trees are limited to one or two isolated trees on four or five islands in the northern section of the atoll. Coconut trees are available in the southern half of the atoll but the radionuclide concentrations are very low and it is difficult to develop reliable data.

As a result of the scarcity of locally grow foods at Enewetak which can be directly analyzed, we have developed concentration ratios between food products and soil (pCi/g wet weight in food/pCi/g dry weight in soil) for each radionuclide, using data obtained from our test plots on Enewetak and Bikini Atolls, from the coconut trees on Bikini Atoll which are now producing fruit, and from the few isolated trees on 4 islands at Enewetak Atoll. The mean, standard deviation, median and the high and low values for the concentration ratios developed from samples collected through November 1978 are listed in Tables 10-13 for ^{137}Cs, ^{90}Sr, $^{239+240}$Pu and for ^{241}Am respectively. The concentration ratios are developed from soil profiles taken to a depth of 40 cm through the root zone of the plants being sampled. This depth is used because from our observations this depth encompasses most of the root zone of the subsistence plants we have looked at on Enewetak and Bikini Atoll. A report on the root activity (10) of large mature coconut and banana trees showed most of the activity in the 0-60 cm depth which is consistent with our observations of the physical location of the root zone. The depth which included most all of the root activity varied by age and by species but supports our use of the 0-40 cm profile depth for developing the concentration ratios.

Food Concentration. As a result of the paucity of available food products which can be directly analyzed to determine the radionuclide concentrations in locally grown foods at the atoll, we have predicted the radionuclide concentrations in foods for each island by multiplying the average island soil concentrations for the 0-40 cm depth as discussed above by the concentration ratios developed for the 0-40 cm profile as discussed in "Concentration Ratios". These predicted radionuclide concentrations in foods are then used in conjunction with the diets and dose models to develop the dose assessment for alternate living

patterns.

Marine Foods

The concentrations in marine fish, shellfish, and invertebrates are listed in Table 14 along with the source of data. Much of the data were abstracted from the 1973 Radiological Survey Report.[1] The $^{239+240}$Pu and ^{241}Am data are recently developed by V. E. Noshkin and are lower than previously published values; these fish data, when compared with the corresponding atoll lagoon water concentrations, are more in line with other published concentration ratios (pCi/g in fish/pCi/g in water). The previously published transuranic data are anomalous and we feel the current data are based on reliable collection and analytical methods and they are therefore used in this evaluation. Other assumptions have been identified in the foot notes of the table.

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Diet

The diet used in this dose assessment was recently developed from a survey conducted of the Enewetak people on Ujelang Atoll by the Microesian Legal Service (MLS). The field notes from Mr. Michael Pritchard, who conducted the survey for MLS, are attached in Appendix C along with a sample questionnaire. A detailed summary by LLL on that survey is also included in Appendix C.

The school teacher on Ujelang Atoll joined Mr. Pritchard and MLS staff in conducting the survey. Approximately 25 percent of the Ujelang population were interviewed. The breakdown by age group was:

36	Adult males
36	Adult females
19	12 through 17 y of age
37	4 through 11 y of age
16	0 through 3 y of age

A total of 144 persons were interviewed with 2 females declining to complete the dietary questionaire.

Some people were away from the atoll at the time of the interview and so selection was limited to those households where several people were available. The households were selected at random from the available pool with constraints to meet the goals outlined in Chart 2 of Appendix C.

Throughout our discussions of diet and estimated dose, three expressions are used extensively: normal conditions, famine conditions, and subsistence foods. Normal conditions are those existing within a month of a recent field ship. Famine conditions imply a complete absence of outside or imported foods. Both conditions were defined by Pritchard for the Ujelang diet survey and have been retained by LLL. Subsistence foods are an LLL expression for the locally grown foods of the Ujelang Survey. Under normal conditions, imported foods are preferred over local subsistence food items. During famine conditions subsistence foods are the only source of dietary intake assumed.

Data on the dietary preferences of the Enewetak people were provided to LLL in three parts: (1) Household Survey results for the Ujelang/Japtan population, (2) individual Medical and Diet Survey (IMD) results for 144 persons, and (3) a memorandum from Michael Pritchard (Micronesian Legal Service) - Subject: Report and Field Notes on Ujelang Food Survey, April 22 to May 9, 1979. This report, with minor editing for style but with content unchanged, is attached in Appendix C. According to Pritchard, "the household survey met three major needs: it provided in descriptive fashion an account of the eating habits for the entire population of Ujelang; it provided data on certain special diets for certain types of individuals such as pregnant women; and served as a census document for locating individuals for the IMD survey." The completed IMD questionnaires provided, when known, each surveyed individuals name, age, sex, height, weight, sickness frequency, prior medical treatment, x-ray history, radiation therapy history, parental data, and preference for various subsistence and imported foods under both normal and famine conditions. Consumed quantities of each food item preferred were expressed in 12 oz beverage can volume equivalents per day, week, and month. Pritchard's memorandum provided

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insight into such things as the overall survey procedure, the estimated uncertainties in some reported values, the preferences in preparation and consumption of many food items, and the can conversion data (grams of food per 12 oz can) for some food items.

In the time available, LLL has used the dietary results of the IMD questionnaires to determine the mean intakes in grams/day of subsistence and imported foods under both normal and famine conditions for adult males, adult females, and children in the 0 through 3, 4 through 11, and 12 through 17 year ranges. However, before presenting the results for mean intakes, a brief description of the procedure is in order.

Initially, we examined each questionnaire to determine the total number of individual food items indicated as preferred. Once this was done, we established a standard computer card format for all the food items and then transferred each individuals monthly dietary preferences to cards. Where an individual showed no preference (response) for a specific food item, a blank field appears on the card. In those cases where an individual showed a preference for a specific organ of domestic meat (pork) or poultry (chicken), they have been so recorded. However, in those cases where more than one organ was preferred, but no relative preference given, we have arbitrarily recorded them under the liver.

Concurrently, we developed the can conversion data necessary to convert the 12 oz cans/month into grams/day. The methods used to determine these conversions were many and varied. In some cases, 12 oz cans were packed with the specific food item and weighed; in others, the

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weights for canned or packaged foods were used. In still others, like some marine foods, densities in grams/cc were computed and used for the conversion. Some assumptions were also made where a specific food item was unavailable. Tables 15 and 16 summarize the can conversion data we developed for the subsistence and imported foods, respectively. In each table, the foods have been grouped under the major categories we will eventually refer to in our dietary means. We have included the results reported by Pritchard, where appropriate; and have made liberal use of footnotes to clarify the sources of data. In terms of accuracy, our can conversion data has some limitations. First, we were not able to obtain samples of all foods. Second, our data for fish, shellfish, clams, crabs, octopus, turtle, domestic meat, and wild birds is raw weight, whereas, the majority of these foods are only consumed after some form of cooking. Third, we have assumed an average for raw and scrambled eggs since Pritchard reports that bird eggs are "usually eaten scrambled," chicken eggs are not described, and turtle eggs are "usually eaten raw or scrambled." Fourth, pumpkin, and undoubtedly squash, is consumed cooked rather than uncooked. Fifth, there may be other foods that are consumed in a form different than we reported. Finally, the differences between the LLL and Pritchard values for a specific food item could reflect differences in food form (e.g., raw or cooked), can packing, or both. To be more precise in the can conversion data would require detailed weighing of each food item in the form consumed by the Enewetak people.

The final step in our procedure was analyses of the data with a computer code specifically developed for that purpose. For each specific food item and major category identified, the mean intake, standard deviation, high intake, low intake, and proportion of nonzeroes in the sample (N_o/N) were determined. Likewise for the total diet.

Tables 17 through 21 summarize our dietary intake results for subsistence foods under normal and famine conditions for adult males, adult females, and children in the 0 to 4, 4 to 12, and 12 to 18 year ranges, respectively. Results for imported foods (normal conditions only) are summarized in Tables 22 through 24.

Dr. Jan Naidu documented the dietary intake of Marshallese people on Rongelap and Uterik Atolls as part of a multi-atoll survey conducted from September through November of 1978.[10] The preliminary results from his work are listed in Table 25 and compared with the adult male diet from the Ujelang Survey conducted by the MLS. The diet listed from Dr. Naidu's work is a maximum diet for adult males, i.e., a diet in which people were consuming only locally grown foods. This dietary intake should be compared with the "famine diet" situation from the Ujelang Survey. The dietary intake between the different atolls is not to different; intake of all dietary items is similar except for breadfruit and Pandanus Fruit. This difference can probably be attributed to the large developed trees at Rongelap and Uterik and the lack of the same at Ujelang and certainly Enewetak. It will take 15 years or more for these trees to develop on Enewetak to the stage they have on Rongelap so that sufficient fruit would be available for a higher consumption. Although the coconut meat and milk intake are separately different the combined intake is similar.

Dr. Naidu reports that the "normal diet," which is the one that exists most of the time at the atolls, could be determined by dividing the maximum diet data by a factor of 6 or 7.[11] When this is done the results are comparable to the normal diet developed from the Ujelang Survey. In addition, Dr. Naidu stated that the women's diet is

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approximately 75 percent of the male diet; this is in contrast to the Ujelang Survey in which the female intake exceeded that of the males (see Tables 17 and 18).

In a report summarizing a survey conducted during July and August of 1967 at Majuro Atoll[12] the average coconut use was approximately 0.5 coconuts per day per person. This included young drinking coconuts, old nuts used for grated meat and pressed for small volumes of milk and sprouting nuts used for the sweet, soft core. Recent data from Eneu Island shows that an average drinking coconut contains 325 ml of fluid ($\sigma = 125$ ml) so that even if the entire average coconut use of 0.5 per day were all drinking nuts the average daily intake would be about 160 g per day. This is in good agreement with the results from the Ujelang Survey and Naidu's results for coconut intake.

In summary, two sources of data tend to confirm the magnitude of the intake of coconut and other dietary items developed in the Ujelang Survey. We, therefore, are using the results of the recent Ujelang Dietary Survey to develop the dose estimates in this paper.

The "LLL" diet used in previous assessments[1,7] was developed from observations[13] and published reports in the literature.[14] Because there were no direct surveys of the people in recent years the "LLL" diet was designed to be conservative, i.e., overestimate the intake if anything. From the recent Ujelang Survey it appears that that was indeed the case in that all intake from the current survey is less than that previously used.

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Living Patterns

Doses have been estimated for three major living patterns at Enewetak Atoll. Each living pattern has also been evaluated for options on the source of some subsistence foods and for time distributions. The living patterns are:

1. a. Enjebi (Janet) Island as the residence island with 100 percent of the time spent on the island and all local foods from Enjebi. For the first 8 y after return we assume the coconut, breadfruit and Pandanus Fruit will come from the southern islands. After 8 y the trees which would be planted on Enjebi (Janet) Island at the time of return should be bearing fruit.

   b. Enjebi (Janet) Island as the residence island with 15 percent of a persons time spent on other northern islands Mijikadrek (Kate) through Billae (Wilma) . Ten percent of the coconut intake is assumed to come from these other northern islands otherwise all consumption is again from food crops on Enjebi (Janet) Island. The same situation applies for the first 8 y.

   c. Enjebi (Janet) Island as the residence island with all coconut from the southern islands Jinedrol (Alvin) through Kidrenen (Keith) and 15 percent of a persons time spent on the southern islands. The rest of the local food consumption would be from Enjebi (Janet) Island with the same situation for the first 8 y.

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The Enjebi (Janet) Island living pattern results in the highest predicted doses for the living patterns evaluated in this report.

2. a. The southern islands [Japtan (David), Medren (Elmer), and Enewetak (Fred)] as the residence islands with 100 percent of a persons time spent on the southern islands [Jinedrol (Alivin) through Kidrenen (Keith)] and all local foods from these islands.

   b. The southern islands [Japtan (David), Medren (Elmer), and Enewetak (Fred)] as the residence islands with 10 percent of the coconut intake from the northern islands Mijikadrek (Kate) through Billae (Wilma) and 15 percent of a persons time spent on northern islands.

The southern island living pattern results in the lowest predicted doses for the living patterns evaluated in this report.

3. a. Aomon (Sally) and Bijire (Tilda) as the residence islands with 100 percent of a persons time spent on these islands and all local foods from these islands. Coconut, breadfruit and Pandaus Fruit will come from the southern islands in the first 8 years.

   b. Aomon (Sally) and Bijire (Tilda) as the residence islands with 15 percent of a persons time spent on the other northern islands and 10 percent of the coconut intake coming from other northern islands Mijikadrek (Kate) through Billae (Wilma). The rest of the local foods would come from Aomon (Sally)/Bijire (Tilda) with the usual exception in the first 8 y.

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The doses projected for these living patterns are based upon the adult female diet which represents the maximum intake for adults. The doses are also estimated for two cases from birth through 70 years for Enjebi (Janet) Island only.

In the first scenario, the individual is born within the first year of return to Enjebi (Janet) and resides there continuously for 70 y. With four exceptions, all subsistence foods consumed during a lifetime are assumed to come from Enjebi (Janet) only. Exceptions are the Pandanus Fruit, breadfruit, coconut meat, and coconut fluid. For the first eight y they are assumed to come from the southern islands. Thereafter, they too come from Enjebi (Janet) only.

In the second scenario, the individual is born eight years after return to Enjebi (Janet), and also resides there continuously for the next 70 y. All subsistence foods consumed during that lifetime are assumed to originate from Enjebi (Janet) only. This is consistent and in keeping with our first scenario in which external sources of Pandanus Fruit, breadfruit, coconut meat, and coconut fluid were terminated at the end of the eighth year.

Summarized in Table 26 are the dietary sources and corresponding radionuclide concentration decay periods assumed in estimating the ingestion doses from the two scenarios. Ingestion dose from birth to the fourth year of life is based on the dietary intake of an average child in the 0 to 4 year range. In the first scenario, there is no decay correction applied to the radionuclide concentrations at the time the diet begins. However, in the second scenario, an eight year decay correction is applied to account for the eight year delay in the individuals birth since return of the parents to Enjebi (Janet). Between the fourth to the twelfth years of life, ingestion dose is based on the dietary intake of an average child in the 4 through 11 year range. For the first scenario, two decay period corrections are applied to the radionuclide concentrations. The first occurs at four years and is the point at which the 4 through 11 y range diet commences. The second occurs at eight years and is the point at which all subsistence foods commence to originate from Enjebi (Janet) only. With the second scenario, a single decay period correction is applied at 12 years: the point at which the 4 to 12 y range diet commences. Ingestion dose for the twelfth through seventeenth years of life is based on the dietary intake of an average child in the 12 to 18 y range. Decay period corrections applied in the first and second scenarios reflect commencement of the 12 to 18 y range diet and occur at 12 and 20 y (12 y since birth), respectively. For adulthood, the eighteenth through seventieth years of life, we have assumed the ingestion dose to originate from the dietary intake of adult females. Decay period corrections for commencement of the adult female diet are 18 y for the first scenario and 26 y (18 y since birth) for the second.

Inhalation and external doses estimated for each scenario reflect the previous assumption of continuous residence on Enjebi (Janet). In the first scenario, inhalation and external source contributions commence with the first year of return to Enjebi (Janet). With the second scenario, a decay period correction of eight years is applied to the inhalation and external source contributions before the dose estimates are made.

The predicted doses for each of the above living patterns and options are calculated for normal and famine dietary conditions.

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DOSE CALCULATIONS

Body and Organ Weights

Data from the Brookhaven National Laboratory[15,16] have been summarized to determine the body weight of the Marshallese people. The average body weights of the adult males and females are listed in Table 27. The average adult male body weight is nearly 70 Kg for Bikini and Uterik which is very near the 70 Kg value of reference man.[17] As a result we have used the body and organ weight for reference man in our dose calculations.

^{90}Sr Methodology

Bone marrow doses and dose rates are calculated in two steps. First the model of Bennett[18,19,20] is used to correlate the ^{90}Sr concentrations in diet to that in mineral bone. Next the dosimetric model developed by Spiers[21] is used to calculate the bone marrow dose rate from the concentration in mineral bone.

Bennett's model is an empirical model developed from ^{90}Sr concentrations in New York and San Francisco foods and autopsy bone samples. The concentrations in the diet resulted from world wide fallout. The model is thought to best reflect the ^{90}Sr concentration in bone for the low levels found in the Marshall Islands; it uses as input the actual dietary ^{90}Sr concentration and the output is the actual ^{90}Sr concentration in mineral bone determined from analysis of autopsy samples. It also includes age dependent variations. The calcium content of the normal diet for the Marshallese is listed in Table 28; the average intake is 0.7 g per day which is very similar to the 1.0 g per day estimated for U.S. diets. The model is

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rather insensitive to calcium intake unless it greatly exceeds 1.0 g per day or is less than 0.3 g per day (personal communication, B. G. Bennett and J. Harley). Therefore, the similar nature and the similar intake of Ca for the overall Marshallese diet relative to U.S. diets would indicate no major problems in applying the ^{90}Sr model to the Marshallese population.

Using Spiers model the dose rate, D_o, to a small tissue filled cavity in bone is calculated from the ^{90}Sr concentration in mineral bone. Then, from geometrical considerations, the dose rates to the bone marrow, Dm, and to endosteal cells, Ds, are calculated, using the conversion factors Dm/Do = 0.315 and Ds/Do = 0.434 respectively. The conversion factors are those quoted in UNSCEAR[22] and are equivalent to a marrow dose rate of 1.4 mrad/yr per pCi/gmCa and an endosteal cell dose rate of 1.9 mrad/yr per pCi/gmCa. These dose rates are determined directly and not by comparison to radium so that "rads" are equivalent to "rems." Since bone marrow is considered a blood forming organ (annual dose limit equals 500 mrem/yr) and endosteal cells are in the "other organ" category (annual dose limit equals 1500 mrem/yr), the bone marrow dose is the critical organ in bone (ICRP[23]) for ^{90}Sr.

Example calculations of the model are given in Appendix D.

^{137}Cs and ^{60}Co

For ^{137}Cs and ^{60}Co the methods of ICRP[24,25] and NCRP[26] as developed by Killough and Rohwer in their "INDOS" code[27] are used for the dose calculations. This code is used as published; however, the output is modified to show the body burdens for each year. For ^{137}Cs, which is of major importance in the Marshall Islands, the model consists of two exponential components

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with half times of 1 and 115 days, with 15 percent of the intake going to the 1 day compartment and 85 percent to the 115 day compartment. These data are consistent with preliminary data obtained by Brookhaven National Laboratory[28] on the half time of the long term compartment. The average of 19 Marshallese males showed a mean of 120 days with a range of 75 to 182 for the long term compartment. For 18 females the mean value is 109 days with a range of 50 days to 630 days.

The model for ^{60}Co is a three compartment model with half times of 6 days, 60 days and 800 days with 60 percent, 20 percent, and 20 percent of the intake respectively.[28]

More detail and example calculations for ^{137}Cs and ^{60}Co are given in Appendix D.

Transuranic Radionuclides Methodology

Inhalation. The inhalation model used for the various isotopes of plutonium and for ^{241}Am is that of the ICRP Task Group[29] as adapted by Martin and Bloom.[30] The only difference between Martin and Bloom's model and the ICRP is that the former combines the nasopharyngeal and bronchial compartments into one. The dose is calculated only for the pulmonary compartment so the difference is not significant. Parameters for the lung model are those of the ICRP[31] with the following exceptions: The gut to blood transfer for plutonium isotopes is 1×10^{-4} and for ^{241}Am is 5×10^{-4} [32]; also ^{241}Am is assumed to be a class W compound while plutonium isotopes are class Y.[33]

Ingestion. For the ingestion pathway the gut transfer coefficients are as stated previously: 1×10^{-4} for Pu and 5×10^{-4} for Am. The

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critical organs are bone and liver with 100 year half times for Pu and Am in bone and 40 years in liver. Forty-five percent of the Pu and Am transferred to blood is assumed to reach the bone and 45 percent to reach the liver. The remaining 10 percent is distributed among other organs.

RESULTS

In this section the predicted maximum annual dose rates and the 30 and 50 year integral doses for the different living patterns and options are presented. The "maximum annual dose rate" is defined as that year for the wholebody when the sum of the wholebody ingestion dose from ^{137}Cs and the external gamma dose is a maximum and for bone marrow when the bone marrow ingestion dose from ^{137}Cs and ^{90}Sr and the external gamma dose is a maximum. Due to the build-up of dose from ^{90}Sr ingestion and the continuously decreasing dose after the first year for ^{137}Cs for both ingestion and external gamma, the wholebody and bone marrow "maximum annual dose rates" can occur in a different year and therefore the external dose which contributes to the maximum can be different for the two cases. Figure 3 is a graphical illustration of this point. The maximum annual doses are listed in Table 29 for bone marrow and wholebody for both normal and famine conditions; they are broken down into ingestion and external gamma contributions. The year at which the maximum dose rate occurs is also listed. It is emphasized that doses listed for famine conditions are calculated assuming continuous consumption of foods over a lifetime under famine dietary conditions. This is not a reasonable dietary pattern but it is presented to show the maximum case that could occur. Famine conditions are not expected to occur for more than a month or two each year, if at all.

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In Table 29 are listed the results for Enjebi (Janet) Island that summarize the living pattern of major concern to some of the Enewetak people. In this living pattern all food is assumed to come from Enjebi (Janet) Island except during the first 8 y during which time the coconut meat and fluid, breadfruit and Pandanus Fruit is assumed to come from the southern islands. For normal conditions the predicted maximum annual dose rates are 250 mrem for bone marrow and 235 mrem to the wholebody. If people were to live continually under famine conditions the predicted maximum annual dose rates are 500 mrem and 455 mrem for bone marrow and wholebody respectively.

On comparison of the doses predicted for the four quadrants of Enjebi (Janet), three quadrants are less than the island average (Table 29) and one, the northwest quadrant, exceeds the island average. The doses for the northwest quadrant are 325 mrem/y for bone marrow and 305 mrem/y for wholebody for normal conditions; for famine conditions the doses are 670 mrem/y for bone marrow and 610 mrem/y for wholebody.

The maximum annual dose rates predicted for living patterns Aomon (Sally) and Bijire (Tilda) (all foods from these islands except during the first 8 y) are very similiar. The results are listed in Table 29. For normal conditions the doses predicted for Aomon (Sally) are 50 mrem/y to bone marrow and 45 mrem/y to wholebody and for Bijire (Tilda) the bone marrow and wholebody doses are 46 mrem/y and 44 mrem/y respectively. For famine conditions the bone marrow and wholebody doses are 98 mrem/y and 86 mrem/y for Aomon (Sally) and 89 mrem/y and 82 mrem/y for Bijire (Tilda).

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The dose rates for the southern island living pattern are also listed in Table 29. The maximum annual dose rates predicted for this living pattern are extremely low. For normal conditions the maximum annual bone marrow dose rate is 3.7 mrem and the wholebody dose rate is 3.2 mrem. For continuous famine conditions the maximum annual dose rates for bone marrow and wholebody are only 7.8 mrem and 5.9 mrem respectively.

Table 29 includes the variations to the major living patterns. For example, the maximum annual doses are listed for Enjebi (Janet) Island when 15 percent of a persons time is spent on other northern islands Mijikadrek (Kate) through Billae (Wilma) and 10 percent of this dietary intake of coconut comes from these islands; the other 90 percent of the coconut intake and 85 percent of the time are of course on Enjebi (Janet). Under these conditions the bone marrow dose is reduced from a 250 mrem/y to 230 mrem/y for normal conditions; for famine conditions the reduction is from 500 to 470 mrem. Similar reductions occur in the wholebody doses. For Enjebi (Janet) Island living pattern, options for the net effect of spending time on other northeastern islands is to reduce the dose from those predicted for the Enjebi (Janet) Island living pattern.

The reduction of the predicted Enjebi (Janet) Island doses is of course more dramatic for a case where all of the dietary coconut comes from the southern islands Jinedrol (Alvin) through Kidrenen (Keith) . In this case it is assumed that 15 percent of a persons time would also be spent on the southern islands. The doses for this option for normal conditions are 73 mrem/y for wholebody and 85 mrem/y for bone marrow; for famine conditions the doses are 150 mrem/y and 110 mrem/y for bone marrow and wholebody. The data are listed in Table 29.

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For the living patterns involving Aomon (Sally) and Bijire (Tilda), use of coconuts from other northern islands and time spent on other northern islands slightly increases the predicted doses over those involving Aomon (Sally) and Bijire (Tilda) alone.

The predicted doses when 10 percent of the coconut dietary intake for the southern island pattern is assumed to come from the northern islands and 15 percent of a persons time is spent on northern islands are increased above those predicted for southern islands only. For the combined southern island-northern island living pattern the wholebody and bone marrow doses are 8.3 mrem/y and 9.2 mrem/y for normal conditions and 14 mrem/y and 17 mrem/y for famine conditions.

In Table 29 are also listed the predicted doses for a special case where a child is born on Enjebi (Janet) Island at the time of the peoples return and is raised his entire life on that island. Thus, his entire dietary intake will come from Enjebi (Janet) Island. For normal conditions the wholebody dose is 180 mrem/y and the bone marrow dose is 195 mrem/y. For famine conditions the corresponding doses are 350 mrem/y and 405 mrem/y. For comparison the adults doses for normal conditions for Enjebi (Janet) Island (see Table 29) are 235 mrem/y for wholebody and 250 mrem/y for bone marrow. The corresponding famine condition doses for the adult are 455 mrem/y and 500 mrem/y. The results for the child scenario in which the child is born 8 y after the peoples return is the final entry in Table 29; the doses for normal conditions are 150 mrem/y for wholebody and 170 merem/y for bone marrow, both of which are lower than the other scenario.

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The results for the 30 and 50 y integral doses for wholebody and bone marrow for the living patterns and options being considered are listed in Tables 30 through 44. The doses are broken down into the contributions from the ingestion, external gamma, and inhalation pathway.

The doses predicted for normal and famine conditions on Enjebi (Janet) Island are listed in Table 30. For normal conditions the 30 y integral wholebody dose is 4.9 rem and the bone marrow dose is 5.5 rem. For famine conditions the doses are 9.1 rem and 11 rem respectively. Tables 31-34 list the doses for the four quadrants of Enjebi (Janet) Island. For the case listed in Table 35 where the residence island is Enjebi (Janet) but 10 percent of the dietary coconut comes from other northern islands, the 30 y integral wholebody and bone marrow doses for normal conditions drop to 4.6 rem and 5.1 rem. When Enjebi (Janet) is the residence island, but all coconut comes from the southern islands, the data listed in Table 36 show that for normal conditions the 30 y integral wholebody dose is 1.8 rem and the bone marrow dose is 2.3 rem. For the famine conditions the corresponding doses are 2.6 and 3.8 rem. Tables 37-40 list the results for the Aomon (Sally) and Bijire (Tilda) living patterns; all doses are much less than those predicted for Enjebi (Janet) Island living patterns.

The 30 y doses predicted for the southern island living pattern for normal conditions are 0.069 rem for wholebody and 0.10 rem for bone marrow (Table 41). For famine conditions the corresponding doses rise to 0.12 rem and 0.22 rem. The integral doses for the southern island/northern island option falls between the values given for the Enjebi (Janet) Island pattern and the southern island pattern and are listed in Table 42.

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For the special calculation made for children born at the time of return for the Enjebi (Janet) Island living pattern, the 30 y integral wholebody and bone marrow doses for normal conditions are 4.2 rem and 4.7 rem respectively (Table 43). For the adult case given in Table 30 the results were 4.9 rem and 5.5 rem. For famine conditions the 30 y integral doses for children are again less than those estimated for adults. The doses for the scenario where the child is born 8 years after return (Table 44) are less than when the child is born at the time of return.

The estimated arithmetic mean, $\overline{x}$, of the radionuclide concentrations in soil and foods is used to estimate a dose that, for our data, includes about 65 percent (range, 55 to 75 percent) of samples with equal or lower radionuclide concentrations. Other doses can be estimated from probability plots giving cumulative concentration quantities (for example, Fig. 4). The s^{-1} (s = standard deviation of a log-transformed plot) is the slope of this log-probability plot.[34] By using the slope of the best fitting line, we can estimate the proportion of concentrations that are less than $\overline{x}$, $2\overline{x}$, and $3\overline{x}$; or 90, 95, and 99 percent cumulative probabilities.

Experience with concentrations in soil and air,[35,36] which often follow multiplicative models, yield measured concentrations that have an approximately lognormal probability density. If we refer again to the log-probability plots (Figs. 4 through 10), our otherwise right-skewed untransformed data approximately fit a straight line, and we see at least qualitative evidence for assuming the probability distribution is lognormal.

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To find numerical evidence of lognormality, we chose the Filliben[37] r-test to reject if necessary the hypothesis that each data set is lognormally distributed. Filliben's investigations have shown the r-test to be 98 percent as powerful as Shapiro and Wilk's omnibus W-test[38] for rejecting a lognormal hypothesis when the data are not lognormal. The r-test was validated[37] for sample numbers ranging from 2 to 100. Computationally, the r-test is much more convenient than the W-test in that long lists of constants need not be stored. We approximate the r-probability levels by a second order polynomial in log (number of samples, N) for N 4. The maximum error for this approximation is ± 0.004 in the region N = 10; elsewhere ± 0.001.

We tested all data sets (greater than six measurements each) having more than half the samples greater than the minimum detectable activity (MDA) and found that 91 data sets out of 123 tested lognormal. Of the 91 sets, 56 percent had r-values greater than the 0.5 probability acceptance level; 36 percent, $0.1 \leq r \leq 0.5$; 7 percent $0.05 \leq r \leq 0.1$; and 1 percent, $r \leq 0.05$. The lognormal assumption was rejected for low r-values ($r \leq 0.05$). The resulting inaccuracy is small since those rejected data sets were near the MDA.

Mean ($\overline{x}$), standard variation (s), and cumulative probability were estimated by the (1) Krige's quantile version of the maximum likelihood estimator, (2) log-probability graphical methods, and (3) arithmetic mean. Krige's method is used as outlined by Gilbert,[39] using the

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Finney minimum variance unbiased estimator described by Aitcheson and Brown.[34] The Krige method using a minimum variance unbiased estimator is optimal under the assumption of lognormal distribution (Aitchison and Brown[34] p. 44). The shift parameter, τ, is calculated using Krige's quantile formula.[39] The τ is involved in the log-transform as log $(x_i - \tau)$, where x_i are measurement values in pCi/gm and may be negative and below the minimum detectable activity (MDA). The parameter removes problems of taking logrithms of negative numbers and improves the approximation to the lognormal probability density function. The computer algorithm calculates the first τ. Figure 8, $\tau = 0.6$ pCi/cm, exhibits an example where the left MDA concentrations are forced more closely to a straight line than the same data with $\tau = o$ (Fig. 7) using the Krige method[39] to adjust this parameter about the first approximation to maximize the r-test value. The means and variances are calculated using the Finney fifteen term approximation to a minimum variance estimate (Aitchison and Brown,[34] Eq. 5.37). A visual inspection of each data set is done by a log-probability plot (examples on Figs. 4 to 10). For comparison, the mean and variance was estimated using the quantile method.[34] The minimum variance log-probability-line was used to find the quantile values. Numerical approximations to the cumulative normal distribution used formulas 26.2.23 and 26.2.22 in Abromowitz and Stegun's handbook.[40] Tables 45 through 47 illustrate the comparison of methods for ^{241}Am which have several censored values, and ^{137}Cs at the same sample location. For ^{241}Am, the arithmetic mean frequently underestimates the Krige method (average of 30 percent, underestimation range: 0 to -100 percent, 0-15 cm soils), but the

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quantile method overestimates m and s (average of + 48 percent, range: 0 to + 160 percent, 0-15 cm soil). For ^{137}Cs with few measurements below the MDA, the differences between methods are smaller. For ^{137}Cs 0-15 cm soil measurements the arithmetic mean, x, underestimates -5 percent (range: -32 percent to +6 percent), and for the quantile method, $\overline{x}$ averages 21 percent lower (range -50 percent to 0 percent). As we can see (Table 46), radionuclide concentration data above the MDA the arithmetic averages make a good approximation to the Krige mean for coefficient of variation c, averaging 0.9 (range: 0.6 to 1.5). Recently, White[41] found the arithmetic mean to have a 75 percent efficiency for coefficients of variation, c, less than 2. This efficiency is also shown by Aitchison and Brown.[34]

The value of the shifting parameter can be seen from Tables 45 and 46 to be roughly equal to the MDA values of ^{241}Am (0.2 to 1.5 pCi/gm) and ^{137}Cs (0.1 pCi/gm). Both of these data sets have values less than MDA, set to MDA. Similar analysis on unaltered data exhibits lower or negative values of τ. The ^{137}Cs values (Table 46) are seen on samples Enjebi (Janet) NE and Kidrinen (Lucy) to be unreasonably large, and without physical basis. The improvement in lognormal fit was marginal and the τ could have been set to zero; however, the Krige method is fairly insensitive to τ as illustrated by example,[39] and as our tests have also shown.

The computer computational codes were tested with artificial lognormal samples. A 105 term approximation[42] generated by a rectangular distributed psuedo-random generator produced these artifical samples. Testing samples numbers ranged from 4 to 255.

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Soil radionuclide concentration log-probability plots were constructed for ^{90}Sr, ^{137}Cs, $^{239+240}$Pu, and ^{241}Am at profile depths 0-15 cm, 15-25 cm, 25-40 cm, and 40-60 cm using concentrations in pCi/gm. We examined the islands of Enjebi (Janet) and its four quadrants, Mijikadrek (Kate), Kidrinen (Lucy), Bokenelap (Mary), Elle (Nancy), Aej (Olive), Aomon (Sally), Bijire (Tilda) Lojwa (Ursula), Alembel (Vera), and Billae (Wilma). We evaluated ^{90}Sr and ^{137}Cs concentrations in coconut meat and fluid, and papaya meat from Eneu Island (Bikini Atoll) using the same soil computational algorithms.

Our analyses showed the lognormal probability density assumption to be correct for data sets having a majority of concentration above the MDA. The arithmetic mean is an adequate estimator compared to the minimum variance estimator, particularly when the coefficient of variance is less than two--this includes 96 percent of the analyzed data sets. More importantly, this method evaluates the proportion of measurements less than the mean, $\overline{x}$, and $3\overline{x}$ (Tables 45-47). The analyzed soil and food data $3\overline{x}$ values includes an average of 95 ± 3.5% of the sample (range 88-100 percent) measurements. These $\overline{x}$ and $3\overline{x}$ concentrations are then used to estimate doses that include a known fraction of possible measurements; for $\overline{x}$, more than 64 percent of the measurements are included; and for $3\overline{x}$, 95 percent are included.

Calculations for Alternate Dietary and Time Variations

There is always an interest in developing dose estimates for living patterns, and option within living patterns, which are not developed in the paper. An enormous number of options could be synthesized and it is

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of course impossible to include them all in a paper. We have developed those that we feel are most reasonable and most probable. However, we have included in appendices the data necessary to develop the predicted doses for other variations. By proper use of the appendices one can calculate the external gamma inhalation and dietary coconut contribution for any period of time, for any island, and for any fraction of the diet that one chooses.

Appendix B lists the annual gamma exposure in mrem per year and the cummulative or integral dose in rem for 1 through 70 y for each island. Therefore, once a time distribution on various islands has been established, the external dose can be computed from the data given in Appendix B.

Appendix E lists the doses to the lung and bone due to $^{239+240}$Pu and ^{241}Am as a result of inhalation when 100 percent of a person's time is spent on the listed island. The doses are based upon the inhalation pathway model described in the text. Once again, when a time distribution on various islands has been established, the corresponding lung and bone doses for both dose rates and integral doses, can be calculated from the data given in Appendix E.

Appendix F lists the wholebody and bone marrow annual dose rates and integral doses for normal and famine conditions that result from the entire coconut intake from the listed island after the first 8 y; for the first 8 y, the coconut intake is from the southern islands. The dietary intake of coconut can be prorated among various islands in any fashion desired and the resulting doses can be tabulated; the total dose resulting from any scenario can then be determined. The doses are, of

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course, based upon the coconut intake listed for the famine and normal diets in Table 3. Doses for other intakes can be determined by ratioing the intakes and multiplying by the doses listed in Appendix F.

We listed this information only for coconut because it is the only terrestrial food product likely to be consumed from islands other than the residence island. The three islands or complexes evaluated in this report as residence islands--i.e., Enjebi (Janet), Aomon (Sally), Bijire (Tilda), and the southern islands Japtan (David), Medren (Elmer) and Enewetak (Fred) are the only land masses large enough to sustain a residence of a significant population. Therefore, the dose tables presented in the text are based on the assumption that the rest of the subsistence crops are derived from the identified residence island.

Appendix G contains the average island radionuclide concentration for soil profiles collected on an island; the results are listed for depths of 0-15 cm, 0-25 cm, 0-40 cm, and 0-60 cm. These data, in conjunction with the concentration ratios, are the basis for developing the rationuclide concentrations in food products in the terrestrial food chain. In addition, the data can be used to make relative comparisons of islands at the atoll.

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DISCUSSION

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The doses presented in this assessment are calculated assuming that for northern living patterns the coconut, breadfruit and Pandanus fruit will come from the southern islands for the first 8 years. At the end of 8 years these subsistence crops should be available from initial plantings made on the residence island at the time of return.

The diet used to determine the daily intake of radionuclides is the most direct data available on the current dietary habits of the Enewetak people (see tables 17-24 and appendix 7). The diet is of course very important in predicting doses to a population because the dose will scale directly with dietary intake. We have mentioned in previous assessments the importance of the diet and the uncertainty which was inherent in previously constructed dietary patterns (1,7,21). For the first time we have direct input from a significant number (144) of the Enewetak population as a function of age and of dietary conditions. The "normal condition" in this report refers to the usual and expected living conditions in which the preferred imported foods are available. The "famine condition" is the situation which occurs ocassionally even today when imported foods are in short supply or absent from the diet and there is nearly a total dependence upon locally grown subsistence crops. It is still emphasized that an accurate picture of the diet, especially as it reflects on the consumption of locally grown foodstuffs, is extremely important in the dose predictions for resettlement options at the atoll.

The transuranic doses from inhalation and ingestion are based on an extrapolation of the ^{241}Pu/^{241}Am ratio observed on Enjebi (Janet) Island

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to the entire atoll. The ^{241}Pu data for each island to make these calculations are not yet available and the doses from their source will be refined at a later date. We know their ratio will vary at some of the islands. The results of this increase in ^{241}Am is however insignificant in the overall dose picture for sometime into the future.

Ingestion doses from ^{60}Co are negligible and therefore do not appear in any of the tables. Usually we can not detect ^{60}Co in vegetation samples. It is observed at low concentrations in soil samples but incorporation in plants is such that concentrations rarely exceed the detection limit.

Doses from ^{90}Sr and ^{137}Cs via the inhalation pathway are very small and are therefore not listed in the dose tables. An example calculation for inhalation of ^{137}Cs and ^{90}Sr for Enjebi (Janet) Island is listed in Appendix E for comparison to inhalation doses from other radionuclides.

Uncertainty in the final dose values can result from the uncertainty in three sources of input data: (1) the radionuclide concentration in food, (2) the dietary intake, and (3) the biological parameters such as radionuclide turnover times in the body and fractional deposition in various organs.

The distribution of radionuclide concentration data was discussed in the results and shown in figures 4 through 10. The distribution is lognormal and the use of the arithmetic mean, $\overline{x}$, includes some 65% of the population; two times $\overline{x}$ includes 86% of the population and 3 $\overline{x}$ includes better than 95%. The number of plants in the population with a concentration three times the mean value is less than 5% of the total. Therefore, the probability of a person finding his entire diet for 1, 5, 10 or 30 years from food crops with a concentration of three times the mean value is very small. Soil concentration data are also lognormally distributed with similar percentages accounted for by $\bar{x}$, 2 $\bar{x}$, and 3 $\bar{x}$ and re-enforce those data observed in coconut meat and milk; concentrations in plants should, overall, reflect the concentration in soil.

The observed lognormal distribution of radionuclide concentrations in soils and plants at the atolls is consistent with most elemental distributions in nature. Also the observation that 3 times the mean value includes more than 95% of the population distribution is consistent with other observations several of which have recently been summarized by Cuddihy et al (43).

Strontium-90 concentration distributions in bone have been specifically addressed by Kulp and Schulert (44). They found that ^{90}Sr from fallout was distributed lognormally and that the 98th percentile value was 2.3 times the mean value. Maximum values observed for ^{90}Sr in bone by Bennett were 3 times the mean; most of the data fell below 3 times the mean (18,19). These data also reflect the combined variability of the ^{90}Sr concentration in food products and the variability in dietary intake.

The range of values observed for the retention of ^{137}Cs in humans has been summarized in ICRP 10 and 10A (24,25) and NCRD 52 (26). For example, the range of observed values for the retention time for the short term compartment is 0.5 to 2.1 day with a mean of 1.0 day; the upper limit that has been observed is only a factor of 2, greater than the mean value. For the long term compartment the data range from 60 to 165 with a mean value of 115 days; the maximum value in this case is less than twice the mean value. The fraction of the intake which has been observed to go to the short term (i.e. 1 day) compartment ranges from 0.02 to 0.22 with a mean of 0.15; for the long term (i.e. 115 day) compartment the range is 0.78 to 0.97 with a mean value of 0.85. For both cases the maximum value is less than a factor of two greater than the mean.

The ^{137}Cs gamma exposure data which is listed in table 2 shows that the maximum exposure rate observed at an isolated point on the island is for most islands less than a factor of three greater than the mean volume. In many cases the maximum observed value is only 2 times the mean value. The ^{60}Co data is more variable but it also accounts for a small portion of the external dose over 30 years.

Previous evaluations indicate that dietary intake in a population is lognormally distributed. This would of course mean that x would include more than 50% of the population. We are currently evaluating the data in the Ujelang Dietary Survey to see if the distribution is lognormal and if so what fraction of the population would be included at two or three times the mean value.

In an overall evaluation of the distribution of all of the input data, three times the mean value includes more than 95% of the population; in some cases the maximum observed values were never as great as 3 $\overline{x}$ and closer to like 2 $\overline{x}$. Assuming the variables to be independent and thus combining in a linear fashion the low probability associated with values equal to or exceeding 3 $\overline{x}$ for each of these input parameters, would lead to an extremely small probability of all such events occurring for one person.

In summary, the use of the mean value $\overline{x}$ for estimating the dose to people resettling at Enewetak Atoll provides dose estimates which includes more than half the population. Until a more thorough analysis can be

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performed on the distribution of final doses the above discussion about the uncertainty in the input parameters would indicate that a reasonable estimate of the potential maximum dose would be three times the dose listed in the tables. This dose would be expected to occur in a very small fraction of the population.

A significant feature of the dose analysis is the tremendous reduction in potential dose to Enjebi (Janet) residents if coconuts from Enjebi (Janet) are removed from the diet and replaced by coconuts from Southern Islands. For this option, maximum annual dose rates for a "maximum individual" are less by nearly a factor 3 than when coconut came from Enjebi (Janet) Island (tables 29, 30 and 36). Again this emphasizes how important the diet is in estimating doses at the atoll and the importance of imported foods in reducing potential doses.

The two scenarios used for estimating the dose to children are for Enjebi (Janet) Island living pattern because it leads to the highest dose of all the living patterns evaluated. The doses for the case where the child is born at the time the people return are greater than for the case where the child is born 8 years after return. In addition the maximum dose case from birth through seventy years leads to estimated doses which are less than those predicted for adults, living on Enjebi (Janet) Island. Thefore, the doses predicted for adults for other living patterns could be used as a conservative estimats for the birth through 70 year dose.

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Table 1. Conversion factors relating the net photopeak count rate (cps) for ^{137}Cs to source activity in the soil and to external exposure rate as a functon of source distribution.

Relaxation Depth 1/	Average Activity In the top Z cm		Total Activity per Unit Area	Expanded Exposure Rate at the 1 Meter Level
cm	z ,	$\frac{Sv^{Z}/e}{\overline{N}_p}$,	$\frac{S_A}{\overline{N}_p}$,	$\frac{\mu R/h}{\text{per cps}}$
	cm	$\frac{pCi/g}{cps}$	$\frac{\mu Ci/m^2}{cps}$	
5	0	13	1.09	3.6
	5	8.2		
	10	5.6		
	15	4.1		
	25	2.6		
	40	1.6		
	60	1.1		
10	0	10	1.5	3.7
	5	7.9		
	10	6.3		
	15	5.2		
	25	3.7		
	40	2.5		
	60	1.7		
15	0	8.8	2.0	3.4
	5	7.5		
	10	6.4		
	15	5.6		
	25	4.3		
	40	3.1		
	60	2.2		

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Table 2. Average external exposure rate for ^{137}Cs at 1 meter.

	All Data (Actual Measurement Results)					All Data (MDA Replaced with MDA)[a]				
Island	N	^{137}Cs µR/hr	σ µR/hr	Low Value µR/hr	High Value µR/hr	N	^{137}Cs µR/hr	σ µR/hr	Low Value µR/hr	High Value µR/hr
Bokoluo (Alice)	64	29.23	14.53	3.6	63.3	-	-	-	-	-
Bokombako (Belle)	43	35.80	15.80	0.9	62.8	-	-	-	-	-
Kirunu (Clara)	25	18.28	10.75	3.3	42.8	-	-	-	-	-
Louj (Daisy)	30	4.39	4.71	0.7	16.8	-	-	-	-	-
Boken (Irene)[b]	60	4.41	3.53	0.22	13.63	-	-	-	-	-
Sand Spit	19	0.42	0.11	0.25	0.65	-	-	-	-	-
Enjebi (Janet)	980	10.07	5.27	0.05	36.2	980	10.07	5.27	0.2	36.2
NE Quadrant	272	10.03	5.58	0.05	36.2	272	10.03	5.58	0.2	36.2
SE Quadrant	285	8.86	3.24	2.3	23.2	-	-	-	-	-
SW Quadrant	128	9.07	4.47	0.6	19.8	-	-	-	-	-
NW Quadrant	295	11.70	6.37	0.5	29.5	-	-	-	-	-
Mijikadrek (Kate)	21	4.95	3.03	0.4	10.8	-	-	-	-	-
Kidrinen (Lucy)	28	6.09	4.13	0.2	14.0	-	-	-	-	-
Bokenelab (Mary)	19	3.14	1.55	1.1	6.9	-	-	-	-	-
Elle (Nancy)	47	6.76	1.76	2.1	10.1	-	-	-	-	-
Aej (Olive)	54	5.09	1.79	1.2	8.7	-	-	-	-	-
Eleleron (Ruby)	9	0.65	0.32	0.39	1.31	-	-	-	-	-
Aomon (Sally)	142	2.20	1.80	0.1	9.5	142	2.21	1.80	0.2	9.5
Wist Tip	63	2.71	3.03	0.2	14.8	-	-	-	-	-
Bijire (Tilda)	58	2.29	0.74	0.4	4.2	-	-	-	-	-
Lojwa (Ursula)[c]	16	0.8	-	-	-	-	-	-	-	-
Alembel (Vera)	57	1.68	0.74	0.2	2.8	-	-	-	-	-
Billae (Wilma)	20	0.77	0.38	0.1	1.5	20	0.77	0.37	0.2	1.5

[a] MDA is 0.2 µR/hr

[b] Additional cleanup done on Boken (Irene). Results may change.

[c] Data collection is incomplete. Results reported are preliminary.

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Table 3. Average external exposure rate for ^{60}Co at 1 meter.

	All Data (Actual Measurement Results)					All Data (<MDA Replaced with MDA)[a]				
Island	N	^{60}Co μR/hr	σ μR/hr	Low Value μR/hr	High Value μR/hr	N	^{60}Co μR/hr	σ μR/hr	Low Value μR/hr	High Value μR/hr
Bokoluo (Alice)	64	17.40	8.09	4.1	32.5	–	–	–	–	–
Bokombako (Belle)	43	15.15	6.60	1.9	23.7	–	–	–	–	–
Kirunu (Clara)	25	9.25	4.85	2.1	19.5	–	–	–	–	–
Louj (Daisy)	30	7.02	5.60	0.4	20.8	30	7.02	5.60	0.5	20.8
Boken (Irene)[b]	60	19.91	23.51	0.30	115.20	60	19.92	23.50	0.5	115.20
Sand Spit	19	2.03	0.81	0.6	3.6	–	–	–	–	–
Enjebi (Janet)	965	2.88	3.03	0.0	38.6	965	2.92	2.99	0.5	38.6
NE Quadrant	259	3.74	4.48	0.0	24.4	272	10.03	3.44	0.5	24.4
SE Quadrant	285	1,86	1.09	0.0	05.0	–	–	1.02	0.5	5.0
SW Quadrant	128	2.80	5.15	0.0	33.6	–	–	5.12	0.5	38.6
NW Quadrant	293	3.16	2.26	0.0	16.3	–	–	2.22	0.5	16.3
Mijikadrek (Kate)	21	1.85	1.09	0.4	3.5	–	–	1.08	0.5	3.5
Kidrinen (Lucy)	28	2.63	1.50	0.1	4.6	–	–	1.42	0.5	4.6
Bokenelab (Mary)	19	1.40	0.70	0.3	2.8	–	–	0.68	0.5	2.8
Elle (Nancy)	47	2.22	0.54	0.5	3.2	–	–	–	–	–
Aej (Olive)	54	1.87	0.71	0.2	3.0	–	–	0.70	0.5	3.0
Eleleron (Ruby)	9	3.82	6.04	0.4	19.5	–	–	6.03	0.5	19.5
Aomon (Sally)	142	0.71	0.52	0.0	3.5	142	2.21	0.43	0.5	3.5
Wist Tip	63	3.94	6.47	0.2	33.8	–	–	6.45	0.5	33.8
Bijire (Tilda)	58	0.72	0.31	0.3	1.4	–	–	0.27	0.5	1.4
Lojwa (Ursula)[c]	16	0.2	–	–	–	–	–	–	–	–
Alembel (Vera)	57	0.52	0.22	0.1	1.0	–	–	0.13	0.5	1.0
Billae (Wilma)	20	0.32	0.13	0.1	0.6	20	0.11	0.02	0.5	0.6

[a] MDA is 0.5 μR/hr

[b] Additional cleanup done on Boken (Irene). Results may change.

[c] Data collection is incomplete. Results reported are preliminary.

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Table 4. Average surface soil concentration for ^{241}Am.

	All Data (Actual Measurement Results)					All Data (<MDA Replaced with MDA)[a]				
Island	N	^{241}Am pCi/g	σ pCi/g	Low Value pCi/g	High Value pCi/g	N	^{241}Am pCi/g	σ pCi/g	Low Value pCi/g	High Value pCi/g
Bokoluo (Alice)	64	15.68	8.81	1.4	37.8	–	–	–	–	–
Bokombako (Belle)	43	19.21	8.10	2.5	30.6	–	–	–	–	–
Kirunu (Clara)	25	7.48	3.11	3.7	14.2	–	–	–	–	–
Louj (Daisy)	30	9.02	4.84	2.3	24.6	–	–	–	–	–
Boken (Irene)[b]	60	2.65	1.50	0.8	7.0	–	–	–	–	–
Sand Spit	19	1.28	0.42	0.5	2.3	–	–	–	–	–
Enjebi (Janet)	1015	5.01	3.35	0.0	15.9	1015	5.02	3.34	0.5	15.9
NE Quadrant	302	5.69	3.42	0.2	14.5	302	5.69	3.42	0.5	15.9
SE Quadrant	285	5.38	3.11	0.1	13.5	285	5.39	3.10	0.5	13.5
SW Quadrant	128	4.74	3.37	0.5	11.8	–	–	–	–	–
NW Quadrant	300	4.09	3.29	0.0	15.9	300	4.10	3.28	0.5	15.9
Mijikadrek (Kate)	21	6.09	4.53	1.1	15.8	–	–	–	–	–
Kidrinen (Lucy)	28	10.6	8.06	0.5	25.2	–	–	–	–	–
Bokenelab (Mary)	19	4.62	3.31	1.2	12.4	–	–	–	–	–
Elle (Nancy)	47	9.8	3.46	2.2	18.6	–	–	–	–	–
Aej (Olive)	54	5.55	3.45	1.5	14.3	–	–	–	–	–
Eleleron (Ruby)	9	0.90	0.42	0.2	1.4	9	0.96	0.33	0.5	1.4
Aomon (Sally)	142	1.80	2.39	-0.2	14.1	142	1.88	2.33	0.5	14.1
West Tip	63	1.09	0.96	0.0	4.5	63	1.15	0.92	0.5	4.5
Bijire (Tilda)	58	1.96	1.30	0.1	5.8	58	1.98	1.29	0.5	5.8
Lojwa (Ursula)[c]	16	0.5	–	–	–	–	–	–	–	–
Alembel (Vera)	57	2.18	1.03	0.3	4.2	57	2.19	1.01	0.5	4.2
Billae (Wilma)	20	0.83	0.58	0.0	1.9	20	0.94	0.46	0.5	1.9

[a] MDA is 0.5 pCi/g

[b] Additional cleanup done on Boken (Irene). Results may change.

[c] Data collection is incomplete. Results reported are preliminary.

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Table 5. Pulmonary Deposition of Plutonium ($^{239+240}Pu$) for Worst Case andBest Case Conditions on Bikini.

Condition	Inhalation Rate ($m^3\ h^{-1}$)	Dust Aerosol ($\mu g\ m^{-3}$)	Soil Pu Activity ($aCi\ \mu g^{-1}$)	Enhancement Factor (EF)	Personal Enhancement (PDE)	Respirable Fraction (RESP)	Pulmonary Disposition ($aCi\ h^{-1}$)
Bare Field, During tilling	1.04	136	15.3	3.10	0.92	0.24	1476
Stabilized Field, Heavy Work	1.04	21	15.3	0.83	2.64	0.19	139
In and Around Houses, Light work	0.83	21	15.3	0.83	1.86	0.19	78
Coconut Grove Light work	0.83	21	8.0	0.41	1.10	0.19	12
At Roadside, One Vehicle/Hr*	0.023	28	4.1	2.50	(1.0)	0.24	1.58 + BG

*Exposure to one, ten-second, median, vehicular dust-pulse, not including background (BG).

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Table 6. Ratio of the Concentration in Soil of $^{239+240}Pu$ to ^{241}Am for Islands at Enewetak Atoll.

Island	$\frac{^{239+240}Pu}{^{241}Am}$
Mijikadrek (Kate)	1.7
Kidrinen (Lucy)	1.6
Bokenelab (Mary)	1.9
Elle (Nancy)	1.7
Aej (Olive)	1.7
Eleleron (Ruby)	5.4
Aomon (Sally)	2.4
Bijire (Tilda)	1.8
Lojwa (Ursula)	1.8*
Alembel (Vera)	1.5
Billae (Wilma)	1.8
Enjebi (Janet) Northwest	4.3/2.3
Enjebi (Janet) Northeast	2.3
Enjebi (Janet) Southwest	2.3
Enjebi (Janet) Southeast	2.3
Southern Islands	1.8*

*Assumed to be the same as Bijire (Tilda) and Billae (Wilma)

[redacted]

Table 7. Measured and Estimated Radionuclide Concentrations in Meat and Water for Enjebi (Janet) Island.

ENJEBI

pCi/g Wet Weight

	^{137}Cs	^{90}Sr	$^{239+240}Pu$	^{241}Am
Pork	45[a]	0.51[d]	1.3×10^{-3}[d]	0.7×10^{-3}[c]
Chicken	1.9[a]	0.51[d]	1.3×10^{-3}[d]	0.7×10^{-3}[c]
Chicken Eggs*	1.9	0.51	1.3×10^{-3}	0.7×10^{-3}[c]
Groundwater+	90[b]	11[b]	6.7×10^{-3}[b]	2.9×10^{-3}[c]
Cistern Water+	1.8[e]	1.34[c]	1.7×10^{-2}[e]	0.85×10^{-2}[c]

\+ Units are pCi/l rather than pCi/g.

* Assumed to be the same as chicken.

[a] Calculated from pig and chicken data from Bikini Island (W.L. Robison to be published); Bikini meat data is multiplied by the ratio of the Southern Island soil concentration to the Bikini Island soil concentration to develop the Southern Island meat concentration.

[b] From V. Noshkin et al., Plutonium Radionuclides in the Groundwaters at Enewetak Atoll, International Atomic Energy Agency Symposium, Transuranium Nuclides in the Environment, IAEA-SM-199/33 Vienna, 1976.

[c] Calculated from Pu data and the $^{239+240}Pu/^{241}Am$ ratio listed in Table 6.

[d] Assumed to be the same as rat muscle concentrations; taken from Enewetak Radiological Survey Report, NVO-140, Vol. 1, 1973.

[e] Assumed to be the same as Bikini Island Cistern Water; data from V.E. Noshkin et al., Evaluation of the Radiological Quality of the Water on Bikini and Eneu Islands in 1975; Dose Assessment Based on Initial Sampling, Lawrence Livermore Laboratory, Report UCRL-51879, Part 4, 1977.

Table 8. Measured and Estimated Radionuclide Concentrations in Meat and Water for Southern Islands.

SOUTHERN ISLANDS [Jinedrol (Alvin through Kidrenen (Keith))]

pCi/g Wet Weight

	^{137}Cs	^{90}Sr	$^{239+240}Pu$	^{241}Am
Pork	0.51[a]	0.012[d]	1.1×10^{-3}[d]	0.5×10^{-3}[c]
Chicken	0.021[a]	0.012[d]	1.1×10^{-3}[d]	0.5×10^{-3}[c]
Chicken Eggs*	0.021	0.012	1.1×10^{-3}	0.5×10^{-3}[c]
Groundwater+	0.56[e]	0.09[e]	0.51×10^{-3}[b]	0.26×10^{-3}[c]
Cistern Water+	0.09[f]	0.1[f]	0.2×10^{-3}[b]	0.1×10^{-3}[c]

+ Units are pCi/l rather than pCi/g.

* Assumed to be the same as chicken meat.

[a] Calculated from pig and chicken data from Bikini Island (W.L. Robison - to be published); Bikini meat data is multiplied by the ratio of the Southern Island soil concentration to the Bikini Island soil concentration to develop the Southern Island meat concentration.

[b] From V. Noshkin, Plutonium Radionuclides in the Groundwaters at Enewetak Atoll, International Atomic Energy Agency Symposium, Transuranium Nuclides in the Environment, IAEA-SM-199/33 Vienna, 1976.

[c] Calculated from Pu data and the $^{239+240}Pu/^{241}Am$ ratio listed in Table 6.

[d] Assumed to be the same as rat muscle concentrations; taken from Enewetak Radiological Survey Report, NVO-140, Vol. 1, 1973.

[e] V. Noshkin - private communication (Memo August 28, 1974).

[f] Assumed to be the same as Kwajelein Cistern Water, source of Kwajelein Cistern data, V. Noshkin et al., Evaluation of the Radiological Quality of the Water on Bikini and Eneu Islands in 1975; Dose Assessment Based on Initial Sampling, Lawrence Livermore Laboratory, Report UCRL-51879, Part 4, 1977.

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Table 9. Measured and Estimated Radionuclide Concentrations in Meat and Water for Aomon (Sally) and Bijire (Tilda).

AOMON (SALLY)/BIJIRE (TILDA)

pCi/g Wet Weight

	^{137}Cs	^{90}Sr	$^{239+240}Pu$	^{241}Am
Pork	7.7[a]	0.013[a]	1.6×10^{-3}[b]	0.8×10^{-3}[c]
Chicken	0.33[a]	0.013[a]	1.6×10^{-3}[b]	0.8×10^{-3}[c]
Chicken Eggs*	0.33	0.013	1.6×10^{-3}	0.8×10^{-3}[c]
Groundwater+	f	f	f	f
Cistern Water+	0.21[d]	0.36[d]	1.6×10^{-3}[c]	0.1×10^{-3}[c]

\+ Units are pCi/l rather than pCi/g.

* Assumed to be the same as chicken meat.

a Calculated from pig and chicken data from Bikini Island (W.L. Robison - to be published); Bikini meat data is multiplied by the ratio of the Aomon/Bijire radionuclide soil concentration to the Bikini Island soil concentration to develop the Aomon/Bijire meat concentration.

b Assumed to be the same as rat tissue concentrations; taken from Enewetak Radiological Survey Report, NVO-140, Vol. 1, 1973.

c Calculated from Pu data and the $^{239+240}Pu/^{241}Am$ ratio listed in Table 6.

d Assumed to be the same as Eneu Island Cistern Water - Eneu Island data from V. Noshkin report to DOE HQ.

e From V. Noshkin, Plutonium Radionuclides in the Groundwaters at Enewetak Atoll, International Atomic Energy Agency Symposium, Transuranium Nuclides in the Environment, IAEA-SM-199/33 Vienna, 1976. For Aomon (Sally) the cistern water is assumed to have the same concentration as the catchment water contained in small craters in the PACE excavation area.

f The lens water on Aomon/Bijire is not suitable chemically for drinking; the lens water is extremely brackish and a fresh water layer is non-existent - V. Noshkin personal communication.

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Table 10. Concentration Ratio (CR) Estimated over a 0 to 40 cm Soil Profile for Subsistence Crops for ^{137}Cs.

Food Item	Number	$\overline{CR}$[a]	σ	High Value	Median	Low Value
Coconut Meat	26	5.8	4.2	16	4.3	1.3
Coconut Fluid		2.9				
Breadfruit	9	0.54	0.48	1.6	0.38	0.12
Pandanus Fruit	5	3.9	3.8	9.6	2.8	0.18
Papaya	25	0.58	0.44	1.6	0.39	0.2
Squash	12	4.3	1.8	8.2	4.3	1.8
Banana	5	0.16	0.093	0.28	0.14	0.075
Watermelon	17	1.6	1.2	4.3	1.4	0.12

[a] pCi/g fruit wet weight / pCi/g soil dry weight.

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Table 11. Concentration Ratio (CR) Estimated over a 0 to 40 cm Soil Profile for Subsistence Crops for ^{90}Sr.

Food Item	Number	$\overline{CR}$[a]	σ	High Value	Median	Low Value
Coconut Meat	15	6.3(-3)	3.9(-3)	1.6(-2)	5.1(-3)	1.7(-3)
Coconut Fluid		6.3(-3)[b]				
Breadfruit	9	7 (-2)	5.8(-2)	1.5(-1)	5.5(-2)	5.8(-3)
Pandanus Fruit	3	4.6(-1)	2.2(-1)	6.9(-1)	4.2(-1)	2.6(-1)
Papaya	4	6.3(-2)	3.5(-2)	1.1(-1)	5.8(-2)	2.5(-2)
Squash	5	2.6(-2)	1.2(-2)	4.0(-2)	2.8(-2)	8.8(-3)
Banana	3	9.1(-3)	5.5(-3)	1.5(-2)	7.7(-3)	4.4(-3)
Watermelon	8	1.8(-2)	7.9(-3)	2.9(-2)	1.5(-2)	7.2(-3)

[a] pCi/g fruit wet weight / pCi/g soil dry weight.

[b] Assumed to be equal to coconut meat.

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Table 12. Concentration Ratio (CR) Estimated over a 0 to 40 cm Soil Profile for Subsistence Crops for $^{239+240}$Pu.

Food Item	Number	$\overline{CR}$[a]	σ	High Value	Median	Low Value
Coconut Meat	14	5.0(-5)	5 (-5)	1.8(-4)	3.1(-5)	1.5(-6)
Coconut Fluid		5.0(-5)[b]				
Breadfruit	8	1.5(-5)	1.6(-5)	4.7(-5)	1.2(-5)	1.6(-6)
Pandanus Fruit	3	4.3(-5)	4.2(-5)	8.9(-5)	3.3(-5)	6.4(-6)
Papaya	4	2.7(-5)	2.7(-5)	6.1(-5)	2.4(-5)	3.3(-7)
Squash	5	1.9(-5)	1.5(-5)	4.0(-5)	1.2(-5)	3.3(-6)
Banana	3	3 (-5)	3 (-5)	6.4(-5)	1.9(-5)	7.2(-6)
Watermelon	8	4.8(-5)	3.1(-5)	8.9(-5)	4.3(-5)	7.6(-6)

[a] pCi/g fruit wet weight / pCi/g soil dry weight.

[b] Assumed to be the same as coconut meat.

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Table 13. Concentration Ratio (CR) Estimated over a 0 to 40 cm Soil Profile for Subsistence Crops for ^{241}Am.

Food Item	Number	$\overline{CR}$[a]	σ	High Value	Median	Low Value
Coconut Meat	8	3.7(-5)	2.4(-5)	8.3(-5)	3.7(-5)	2.6(-6)
Coconut Fluid		3.7(-5)[b]				
Breadfruit	5	1.7(-5)	2.2(-5)	5.6(-5)	6.5(-6)	2.6(-6)
Pandanus Fruit	2	1.2(-4)	1.5(-4)	2.3(-4)	1.2(-4)	1.0(-5)
Papaya	4	3.1(-4)	5 (-4)	1.0(-3)	9.3(-5)	1.1(-6)
Squash	-	-	-	-	-	-
Banana	1	2.2(-5)	-	-	-	-
Watermelon	7	2.7(-5)	2.7(-5)	7.8(-5)	2.8(-5)	2.5(-6)

[a] pCi/g fruit wet weight / pCi/g soil dry weight.

[b] Assumed to be the same as coconut meat.

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Table 14. Measured and Estimated Radionuclide Concentrations in Marine Species and Birds at Enewetak Atoll.

Animal	pCi/g Wet Weight ^{137}Cs	^{90}Sr	$^{239+240}$Pu	^{241}Am
Fish[a]	0.11[e]	0.021[e]	2.4×10^{-3}[f]	0.52×10^{-3}[f]
Shellfish[b]	0.0025[f]	,0.0038[e]	0.0011[e]	,0.0015[e]
Clams[c]	0.11[g]	0.0057[e]	0.044[e]	0.0095[h]
Birds	0.024[e]	0.011[e]	2.4×10^{-3}[j]	0.52×10^{-3}[j]
Bird Eggs	0.029[e]	0.19[e]	2.4×10^{-3}[j]	0.52×10^{-3}[j]
Crabs[d]	1.7[e]	0.43[e]	8.8×10^{-4}[e]	4.4×10^{-4}[i]
Octopus				
Turtle				

[a] Includes reef fish and pelagic fish. Radionuclide concentrations are assumed to be the same for all species.

[b] Includes lobster and marine crabs which are assumed to have the same radionuclide concentration in tissue.

[c] Includes the different species and both muscle tissue and hepatopancreas.

[d] Includes coconut crabs and land crabs both of which are assumed to have the same radionuclide concentrations in tissue.

[e] Enewetak Radiological Survey, NVO-140, 1973, Vol. 1.

[f] Victor Noshkin - to be published.

[g] Assumed to be the same as fish muscle.

[h] Calculated using the fish $^{239+240}$Pu/^{241}Am ratio.

[i] Calculated assuming the average $^{239+240}$Pu/^{241}Am ratio for all Northern Islands is 2.

[j] Assumed to be the same as fish muscle.

[redacted]

Table 15. Summary of can conversion data for subsistence food items for the Ujelang Survey.

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Food	Food Type	Grams per	Food	Food Type	Grams per
Fish			Eggs		
	Reef Fish	219		Bird Eggs	364[k]
	Tuna	290[a]		Chicken Eggs	364
	Mahi Mahi	250[a]		Turtle Eggs	364[k]
Shellfish			Pandanus		
	Marine Crabs	362[b]		Pandanus Fruit	119 (112)[l]
	Lobster	354[c]		Pandanus Nuts	340[m]
Clams			Breadfruit		217[n]
	Clam Muscle	368[d]			
	Trochus	368[e]	Coconut Fluid		
	Tridacna Muscle	368[e]		Coconut Juice	355[o]
	Tridacna Viscera	368[e]		Coconut Milk	355[o]
	Jedrul	368[e]		Tuba/Jekerd	355[o]
Crabs			Coconut Meat		
	Coconut Crabs	362[f]		Young Coconut	300[a]
	Land Crabs	362[f]		Middle Age Coconut	210 (185)[a]
				Old Coconut	125[a]
Octopus		364[g]		Marshallese Cake	54[p]
Turtle		368[e]	Papaya		360
				Squash (Uncooked)	232
Domestic Meat				Pumpkin (Uncooked)	232
	Chicken Muscle (raw)	369		Banana	252
	Chicken Liver (raw)	409[h]		Watermelon	253
	Chicken Gizzard (raw)	369[i]		Arrowroot	242 (220)[a]
	Pork Muscle (raw)	369[i]		Citrus	319
	Pork Kidney (raw)	367[i]			
	Pork Liver (raw)	409[h]	Aquas Liquids		
	Pork Heart (raw)	369		Rainwater	355
				Wellwater	355
Wild Birds				Malolo	355[o]
	Bird Muscle (raw)	369[i]		Coffee/Tea	355[o]
	Bird Viscera (raw)	409[h]			

[redacted]

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[a] Weight reported by Pritchard.

[b] Calculated from density of Dungeness crab.

[c] Calculated from density of lobster tail.

[d] Calculated from density of Cherrystone clam muscle.

[e] Assumed the same as Clam Muscle.

[f] Assumed the same as Marine crab.

[g] Calculated from density of squid. Assumed the same.

[h] Value is for beef liver. Assumed the same.

[i] Assumed the same as chicken muscle.

[j] Value is for beef kidney. Assumed the same.

[k] Assumed the same as chicken eggs. Value is mean for raw (393 G/can) and scrambled (335 G/can).

[l] Value is for raw Pandanus less fibrous strings. Calculated from data reported by Pritchard.

[m] Value is for roasted peanuts and cashews. Assumed the same.

[n] Calculated from weights reported by Pritchard. Boiled (255 G/can - 60 percent consumption).

[o] Assumed the same as water.

[p] Quantity of coconut meat in marshallese cake. Calculated from data reported by Pritchard.

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Table 16. Summary of can conversion data for imported food items for the Ujelang Survey

FOOD ITEM	GRAMS PER 12oz CAN	FOOD ITEM	GRAMS PER 12oz CAN
Baked Bread	130 (90)[a]	Carbonated Drinks	355[c]
Fried Bread	115 (186)[b]		
Pancakes	166	CANNED JUICES	
Cake	141	Orange Juice	355[c]
Rice (Cooked)	343	Tomatoe Juice	355[c]
Instant Potatoes (Cooked)	355	Pineaple Juice	355[c]
Sugar	350[c]	Other Canned Juice	355[c]
CANNED MEATS AND POULTRY		MILK PRODUCTS	
Canned Chicken	341[c]	Evaporated Milk	355[c]
Corned Beef	340[c]	Powdered Milk	355[c]
Spam	3r0[c]	Whole Milk	355[c]
		Canned Butter	340[c]
CANNED FISH			
Canned Mackeral	340[c]	Onion	235
Canned Sardines	339[c]	Canned Vegetables	340[c]
Canned Tuna	340[c]	Baby Food	341[c]
Canned Salmon	341[c]	Cocoa	355[c]
Other Canned Fish,	340[c]	Ramen Noodles(Cooked)	364
Other Meat, Fish, or Poultry	340[d]	Candy	200

[a] Weight reported by Pritchard.

[b] Mean weight for two forms of fried bread reported by Pritchard. Round doughnut holes (151 G/can) and a heavier version (2200 G/can). Both of equal popularity.

[c] Weight in grams from grocery store containers.

[d] Assumed the same as canned meat, fish, and poultry.

[c] Weight reported is for lard.

[redacted]

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Table 17. Dietary intake in g/day for selected subsistence food items in the Ujelang Survey for adult males.

	Normal Conditions						Famine Conditions					
Food	Number	Mean	σ	Low Value	High Value	Proportion of Nonzeros	Number	Mean	σ	Low Value	High Value	Proportion of Nonzeros
Fish	36	41.5	34.7	7.9	194.6	1.00	36	89.3	67.0	12.7	341.7	1.00
Shellfish	36	5.8	7.7	0.0	28.4	0.53	36	27.6	46.1	0.0	202.9	0.92
Clams	36	9.3	15.0	0.0	60.8	0.50	36	53.1	67.4	0.0	276.0	0.97
Crabs	36	3.4	7.3	0.0	38.9	0.44	36	14.1	31.0	0.0	181.0	0.86
Octopus	36	2.6	5.2	0.0	26.1	0.56	36	12.1	21.8	0.0	91.0	0.86
Turtle	36	3.7	6.9	0.0	26.4	0.72	36	7.6	13.0	0.0	52.8	0.94
Domestic Meat	36	18.6	22.0	0.0	92.7	0.92	36	32.0	36.9	1.0	145.4	1.00
Wild Birds	36	8.8	12.6	0.0	41.4	0.42	36	25.4	25.3	0.0	108.6	0.83
Eggs	36	7.9	11.9	0.0	45.3	0.64	36	15.3	14.2	0.0	58.2	0.92
Pandanus	36	2.7	3.5	0.0	13.1	0.44	36	27.9	33.5	0.0	112.0	0.97
Breadfruit	36	12.8	12.7	0.0	54.2	0.75	36	57.6	51.4	7.8	217.0	1.00
Coconut Fluid	36	98.6	82.2	0.0	367.8	0.97	36	167.7	114.3	51.0	380.4	1.00
Coconut Meat	36	32.5	30.1	3.9	146.5	1.00	36	125.1	111.5	33.0	610.0	1.00
Papaya	36	1.6	5.4	0.0	27.2	0.14	36	6.8	11.2	0.0	38.0	0.36
Squash	0	-	-	-	-	-	0	-	-	-	-	-
Pumpkin	23	0.2	0.8	0.0	3.9	0.04	23	0.7	2.0	0.0	8.4	0.13
Banana	36	0.0	0.0	0.0	0.0	0.0	36	0.0	0.0	0.0	0.0	0.0
Watermelon	0	-	-	-	-	-	0	-	-	-	-	-
Arrowroot	36	2.3	6.9	0.0	31.5	0.17	36	64.8	75.6	0.0	220.0	0.97
Citrus	36	0.0	0.0	0.0	0.0	0.0	36	0.0	0.0	0.0	0.0	0.0
Aquas Liquids	36	915.0	570.4	228.4	2751.2	1.00	36	548.6	447.4	0.0	2130.0	0.97
TOTAL	36	1167.1	597.0	333.9	3183.4	1.00	36	1275.4	553.3	379.2	2849.4	1.00

Table 18. Dietary intake in g/day for selected subsistence food items in the Ujelang Survey for adult females.

	Normal Conditions						Famine Conditions					
Food	Number	Mean	σ	Low Value	High Value	Proportion of Nonzeros	Number	Mean	σ	Low Value	High Value	Proportion of Nonzeros
Fish	34	41.5	28.8	3.6	118.5	1.00	34	90.1	81.1	17.0	409.6	1.00
Shellfish	34	5.1	9.3	0.0	34.8	0.47	34	25.2	42.3	0.0	231.7	0.85
Clams	34	8.9	14.1	0.0	52.8	0.65	34	43.6	48.4	0.5	197.2	1.00
Crabs	34	3.1	7.4	0.0	39.0	0.32	34	12.5	31.2	0.0	181.0	0.77
Octopus	31	4.5	8.3	0.0	26.1	0.45	31	24.5	50.5	0.0	273.0	0.87
Turtle	31	4.3	9.5	0.0	49.1	0.58	30	8.9	12.0	0.0	49.1	0.93
Domestic Meat	34	21.2	52.4	0.0	292.9	0.74	34	34.5	98.1	1.0	576.6	1.00
Wild Birds	34	4.2	8.7	0.0	33.2	0.29	34	17.8	23.6	0.0	107.0	0.88
Eggs	34	10.7	32.2	0.0	182.0	0.38	34	55.8	152.5	0.0	791.7	0.91
Pandanus	34	9.2	16.6	0.0	82.1	0.68	34	32.5	32.3	0.0	114.3	0.94
Breadfruit	34	27.2	38.1	0.0	182.3	0.82	34	93.1	94.0	7.2	325.5	1.00
Coconut Fluid	34	141.8	122.0	25.4	520.7	1.00	34	216.6	179.3	28.4	710.0	1.00
Coconut Meat	34	63.3	98.8	0.0	518.4	0.97	34	187.2	252.0	15.6	1317.5	1.00
Papaya	34	6.6	32.8	0.0	190.0	0.12	34	13.5	65.0	0.0	380.0	0.27
Squash	0	-	-	-	-	-	0	-	-	-	-	-
Pumpkin	18	1.2	4.0	0.0	16.9	0.28	18	2.7	6.8	0.0	25.0	0.39
Banana	34	0.02	0.12	0.0	0.67	0.03	34	0.3	1.6	0.0	9.1	0.06
Watermelon	0	-	-	-	-	-	0	-	-	-	-	-
Arrowroot	34	3.9	12.0	0.0	63.1	0.18	34	47.4	61.3	0.0	227.3	0.77
Citrus	34	0.0	0.0	0.0	0.0	0.0	34	0.0	0.0	0.0	0.0	0.0
Aquas Liquids	34	829.8	452.6	177.5	2751.2	1.00	34	530.0	399.2	0.0	2130.0	0.97
TOTAL	34	1185.2	517.9	431.6	3182.3	1.00	34	1431.7	672.9	525.0	2784.0	1.00

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Table 19. Dietary intake in g/day for selected subsistence food items in the Ujelang Survey for childern from 0-3 Years.

	Normal Conditions						Famine Conditions					
Food	Number	Mean	σ	Low Value	High Value	Proportion of Nonzeros	Number	Mean	σ	Low Value	High Value	Proportion of Nonzeros
Fish	16	20.5	14.7	0.0	54.4	0.81	16	35.9	42.0	0.0	167.6	0.81
Shellfish	16	1.0	3.2	0.0	12.7	0.19	16	3.7	7.2	0.0	25.4	0.38
Clams	16	3.2	7.0	0.0	26.5	0.31	16	8.0	14.2	0.0	52.8	0.50
Crabs	16	2.0	3.8	0.0	13.0	0.38	16	3.9	6.5	0.0	25.9	0.63
Octopus	12	1.7	3.0	0.0	10.4	0.58	12	1.7	3.0	0.0	10.4	0.58
Turtle	12	0.7	1.7	0.0	6.1	0.50	12	0.9	1.8	0.0	6.1	0.58
Domestic Meat	16	7.0	11.6	0.0	41.3	0.81	16	6.9	8.1	0.0	28.1	0.81
Wild Birds	16	1.6	3.2	0.0	9.6	0.25	16	10.2	11.6	0.0	38.2	0.63
Eggs	16	2.4	4.1	0.0	13.1	0.44	16	6.0	7.1	0.0	23.5	0.69
Pandanus	16	10.2	19.1	0.0	56.0	0.63	16	22.2	24.8	0.0	56.0	0.81
Breadfruit	16	9.9	22.2	0.0	91.1	0.63	16	45.9	57.0	0.0	217.0	0.88
Coconut Fluid	16	70.7	70.3	0.0	266.2	0.94	16	88.6	73.3	11.8	266.2	1.00
Coconut Meat	16	38.4	83.1	0.0	322.2	0.81	16	111.5	177.3	0.0	721.2	0.81
Papaya	14	0.0	0.0	0.0	0.0	0.0	14	0.0	0.0	0.0	0.0	0.0
Squash	0	-	-	-	-	-	1	0.0	0.0	0.0	0.0	0.0
Pumpkin	8	0.04	0.11	0.0	0.31	0.13	8	0.3	0.7	0.0	1.9	0.25
Banana	15	0.02	0.09	0.0	0.34	0.07	15	0.02	0.09	0.0	0.34	0.07
Watermelon	0	-	-	-	-	-	0	-	-	-	-	-
Arrowroot	16	0.2	0.9	0.0	3.7	0.13	16	36.4	79.6	0.0	315.3	0.50
Citrus	15	0.0	0.0	0.0	0.0	0.0	15	0.0	0.0	0.0	0.0	0.0
Aquas Liquids	16	502.3	240.6	139.6	1065.0	1.00	16	282.1	124.6	50.9	532.5	1.00
TOTAL	16	671.2	275.2	169.4	1221.5	1.00	16	663.6	394.5	84.5	1576.9	1.00

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Table 20. Dietary intake in g/day for selected subsistence food items in the Ujelang Survey for children from 4-11 years.

	Normal Conditions						Famine Conditions					
Food	Number	Mean	σ	Low Value	High Value	Proportion of Nonzeros	Number	Mean	σ	Low Value	High Value	Proportion of Nonzeros
Fish	37	29.6	19.4	0.0	101.5	0.97	37	61.2	35.0	18.1	167.6	1.00
Shellfish	37	4.3	6.8	0.0	25.4	0.54	37	17.0	24.0	0.0	115.9	0.89
Clams	37	9.8	17.8	0.0	92.0	0.54	37	38.8	49.4	0.0	190.1	0.92
Crabs	37	2.2	4.3	0.0	13.0	0.49	37	12.3	21.2	0.0	90.5	0.89
Octopus	33	2.1	4.0	0.0	13.1	0.52	34	16.3	48.3	0.0	273.0	0.88
Turtle	35	1.5	2.9	0.0	10.6	0.63	35	3.2	4.3	0.0	13.2	0.94
Domestic Meat	37	13.2	25.9	0.0	146.4	0.84	37	22.1	48.5	0.2	288.2	1.00
Wild Birds	37	3.5	8.5	0.0	41.2	0.32	37	16.3	21.7	0.0	107.0	0.89
Eggs	37	5.5	15.9	0.0	91.0	0.49	37	18.2	46.1	0.0	273.0	0.95
Pandanus	37	5.2	9.8	0.0	56.0	0.62	37	23.3	21.5	0.0	84.0	1.00
Breadfruit	37	9.4	9.4	0.0	54.2	0.81	37	41.6	47.3	7.2	217.0	1.00
Coconut Fluid	37	76.0	57.6	12.8	266.2	1.00	37	150.7	148.5	25.4	710.0	1.00
Coconut Meat	37	36.9	46.4	0.0	249.9	0.97	37	98.3	86.4	32.7	458.3	1.00
Papaya	34	5.6	17.4	0.0	95.0	0.21	34	8.4	18.5	0.0	76.0	0.35
Squash	0	-	-	-	-	-	0	-	-	-	-	-
Pumpkin	15	0.04	0.16	0.0	0.62	0.07	15	1.8	4.6	0.0	16.6	0.27
Banana	37	0.0	0.0	0.0	0.0	0.0	37	0.0	0.0	0.0	0.0	0.0
Watermelon	0	-	-	-	-	-	0	-	-	-	-	-
Arrowroot	37	0.1	0.6	0.0	3.7	0.03	37	25.4	42.4	0.0	220.0	0.76
Citrus	37	0.0	0.0	0.0	0.0	0.0	37	0.0	0.0	0.0	0.0	0.0
Aquas Liquids	37	536.3	226.6	183.4	1331.2	1.00	37	348.7	183.2	50.9	1065.0	1.00
TOTAL	37	740.7	229.9	361.0	1539.8	1.00	37	900.6	406.1	397.0	2717.0	1.00

Table 21. Dietary intake in g/day for selected subsistence food items in the Ujelang Survey for children from 12-17 years.

	Normal Conditions						Famine Conditions					
Food	Number	Mean	σ	Low Value	High Value	Proportion of Nonzeros	Number	Mean	σ	Low Value	High Value	Proportion of Nonzeros
Fish	19	36.1	23.1	0.0	83.6	0.95	19	80.9	110.8	12.4	514.5	1.00
Shellfish	19	2.9	5.7	0.0	25.4	0.63	19	7.4	11.3	0.0	50.7	0.90
Clams	19	11.1	13.2	0.0	52.8	0.79	19	43.6	91.1	0.5	394.4	1.00
Crabs	19	3.7	6.5	0.0	25.9	0.47	19	30.1	62.5	0.0	271.5	0.90
Octopus	19	6.2	10.6	0.0	39.4	0.53	19	24.2	44.9	0.0	182.0	0.90
Turtle	18	2.8	6.2	0.0	26.4	0.56	18	5.4	12.2	0.0	52.8	0.89
Domestic Meat	19	14.2	20.8	0.0	81.4	0.90	19	25.7	28.0	0.8	98.4	1.00
Wild Birds	19	9.9	12.4	0.0	41.2	0.63	19	16.2	13.1	0.0	67.6	0.79
Eggs	19	10.4	13.0	0.0	39.2	0.68	19	27.8	42.8	0.0	182.0	0.84
Pandanus	19	6.7	11.7	0.0	43.2	0.68	19	22.0	23.3	4.0	96.3	1.00
Breadfruit	19	17.8	27.2	0.0	108.5	0.74	19	43.5	40.8	0.0	124.4	0.95
Coconut Fluid	19	106.1	90.5	0.0	355.0	0.95	19	157.7	165.4	25.4	710.0	1.00
Coconut Meat	19	54.2	71.6	1.9	307.7	1.00	19	133.0	109.9	43.7	471.2	1.00
Papaya	19	0.0	0.0	0.0	0.0	0.0	19	3.9	8.8	0.0	27.2	0.32
Squash	0	-	-	-	-	-	0	-	-	-	-	-
Pumpkin	11	4.1	8.7	0.0	25.5	0.27	11	7.0	12.1	0.0	33.2	0.45
Banana	19	0.0	0.0	0.0	0.0	0.0	19	0.0	0.0	0.0	0.0	0.0
Watermelon	0	-	-	-	-	-	0	-	-	-	-	-
Arrowroot	19	0.0	0.0	0.0	0.0	0.0	19	32.7	33.0	0.0	110.0	0.95
Citrus	19	0.0	0.0	0.0	0.0	0.0	19	0.0	0.0	0.0	0.0	0.0
Aquas Liquids	19	595.5	283.8	266.2	1153.8	1.00	19	368.2	144.2	159.8	710.0	1.00
TOTAL	19	879.7	359.9	456.9	1598.6	1.00	19	1031.0	432.4	439.4	2134.0	1.00

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Table 22. Dietary intake in g/day for selected imported food items in the Ujelang Survey for adult males and females.

	Adult Males						Adult Females					
Food	Number	Mean	σ	Low Value	High Value	Proportion of Nonzeros	Number	Mean	σ	Low Value	High Value	Proportion of Nonzeros
Baked Bread	36	31.8	33.4	1.5	180.0	1.00	34	30.3	33.5	3.2	180.0	1.00
Fried Bread	36	62.8	67.9	6.7	372.0	1.00	34	72.0	55.6	6.7	186.0	1.00
Pancakes	36	48.0	38.9	0.0	166.0	0.97	34	59.5	49.9	6.0	166.0	1.00
Cake	36	2.4	6.4	0.0	30.3	0.56	34	2.6	3.2	0.0	10.1	0.85
Rice	36	240.6	123.5	36.9	514.5	1.00	34	233.5	130.6	36.9	686.0	1.00
Instant Potatoes	36	67.7	102.8	0.0	355.0	0.72	32	126.8	133.0	0.0	443.8	0.94
Sugar	36	73.1	29.2	2.8	146.2	1.00	34	65.2	35.2	12.2	170.0	1.00
Canned Meat and Poultry	36	102.5	81.1	24.5	340.0	1.00	34	146.6	135.6	13.6	510.5	1.00
Canned Fish	36	97.1	100.2	0.0	509.5	0.97	34	145.5	156.7	2.8	523.2	1.00
Other Meat, Fish, Poultry	0	-	-	-	-	-	0	-	-	-	-	-
Carbonated Drinks	36	360.7	224.3	50.9	1065.0	1.00	34	337.9	206.4	50.9	1065.0	1.00
Canned Juices	36	197.8	263.9	0.0	1065.0	0.83	34	306.1	286.9	0.0	1065.0	0.91
Milk Products	36	210.1	140.4	0.0	621.2	0.97	34	274.0	227.1	0.0	710.0	0.97
Onion	1	0.0	0.0	0.0	0.0	0.0	2	0.0	0.0	0.0	0.0	0.0
Canned Vegetables	1	0.0	0.0	0.0	0.0	0.0	0	-	-	-	-	-
Baby Food	0	-	-	-	-	-	0	-	-	-	-	-
Cocoa	0	-	-	-	-	-	1	177.5	0.0	177.5	177.5	1.00
Ramen Noodles	0	-	-	-	-	-	1	6.1	0.0	6.1	6.1	1.00
Candy	0	-	-	-	-	-	0	-	-	-	-	-
TOTAL	36	1494.6	486.1	627.1	2720.5	1.00	34	1797.9	690.1	457.7	3136.5	1.00

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Table 23. Dietary intake in g/day for selected imported food items in the Ujelang Survey for children from 0 to 3 years and from 4 to

	Child: 0-3 years						Child: 4-11 years					
Food	Number	Mean	σ	Low Value	High Value	Proportion of Nonzeros	Number	Mean	σ	Low Value	High Value	Proportion of Nonzeros
Baked Bread	16	10.5	11.1	0.8	45.0	1.00	37	21.1	16.8	2.2	67.5	1.00
Fried Bread	16	26.2	30.7	0.0	93.3	0.81	37	43.4	29.0	6.7	93.0	1.00
Pancakes	16	25.2	30.9	0.0	83.3	0.81	37	38.4	27.7	4.8	83.0	1.00
Cake	16	1.5	2.9	0.0	10.1	0.56	37	1.2	2.4	0.0	10.1	0.51
Rice	16	97.0	89.8	0.0	343.0	0.88	36	153.7	84.2	24.6	343.0	1.00
Instant Potatoes	14	49.0	37.4	0.0	83.8	0.93	37	80.3	92.0	0.0	355.0	0.87
Sugar	16	44.9	34.0	2.8	85.0	1.00	37	55.7	27.7	5.7	85.0	1.00
Canned Meat and Poultry	16	49.9	67.7	0.0	255.2	0.81	37	95.9	67.8	5.7	255.2	1.00
Canned Fish	16	43.4	63.6	0.0	254.8	0.81	37	99.5	99.9	11.3	509.5	1.00
Other Meat, Fish, Poultry	1	0.0	0.0	0.0	0.0	0.0	2	48.7	34.5	24.4	73.1	1.00
Carbonated Drinks	16	171.3	118.5	0.0	355.0	0.88	37	226.5	120.7	50.9	532.5	1.00
Canned Juices	16	84.5	105.1	0.0	355.0	0.81	37	157.8	149.9	0.0	532.5	0.92
Milk Products	15	123.1	125.2	11.8	443.8	1.00	37	197.2	150.3	12.8	532.5	1.00
Onion	0	-	-	-	-	-	1	0.06	0.0	0.06	0.06	1.00
Canned Vegetables	1	24.4	0.0	24.4	24.4	1.00	0	-	-	-	-	-
Baby Food	1	68.2	0.0	68.2	68.2	1.00	0	-	-	-	-	-
Cocoa	0	-	-	-	-	-	1	0.0	0.0	0.0	0.0	0.0
Ramen Noodles	0	-	-	-	-	-	0	-	-	-	-	-
Candy	1	0.5	0.0	0.5	0.5	1.00	1	0.5	0.0	0.5	0.5	1.0
TOTAL	16	726.3	320.4	203.3	1443.0	1.00	37	1174.1	417.8	374.0	2547.6	1.00

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Table 24. Dietary intake in g/day for selected imported food items in the Ujelang Survey for children from 12 to 17 years.

Food	Number	Mean	σ	Low Value	High Value	Proportion Nonzeros
Baked Bread	19	23.5	23.3	3.2	90.0	1.00
Fried Bread	19	52.8	36.3	13.3	139.5	1.00
Pancakes	19	43.7	45.9	0.0	166.0	0.95
Cake	19	1.7	2.6	0.0	10.1	0.63
Rice	19	210.8	93.3	61.5	343.0	1.00
Instant Potatoes	19	134.7	159.3	11.8	710.0	1.00
Sugar	19	67.6	27.5	5.7	85.0	1.00
Canned Meat and Poultry	19	123.5	84.8	24.5	364.4	1.00
Canned Fish	19	124.9	114.5	24.4	509.5	1.00
Other Meat, Fish, Poultry	0	-	-	-	-	-
Carbonated Drinks	19	286.3	101.2	25.4	355.0	1.00
Canned Juices	19	220.2	259.0	0.0	1055.0	0.90
Milk Products	19	247.6	165.2	0.0	532.5	0.90
Onion	1	0.0	0.0	0.0	0.0	0.0
Canned Vegetables	0	-	-	-	-	-
Baby Food	0	-	-	-	-	-
Cocoa	0	-	-	-	-	-
Ramen Noodles	1	6.1	0.0	6.1	6.1	1.0
Candy	0	-	-	-	-	-
TOTAL	19	1537.6	478.5	1108.6	2720.9	1.00

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Table 25. Diet comparisons for adult males from the Ujelang Survey and observations at Rongelap and Uterik.

Food	Ujelang Survey Normal grams per day	 Famine grams per day	Rongelap and Uterik[a] Maximum Diet grams per day
Fish	42	89	168
Shellfish[b]	5.8	28	19
Clams	9.3	53	7.2
Coconut Crabs[c]	3.4	14	9.6
Domestic Meat[d]	19	32	21.6
Wild Birds	8.8	25	4.8
Eggs[e]	7.9	15	2.4
Pandanus	2.7	28	179
Breadfruit	13	58	288
Coconut Fluid	99	168	62
Coconut Meat	32	125	204
Squash (Pumpkin)	0.2	0.7	23
Arrowroot	2.3	65	31.5

[a] Work performed at Rongelap and Uterik by Dr. Jan Naidu of BNL. These are preliminary data and a final report is in preparation.

[b] Marine crab and lobster.

[c] Includes land crabs.

[d] Pork and chicken.

[e] Bird, chicken and turtle.

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Table 26. Summary of Dietary Sources and Corresponding Radionuclide Concentration Decay Periods Assumed in Estimating the Ingestion Dose to an Individual From Birth Through 70 Years of Age

	First Scenario Birth Within First Year		Second Scenario Birth at Close of Eighth Year	
Ingestion Period	Dietary Source	Decay Period	Dietary Source	Decay Period
Birth to Fourth Year	Child 0-3 years normal and famine	None	Child 0-3 years normal and famine	8 years
Fourth to Twelfth Year	Child 4-11 years normal and famine	4 years	Child 4-11 years normal and famine	12 years
	Child 4-11 years normal and famine	8 years		
Twelfth to Eighteenth Year	Child 12-17 years normal and famine	12 years	Child 12-17 years normal and famine	20 years
Adulthood	Adult females normal and famine	18 years	Adult females normal and famine	26 years

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Table 27. Body Weights of Marshallese Adult Males in Kg

Atoll	Number	X	S	M/N	MAX
Utcrik[a]	9	69.0	12.9	59.5	92.7
Bikini[b]	18	71.9	12.4	50.0	100.5
Rongelap[a]	22	61.2[a]	9.2	46.4	86.8
TOTAL	49	66.6	6.4	46.4	100.5

[a] A Twenty-Year Review of Medical Findings in a Marshallese Population Accidentally Exposed to Radioactive Fallout, Brookhaven Nat. Lab., Upton, New York, BN-50424 (1975).

[b] H. Greenhouse, Brookhaven Nat. Lab., private communication (June, 1979).

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Table 28. Average Daily Calcium Intake for the Marshallese Female Diet for Normal Conditions

Food	mg Ca per 100 g[a]	Intake, g per day	mg Ca per day
Fish	20	187	37
Meat	12	168	20
Breadfruit	22	27	5.9
Pandanus	10	9.2	0.92
Banana	7	0.02	0.001
Lobster	45	5.1	2.3
Milk	120	274	328
Coconut meat	10	63	63
Coconut fluid	30	142	43
Bread	23	102	23
Rice	10	234	23
Carbonated Drink	8[b]	338	27
Canned Juices	8[b]	306	25
Clams	100	8.9	8.9
Crabs	45	3.1	1.4
Potatoes	10	127	13
Eggs	55	11	6.1
Pancakes	215	60	129
		Total	700 mg/day

[a] J.R.C. Buchanan, A guide to Pacific Island Dietaries, South Pacific Board of Health, Sava, Fiji (1947).

[b] J.A.T. Pennington, Dietary Nutrient Guide, Avi Publishing Co., Westport, Conn. (1976).

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Table 29. Maximum annual dose rates in mrem/y for adult females in both normal and famine dietary conditions.

Location	Type of Diet	Organ	Pathway			Year of Maximum Dose
			Ingestion	External Gamma	Total	
Engebi (Janet)	Normal	Bone Marrow	192.7	55.72	250	10
		Wholebody	175.7	57.63	235	9
	Famine	Bone Marrow	445.6	55.72	500	10
		Wholebody	396.1	57.63	455	9
Engebi (Janet) Northeast Quadrant	Normal	Bone Marrow	187.9	57.06	245	10
		Wholebody	168.8	59.18	230	9
	Famine	Bone Marrow	436.74	57.06	495	10
		Wholebody	380.6	59.18	440	9
Engebi (Janet) Southeast Quadrant	Normal	Bone Marrow	145.3	47.82	190	9
		Wholebody	135.6	49.33	185	9
	Famine	Bone Marrow	337.7	47.82	385	10
		Wholebody	304.8	49.33	355	9
Engebi (Janet) Southwest Quadrant	Normal	Bone Marrow	128.5	50.56	180	9
		Wholebody	116.8	52.33	170	9
	Famine	Bone Marrow	302.1	50.56	355	10
		Wholebody	262	52.33	315	9
Engebi (Janet) Northwest Quadrant	Normal	Bone Marrow	260.7	64.41	325	10
		Wholebody	239.3	66.58	305	9
	Famine	Bone Marrow	604.1	64.41	670	10
		Wholebody	544.9	64.41	610	10
Aomon (Sally)	Normal	Bone Marrow	37.19	12.32	50	10
		Wholebody	32.18	12.76	45	9
	Famine	Bone Marrow	85.47	12.32	98	10
		Wholebody	72.86	12.76	86	9

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Table 29 Continued

Location	Type of Diet	Organ	Pathway Ingestion	Pathway External Gamma	Total	Year of Maximum Dose
Bijire (Tilda)	Normal	Bone Marrow	32.50	13.24	46	9
		Wholebody	30.28	13.24	44	9
	Famine	Bone Marrow	76.62	12.79	89	10
		Wholebody	68.57	13.24	82	9
Southern Islands	Normal	Bone Marrow	2.520	1.228	3.7	3
		Wholebody	1.929	1.281	3.2	2
	Famine	Bone Marrow	6.639	1.135	7.8	5
		Wholebody	4.626	1.281	5.9	2
Engebi (Janet) Island/Northern Islands[a]	Normal	Bone Marrow	180.2	50.12	230	10
		Wholebody	163.4	51.86	215	9
	Famine	Bone Marrow	418.3	50.12	470	10
		Wholebody	371.5	50.12	420	10
Engebi (Janet) Island/Southern Islands[b]	Normal	Bone Marrow	35.76	49.14	85	9
		Wholebody	23.52	49.14	73	9
	Famine	Bone Marrow	106.3	45.95	150	11
		Wholebody	61.11	49.14	110	9
Aomon (Sally) Island/Northern Islands[a]	Normal	Bone Marrow	37.85	13.86	52	10
		Wholebody	33.05	14.41	47	9
	Famine	Bone Marrow	86.94	13.86	101	10
		Wholebody	74.79	14.41	89	9

[a] Ten percent of the coconut intake is from the Northern Islands

[b] All of the coconut intake is from the Southern Islands

Table 29 Continued

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Location	Type of Diet	Organ	Pathway			Year of Maximum Dose
			Ingestion	External Gamma	Total	
Bijire (Tilda) Island/Northern Islands[a]	Normal	Bone Marrow	33.56	14.22	48	9
		Wholebody	31.32	14.22	46	9
	Famine	Bone Marrow	78.98	13.72	93	10
		Wholebody	70.86	14.22	85	9
Southern Islands/Northern Islands	Normal	Bone Marrow	5.47	3.71	9.2	9
		Wholebody	4.62	3.71	8.3	9
	Famine	Bone Marrow	13.1	3.71	17	9
		Wholebody	10.5	3.71	14	9
Engebi (Janet) Birth through 70 y[c]	Normal	Bone Marrow	155.5	40.43	195	21
		Wholebody	136.7	40.43	180	21
	Famine	Bone Marrow	365.1	40.43	405	21
		Wholebody	308.5	40.43	350	21
Engebi (Janet) Birth through 70 y[d]	Normal	Bone Marrow	112.8	57.63	170	1
		Wholebody	90.70	57.63	150	1
	Famine	Bone Marrow	303.4	33.03	335	21
		Wholebody	256.6	33.03	290	21

[a] Ten percent of the coconut intake is from the Northern Islands

[c] It is assumed that the child is born at the time of return and lives his entire lifespan on Enjebi (Janet) Island

[d][c] It is assumed that the child is born at the time of return and lives his entire lifespan on Enjebi (Janet) Island

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Table 30. 30 and 50 year integral doses in rem for adult females under normal and famine dietary conditions for the Engebi (Janet) Island living pattern.

	30 year Integral Dose, Rem				50 year Integral Dose, Rem			
	Wholebody		Bone Marrow		Wholebody		Bone Marrow	
Pathway Nuclide	Normal	Famine	Normal	Famine	Normal	Famine	Normal	Famine
Ingestion								
^{137}Cs	3.4	7.6	3.4	7.6	5.2	12	5.2	12
^{90}Sr	-	-	0.42	1.2	-	-	0.66	2
$^{239+240}$Pu	-	-	0.0032	0.013	-	-	0.0087	0.034
^{241}Am	-	-	0.0045	0.017	-	-	0.012	0.046
^{241}Pu (^{241}Am)	-	-	0.0021	0.0077	-	-	0.0078	0.029
External Gamma								
^{137}Cs + ^{60}Co	1.5	1.5	1.5	1.5	2.0	2.0	2.0	2.0
Inhalation								
$^{239+240}$Pu	-	-	0.072	0.072	-	-	0.21	0.21
^{241}Am	-	-	0.042	0.042	-	-	0.11	0.11
^{241}Pu (^{241}Am)	-	-	0.014	0.014	-	-	0.050	0.050
TOTAL	4.9	9.1	5.5	11	7.2	14	8.3	16

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Table 31. 30 and 50 year integral doses in rem for adult females under normal and famine dietary conditions for the Northeast Quadrant of Engebi (Janet) Island living pattern.

Pathway	30 year Integral Dose, Rem				50 year Integral Dose, Rem			
	Wholebody		Bone Marrow		Wholebody		Bone Marrow	
Nuclide	Normal	Famine	Normal	Famine	Normal	Famine	Normal	Famine
Ingestion								
^{137}Cs	3.3	7.3	3.3	7.3	5	11	5	11
^{90}Sr	-	-	0.48	1.4	-	-	0.75	2.3
$^{239+240}Pu$	-	-	0.0031	0.013	-	-	0.0085	0.034
^{241}Am	-	-	0.0045	0.017	-	-	0.012	0.046
^{241}Pu (^{241}Am)	-	-	0.0021	0.0077	-	-	0.0078	0.029
External Gamma								
^{137}Cs + ^{60}Co	1.5	1.5	1.5	1.5	2.0	2.0	2.0	2.0
Inhalation								
$^{239+240}Pu$	-	-	0.063	0.063	-	-	0.19	0.19
^{241}Am	-	-	0.036	0.036	-	-	0.097	0.097
^{241}Pu (^{241}Am)	-	-	0.012	0.012	-	-	0.043	0.043
TOTAL	4.8	8.8	5.4	11	7.2	13	8.1	15.

[redacted]

Table 32. 30 and 50 year integral doses in rem for adult females under normal and famine dietary conditions for the Southeast Quadrant of Engebi (Janet) Island living pattern.

Pathway Nuclide	30 year Integral Dose, Rem				50 year Integral Dose, Rem			
	Wholebody		Bone Marrow		Wholebody		Bone Marrow	
	Normal	Famine	Normal	Famine	Normal	Famine	Normal	Famine
Ingestion								
^{137}Cs	2.6	5.9	2.6	5.9	4	9	4	9
^{90}Sr	-	-	0.028	0.82	-	-	0.44	1.3
$^{239+240}Pu$	-	-	0.0030	0.012	-	-	0.0082	0.033
^{241}Am	-	-	0.0043	0.017	-	-	0.012	0.045
^{241}Pu (^{241}Am)	-	-	0.0019	0.0074	-	-	0.0073	0.028
External Gamma								
^{137}Cs + ^{60}Co	1.3	1.3	1.3	1.3	1.7	1.7	1.7	1.7
Inhalation								
$^{239+240}Pu$	-	-	0.10	0.10	-	-	0.31	0.31
^{241}Am	-	-	0.059	0.059	-	-	0.16	0.16
^{241}Pu (^{241}Am)	-	-	0.019	0.019	-	-	0.071	0.071
TOTAL	3.9	7.2	4.4	8.2	5.7	10	6.7	12

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Table 34. 30 and 50 year integral doses in rem for adult females under normal and famine dietary conditions for the Northwest quadrant of Engebi (Janet) Island living pattern.

Pathway Nuclide	30 year Integral Dose, Rem				50 year Integral Dose, Rem			
	Wholebody		Bone Marrow		Wholebody		Bone Marrow	
	Normal	Famine	Normal	Famine	Normal	Famine	Normal	Famine
Ingestion								
^{137}Cs	4.6	10	4.6	10	7	16	7	16
^{90}Sr	-	-	0.52	1.6	-	-	0.82	2.5
$^{239+240}Pu$	-	-	0.0034	0.013	-	-	0.0096	0.036
^{241}Am	-	-	0.0047	0.017	-	-	0.013	0.047
^{241}Pu (^{241}Am)	-	-	0.0022	0.0076	-	-	0.0082	0.029
External Gamma								
^{137}Cs + ^{60}Co	1.7	1.7	1.7	1.7	2.3	2.3	2.3	2.3
Inhalation								
$^{239+240}Pu$	-	-	0.011	0.011	-	-	0.32	0.32
^{241}Am	-	-	0.034	0.034	-	-	0.091	0.091
^{241}Pu (^{241}Am)	-	-	0.011	0.011	-	-	0.042	0.042
TOTAL	6.3	11	7.0	13	9	18	10	21

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Table 35. 30 and 50 year integral doses in rem for adult females under normal and famine dietary conditions for the Engebi (Janet) Island/Northern Island living pattern.

	30 year Integral Dose, Rem				50 year Integral Dose, Rem			
	Wholebody		Bone Marrow		Wholebody		Bone Marrow	
Pathway Nuclide	Normal	Famine	Normal	Famine	Normal	Famine	Normal	Famine
Ingestion								
^{137}Cs	3.2	7.1	3.2	7.1	4.8	11	4.8	11
^{90}Sr	-	-	0.42	1.2	-	-	0.65	2
$^{239+240}$Pu	-	-	0.0032	0.013	-	-	0.0086	0.034
^{241}Am	-	-	0.0045	0.017	-	-	0.0012	0.046
^{241}Pu (^{241}Am)	-	-	0.0021	0.0076	-	-	0.0078	0.029
External Gamma								
^{137}Cs + ^{60}Co	1.4	1.4	1.4	1.4	1.8	1.8	1.8	1.8
Inhalation								
$^{239+240}$Pu	-	-	0.067	0.067	-	-	0.20	0.20
^{241}Am	-	-	0.040	0.040	-	-	0.011	0.011
^{241}Pu (^{241}Am)	-	-	0.013	0.013	-	-	0.047	0.047
TOTAL	4.6	8.5	5.1	10	6.6	12	7.6	15

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Table 36. 30 and 50 year integral doses in rem for adult females under normal and famine dietary conditions for the Engebi (Janet) Island/Southern Island living pattern.

Pathway Nuclide	30 year Integral Dose, Rem				50 year Integral Dose, Rem			
	Wholebody		Bone Marrow		Wholebody		Bone Marrow	
	Normal	Famine	Normal	Famine	Normal	Famine	Normal	Famine
Ingestion								
^{137}Cs	0.54	1.3	0.54	1.3	0.77	1.9	0.77	1.9
^{90}Sr	–	–	0.36	1.1	–	–	0.57	1.8
$^{239+240}$Pu	–	–	0.0029	0.012	–	–	0.0078	0.044
^{241}Am	–	–	0.0042	0.016	–	–	0.011	0.037
^{241}Pu (^{241}Am)	–	–	0.0018	0.0072	–	–	0.0069	0.027
External Gamma								
^{137}Cs + ^{60}Co	1.3	1.3	1.3	1.3	1.7	1.7	1.7	1.7
Inhalation								
$^{239+240}$Pu	–	–	0.061	0.061	–	–	0.18	0.18
^{241}Am	–	–	0.036	0.036	–	–	0.094	0.094
^{241}Pu (^{241}Am)	–	–	0.012	0.012	–	–	0.043	0.043
TOTAL	1.8	2.6	2.3	3.8	2.5	3.6	3.4	5.8

Table 37. 30 and 50 year integral doses in rem for adult females under normal and famine dietary conditions for the Aomon (Sally) Island living pattern.

Pathway Nuclide	30 year Integral Dose, Rem				50 year Integral Dose, Rem			
	Wholebody		Bone Marrow		Wholebody		Bone Marrow	
	Normal	Famine	Normal	Famine	Normal	Famine	Normal	Famine
Ingestion								
^{137}Cs	0.63	1.4	0.63	1.4	0.95	2.2	0.95	2.2
^{90}Sr	-	-	0.013	0.32	-	-	0.020	0.51
$^{239+240}$Pu	-	-	0.003	0.12	-	-	0.008	0.033
^{241}Am	-	-	0.0041	0.016	-	-	0.011	0.044
^{241}Pu (^{241}Am)	-	-	0.0018	0.0072	-	-	0.0068	0.027
External Gamma								
^{137}Cs + ^{60}Co	0.33	0.33	0.33	0.33	0.44	0.44	0.44	0.44
Inhalation								
$^{239+240}$Pu	-	-	0.020	0.020	-	-	0.059	0.059
^{241}Am	-	-	0.0011	0.0011	-	-	0.030	0.030
^{241}Pu (^{241}Am)	-	-	0.0036	0.0036	-	-	0.013	0.013
TOTAL	0.99	1.5	0.87	1.9	1.4	2.7	1.8	3.4

Table 38. 30 and 50 year integral doses in rem for adult females under normal and famine dietary conditions for the Aomon (Sally) Island/Northern Islands living pattern.

Pathway Nuclide	30 year Integral Dose, Rem Wholebody Normal	 Famine	 Bone Marrow Normal	 Famine	50 year Integral Dose, Rem Wholebody Normal	 Famine	 Bone Marrow Normal	 Famine
Ingestion								
^{137}Cs	0.64	1.5	0.64	1.5	0.98	2.2	0.98	2.2
^{90}Sr	-	-	0.12	0.31	-	-	0.19	0.49
$^{239+240}$Pu	-	-	0.003	0.012	-	-	0.0080	0.033
^{241}Am	-	-	0.0041	0.016	-	-	0.011	0.044
^{241}Pu (^{241}Am)	-	-	0.0018	0.0072	-	-	0.0068	0.027
External Gamma								
^{137}Cs + ^{60}Co	0.36	0.36	0.36	0.36	0.48	0.48	0.48	0.48
Inhalation								
$^{239+240}$Pu	-	-	0.022	0.022	-	-	0.065	0.065
^{241}Am	-	-	0.015	0.015	-	-	0.04	0.04
^{241}Pu (^{241}Am)	-	-	0.005	0.005	-	-	0.018	0.018
TOTAL	0.99	1.9	1.2	2.3	1.5	2.7	1.8	3.4

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Table 39. 30 and 50 year integral doses in rem for adult females under normal and famine dietary conditions for the Bijire (Tilda) Island living pattern.

	30 year Integral Dose, Rem				50 year Integral Dose, Rem			
Pathway	Wholebody		Bone Marrow		Wholebody		Bone Marrow	
Nuclide	Normal	Famine	Normal	Famine	Normal	Famine	Normal	Famine
Ingestion								
^{137}Cs	0.59	1.3	0.59	1.3	0.9	2.0	0.9	2.0
^{90}Sr	-	-	0.064	0.20	-	-	0.099	0.31
$^{239+240}$Pu	-	-	0.0029	0.012	-	-	0.0079	0.032
^{241}Am	-	-	0.0041	0.016	-	-	0.0011	0.043
^{241}Pu (^{241}Am)	-	-	0.0018	0.0072	-	-	0.0068	0.027
External Gamma								
^{137}Cs + ^{60}Co	0.34	0.34	0.34	0.34	0.46	0.46	0.46	0.46
Inhalation								
$^{239+240}$Pu	-	-	0.018	0.018	-	-	0.053	0.053
^{241}Am	-	-	0.013	0.013	-	-	0.035	0.035
^{241}Pu (^{241}Am)	-	-	0.0042	0.0042	-	-	0.015	0.015
TOTAL	0.89	1.7	0.99	1.9	1.4	2.5	1.6	3

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Table 40. 30 and 50 year integral doses in rem for adult females under normal and famine dietary conditions for the Bijire (Tilda) Island/Northern Islands living pattern.

Pathway Nuclide	30 year Integral Dose, Rem				50 year Integral Dose, Rem			
	Wholebody		Bone Marrow		Wholebody		Bone Marrow	
	Normal	Famine	Normal	Famine	Normal	Famine	Normal	Famine
Ingestion								
^{137}Cs	0.61	1.4	0.61	1.4	0.93	2.1	0.93	2.1
^{90}Sr	–	–	0.065	0.20	–	–	0.10	0.31
$^{239+240}Pu$	–	–	0.003	0.012	–	–	0.0079	0.033
^{241}Am	–	–	0.0041	0.016	–	–	0.0011	0.043
^{241}Pu (^{241}Am)	–	–	0.0018	0.0072	–	–	0.0068	0.027
External Gamma								
^{137}Cs + ^{60}Co	0.37	0.37	0.37	0.37	0.5	0.5	0.5	0.5
Inhalation								
$^{239+240}Pu$	–	–	0.022	0.022	–	–	0.065	0.065
^{241}Am	–	–	0.015	0.015	–	–	0.04	0.04
^{241}Pu (^{241}Am)	–	–	0.005	0.005	–	–	0.018	0.018
TOTAL	0.99	1.8	1.1	2.1	1.5	2.6	1.7	3.1

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Table 41. 30 and 50 year integral doses in rem for adult females under normal and famine dietary conditions for the Southern Islands living pattern.

	30 year Integral Dose, Rem				50 year Integral Dose, Rem			
Pathway	Wholebody		Bone Marrow		Wholebody		Bone Marrow	
Nuclide	Normal	Famine	Normal	Famine	Normal	Famine	Normal	Famine
Ingestion								
^{137}Cs	0.043	0.10	0.043	0.10	0.059	0.14	0.059	0.14
^{90}Sr	-	-	0.019	0.059	-	-	0.027	0.086
$^{239+240}Pu$	-	-	0.0028	0.012	-	-	0.0075	0.032
^{241}Am	-	-	0.0037	0.015	-	-	0.0097	0.041
^{241}Pu (^{241}Am)	-	-	0.0016	0.0067	-	-	0.0059	0.025
External Gamma								
^{137}Cs + ^{60}Co	0.026	0.026	0.026	0.026	0.034	0.034	0.034	0.034
Inhalation								
$^{239+240}Pu$	-	-	0.00060	0.00060	-	-	0.0018	0.0018
^{241}Am	-	-	0.00046	0.00046	-	-	0.0012	0.0012
^{241}Pu (^{241}Am)	-	-	0.00015	0.00015	-	-	0.00056	0.00056
TOTAL	0.069	0.12	0.10	0.22	0.089	0.18	0.17	0.36

[redacted]

Table 42. 30 and 50 year integral doses in rem for adult females under normal and famine dietary conditions for the Southern Islands/Northern Islands living pattern.

Pathway	30 year Integral Dose, Rem				50 year Integral Dose, Rem			
	Wholebody		Bone Marrow		Wholebody		Bone Marrow	
Nuclide	Normal	Famine	Normal	Famine	Normal	Famine	Normal	Famine
Ingestion								
^{137}Cs	0.099	0.23	0.099	0.23	0.15	0.33	0.15	0.33
^{90}Sr	-	-	0.021	0.066	-	-	0.031	0.094
$^{239+240}$Pu	-	-	0.0028	0.012	-	-	0.0075	0.032
^{241}Am	-	-	0.0037	0.015	-	-	0.0097	0.041
^{241}Pu (^{241}Am)	-	-	0.0016	0.0067	-	-	0.0060	0.025
External Gamma								
^{137}Cs + ^{60}Co	0.096	0.096	0.096	0.096	0.13	0.13	0.13	0.13
Inhalation								
$^{239+240}$Pu	-	-	0.0060	0.0060	-	-	0.018	0.018
^{241}Am	-	-	0.0045	0.0045	-	-	0.012	0.012
^{241}Pu (^{241}Am)	-	-	0.015	0.015	-	-	0.054	0.054
TOTAL	0.2	0.33	0.25	0.46	0.28	0.46	0.32	0.56

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Table 43. 30 and 50 year integral doses in rem for a child[*] under normal and famine dietary conditions for the Enjebi (Janet) Island living pattern.

Pathway Nuclide	30 year Integral Dose, Rem				50 year Integral Dose, Rem			
	Wholebody		Bone Marrow		Wholebody		Bone Marrow	
	Normal	Famine	Normal	Famine	Normal	Famine	Normal	Famine
Ingestion								
$^{137}\mathrm{Cs}$	2.7	5.9	2.7	5.9	4.5	9.9	4.5	9.9
$^{90}\mathrm{Sr}$	-	-	0.36	1.1	-	-	0.60	1.8
$^{239+240}\mathrm{Pu}$	-	-	0.0028	0.0097	-	-	0.0081	0.029
$^{241}\mathrm{Am}$	-	-	0.0037	0.013	-	-	0.011	0.038
$^{241}\mathrm{Pu}$ ($^{241}\mathrm{Am}$)	-	-	0.0017	0.0059	-	-	0.0072	0.024
External Gamma								
$^{137}\mathrm{Cs}$ + $^{60}\mathrm{Co}$	1.5	1.5	1.5	1.5	2.0	2.0	2.0	2.0
Inhalation								
$^{239+240}\mathrm{Pu}$	-	-	0.072[+]	0.072[+]	-	-	0.21[+]	0.21[+]
$^{241}\mathrm{Am}$	-	-	0.042[+]	0.072[+]	-	-	0.11[+]	0.11[+]
$^{241}\mathrm{Pu}$ ($^{241}\mathrm{Am}$)	-	-	0.014[+]	0.072[+]	-	-	0.050[+]	0.050[+]
TOTAL	4.2	7.4	4.7	8.7	6.5	12	7.5	14

[*] It is assumed that the child is born at the time of return and lives his entire life span on Engebi Island

[+] Adult data used because no information is available for children; this probably overestimates the dose due to increased dietary intake of the adult

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Table 44. 30 and 50 year integral doses in rem for a child* under normal and famine dietary conditions for the Engebi (Janet) Island living pattern.

Pathway Nuclide	30 year Integral Dose, Rem				50 year Integral Dose, Rem			
	Wholebody		Bone Marrow		Wholebody		Bone Marrow	
	Normal	Famine	Normal	Famine	Normal	Famine	Normal	Famine
Ingestion								
^{137}Cs	2.8	6.3	2.8	6.3	4.3	9.6	4.3	9.6
^{90}Sr	-	-	0.40	1.2	-	-	0.60	1.8
$^{239+240}$Pu	-	-	0.0029	0.0099	-	-	0.0082	0.029
^{241}Am	-	-	0.0039	0.013	-	-	0.011	0.038
^{241}Pu (^{241}Am)	-	-	0.0018	0.0059	-	-	0.0072	0.024
External Gamma								
^{137}Cs + ^{60}Co	1.2	1.2	1.2	1.2	1.6	1.6	1.6	1.6
Inhalation								
$^{239+240}$Pu	-	-	0.072^{+}	0.072^{+}	-	-	0.21^{+}	0.21^{+}
^{241}Am	-	-	0.042^{+}	0.042^{+}	-	-	0.11^{+}	0.11^{+}
^{241}Pu (^{241}Am)	-	-	0.014^{+}	0.014^{+}	-	-	0.050^{+}	0.050^{+}
TOTAL	4.0	7.5	4.5	8.9	5.9	12	6.9	14

*It is assumed that the child is born 8 years after return and lives his entire life span on Engebi Island

$^{+}$Adult data used because no information is available for children; this probably overestimates the dose due to increased dietary intake of the adult

[redacted]

Table 45. ^{241}Am Soil Analysis for 0-15 cm. Soil concentrations less than the MDA are set to the MDA.

Sample	No.	Arith mean $\bar{x}$ pCi/g	τ[a]	r-test[b]	Krige's method $\bar{x}$	Krige's method s	Krige's method C.V.	Quantiles m	Quantiles s	x %	3x %[c]	99%[d] pCi/g	Maximum sample
Engebi total	99	4.6	0.5	0.5	5.4	10.3	1.9	5.6	12.2	73	93	50	98
NW	30	4.9	0.4	0.5	5.1	5.8	1.3	5.5	8.7	69	93	40	97
NE	26	5.9	0.6	0.5	7.0	13.1	1.9	8.3	22.7	73	92	83	93
SW	12	2.3	0.6	0.5	2.6	4.2	1.6	3.7	15.1	71	91	41	90
SE	27	4.0	0.3	0.5	4.3	5.6	1.3	4.6	7.4	69	93	34	96
Aej	12	5.5	0.6	0.5	7.6	20.0	2.6	15.2	168	78	90	218	88
Alembel	13	1.5	0.6	0.5	1.7	1.7	1.1	2.1	4.1	70	93	16	86
Aomon	35	1.6	0.5	0.5	1.4	1.8	1.3	1.6	2.7	74	95	11	99
Bijire	15	1.4	0.4	0.5	1.4	1.6	1.2	1.7	3.7	71	93	14	95
Billae	5	1.1	0.5	0.1	1.2	1.2	1.0	2.9	27.5	71	89	36	84
Lojwa	15	0.7	0.1	0.5	0.7	0.2	0.3	0.7	0.2	56	100	1.4	97
Mijikadrek	5	3.5	-0.8	0.5	3.5	1.4	0.4	3.6	1.6	54	100	8.4	88
Kidrinen	7	4.0	0.9	0.5	4.6	7.5	1.6	9.9	84.5	74	89	133	87
Elle	6	5.7	0.0	0.5	5.2	7.5	1.5	9.8	41.2	70	94	35	97
Bokenelab	4	3.3	0.0	0.5	3.4	1.6	0.5	3.7	2.4	59	100	8.8	74

[a] Shift parameter pCi/g.

[b] Acceptance level ranges: $r < 0.05$, $.05 < r < 0.1$, $0.1 < r < 0.5$, $r < 0.5$.

[c] Quantile of the Krige m position.

[d] 99% percentile value in pCi/g.

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Table 46. ^{137}Cs Soil Analysis for 0-15 cm.

Sample	No.	Arith mean $\bar{x}$ pCi/g	τ[a]	r-test[b]	Krige's method $\bar{x}$	Krige's method s	Krige's method C.V.	Quantiles m	Quantiles s	x %[c]	3x %[c]	99%[d] pCi/g	Maximum sample %
Engebi total	99	18.5	- 2.1	0.5	18.6	18.0	1.0	19.0	19.0	64	96	92	100
NW	30	24.4	- 2.9	0.5	24.7	27.6	1.1	26.1	32.5	66	94	154	98
NE	26	19.6	-17.2	0.5	19.5	13.2	0.7	19.8	14.1	56	98	64	96
SW	12	10.6	0.0	0.5	10.5	9.5	0.9	11.6	13.3	64	94	64	92
SE	27	14.6	- 2.5	0.5	14.7	10.9	0.7	15.1	12.1	61	97	59	93
Aej	12	8.8	0.0	0.5	9.9	15.2	1.5	12.9	33.5	71	90	130	89
Alembel	13	2.9	0.0	0.5	3.0	2.6	0.9	3.3	3.5	65	94	17	92
Aomon	35	3.2	0.1	0.5	3.3	4.4	1.4	3.5	5.5	70	93	25	97
Bijire	15	3.6	0.6	0.5	3.7	3.4	0.9	4.1	4.9	65	94	23	96
Billae	5	1.1	0.0	0.5	1.1	0.9	0.8	1.3	1.5	61	93	7	87
Lojwa	15	1.2	0.0	0.5	1.2	0.7	0.6	1.2	0.8	61	90	4	95
Mijikadrek	5	6.5	0.0	0.5	7.0	7.0	1.0	10.0	18.2	63	89	80	76
Kidrinen	7	10.0	-2150	0.5	10.0	5.6	0.6	10.0	6.2	50	100	24	89
Elle	6	12.2	1.7	0.5	13.0	18.7	1.4	25.1	134.3	70	88	320	89
Bokenelab	4	7.6	5.2	0.5	7.6	2.9	0.4	9.4	12.5	65	96	50	86

[a] Shift parameter pCi/g.

[b] Acceptance level ranges: $r < 0.05$, $.05 < r < 0.1$, $0.1 < r < 0.5$, $r < 0.5$.

[c] Quantile of the Krige m position.

[d] 99% percentile value in pCi/g.

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Table 47. Radioanalysis of local foods for Bikini and Eneu Islands

Sample	No.	Arith mean $\bar{x}$ pCi/g	τ[a]	r-test[b]	Krige's method $\bar{x}$	Krige's method s	Krige's method C.V.	Quantiles m	Quantiles s	x %	3x %[c]	99%[d] pCi/g	Maximum sample %
Bikini Coconut meat, ^{137}Cs	8	233	-1.9	0.5	233	108	0.5	233	119	59	100	589	89
Bikini Coconut meat, & juice, ^{137}Cs	8	127	-113	0.5	127	95	0.7	133	110	63	98	480	95
Eneu Coconut meat, ^{137}Cs	15	28	-1.4	0.5	27	21	0.8	29	25	63	98	104	98
Eneu Coconut meat, ^{90}Sr	9	0.02	0.0	0.5	0.02	0.02	0.8	0.02	0.02	63	97	0.1	95
Eneu Coconut meat, & juice, ^{137}Cs	16	19	-1.4	0.5	19	15	0.8	20	18	64	97	76	97
Eneu Coconut juice only, ^{137}Cs	15	8.0	-0.7	0.5	7.9	6.1	0.8	8.3	7.2	63	98	31	97
Eneu Papaya ^{137}Cs	7	16	6.0	0.5	16	12	0.7	17	14	63	98	61	95

[a] Shift parameter pCi/g.

[b] Acceptance level ranges: $r < 0.05$, $.05 < r < 0.1$, $0.1 < r < 0.5$, $r < 0.5$.

[c] Quantile of the Krige m position.

[d] 99% percentile value in pCi/g.

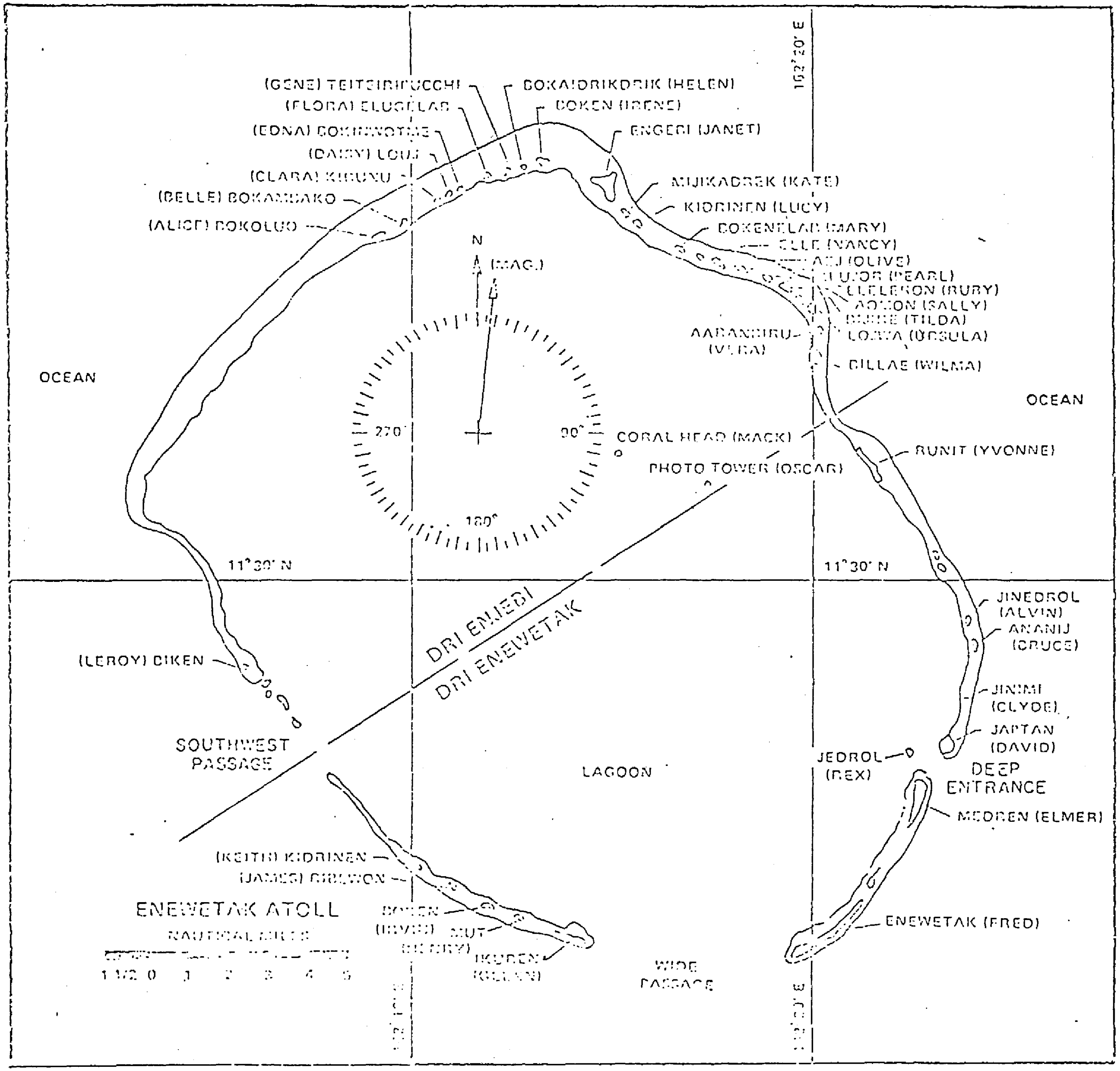

Fig. 1 Map of Enewetak Atoll

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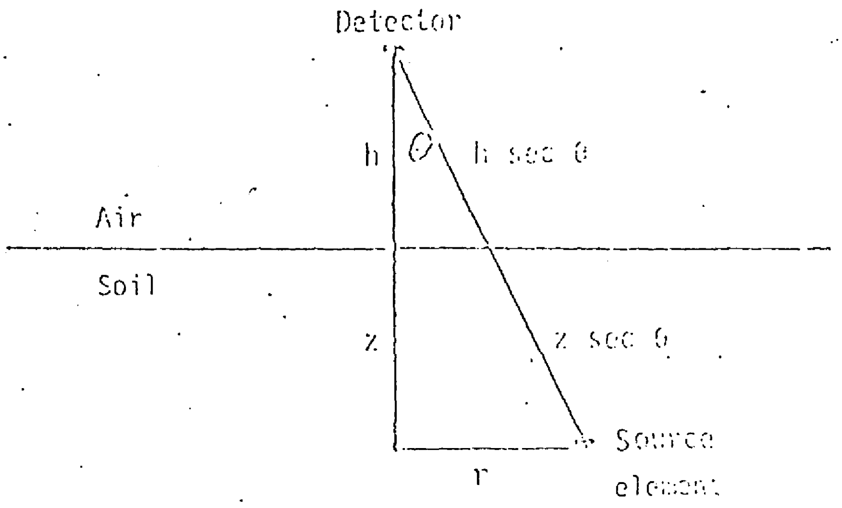

fig. 2. Geometry used in the derivation of conversion factors relating *in situ* photopeak count rate data to isotope concentration in the ground.

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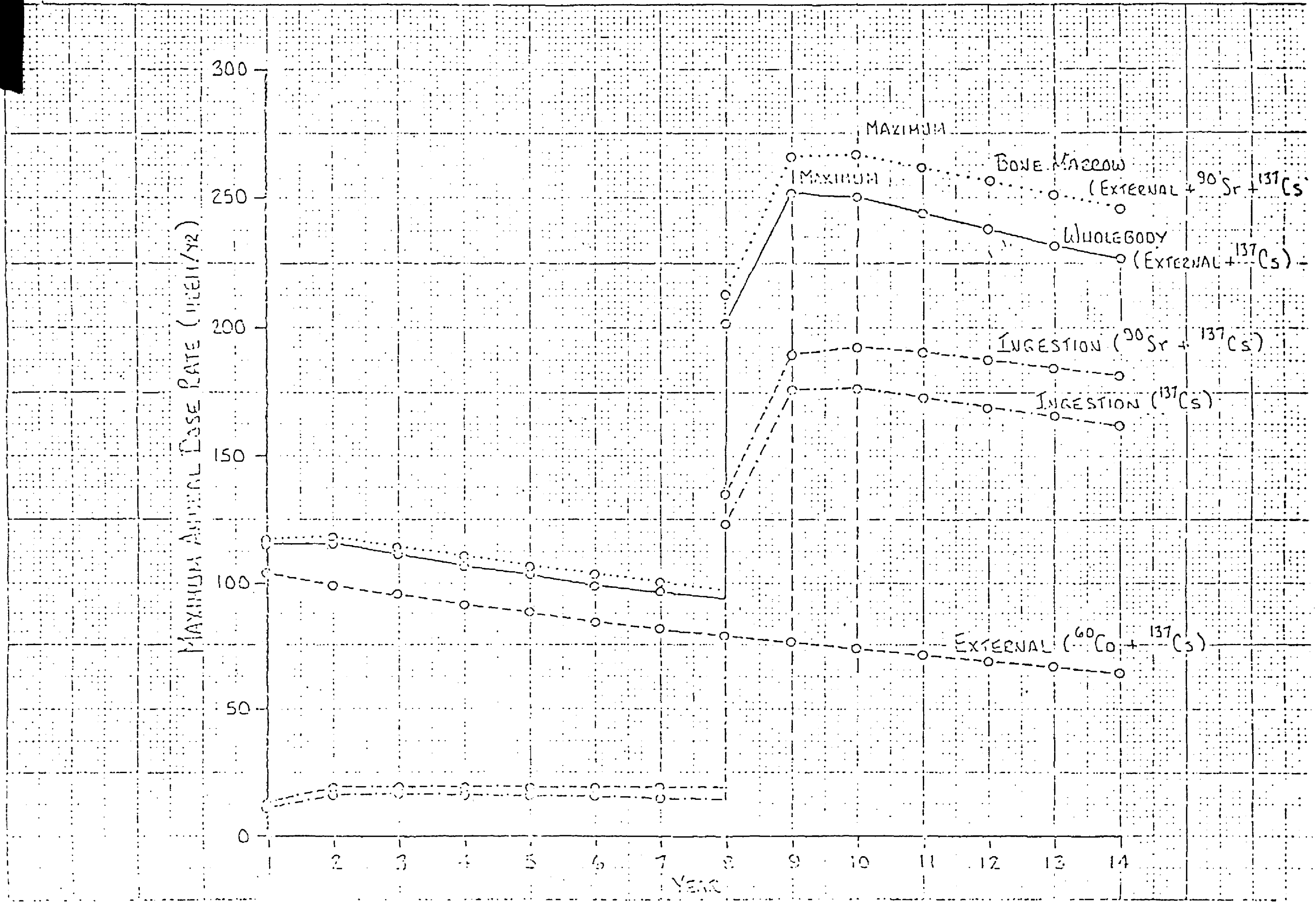

Fig. 3. Graphical presentation showing the Maximum Annual Dose Rates for Wholebody and Bone Marrow and the Corresponding

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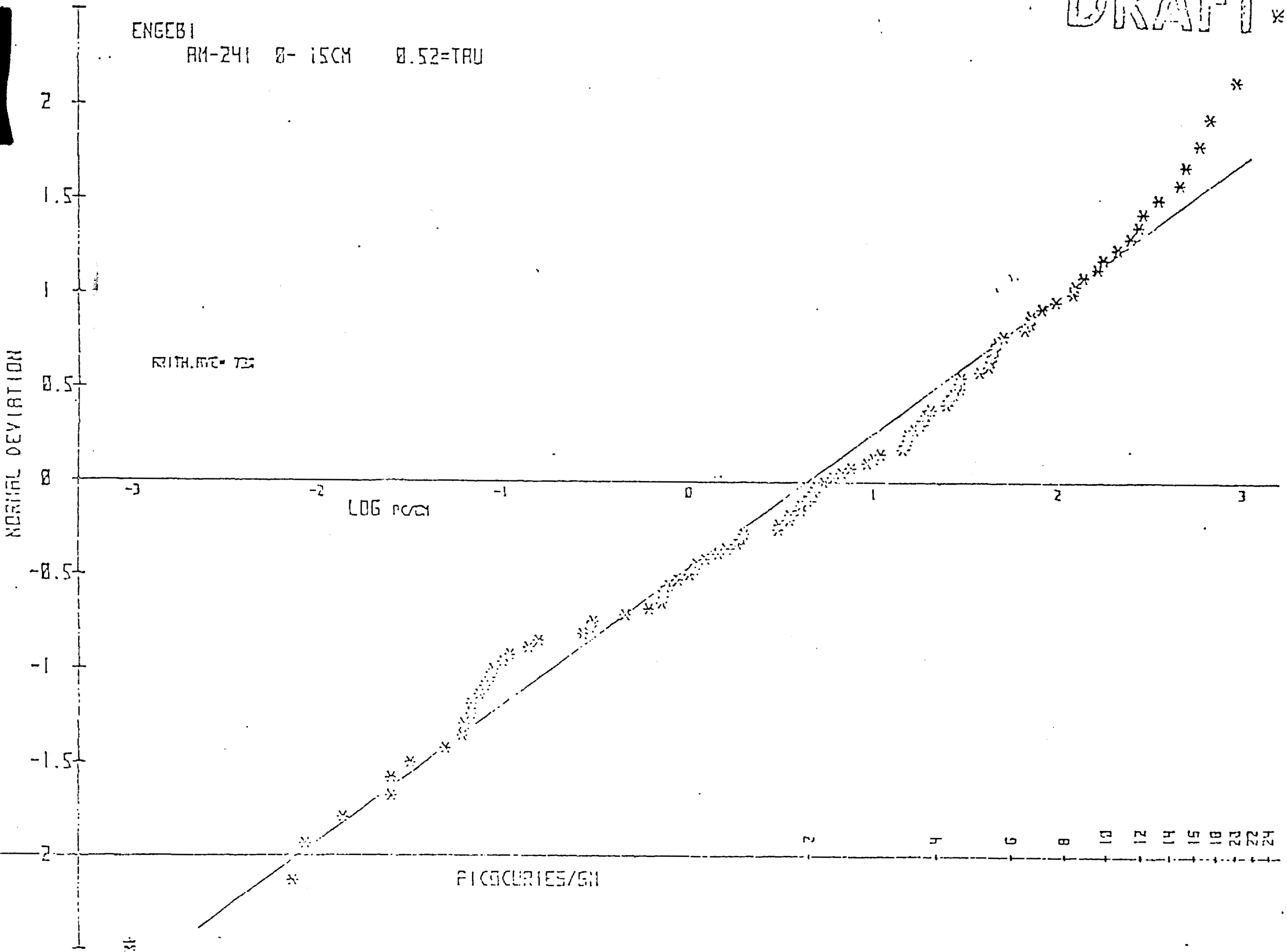

Fig. 4. ^{241}Am, 0-15 cm soil concentrations for Engebi (Janet), λ = -0.5

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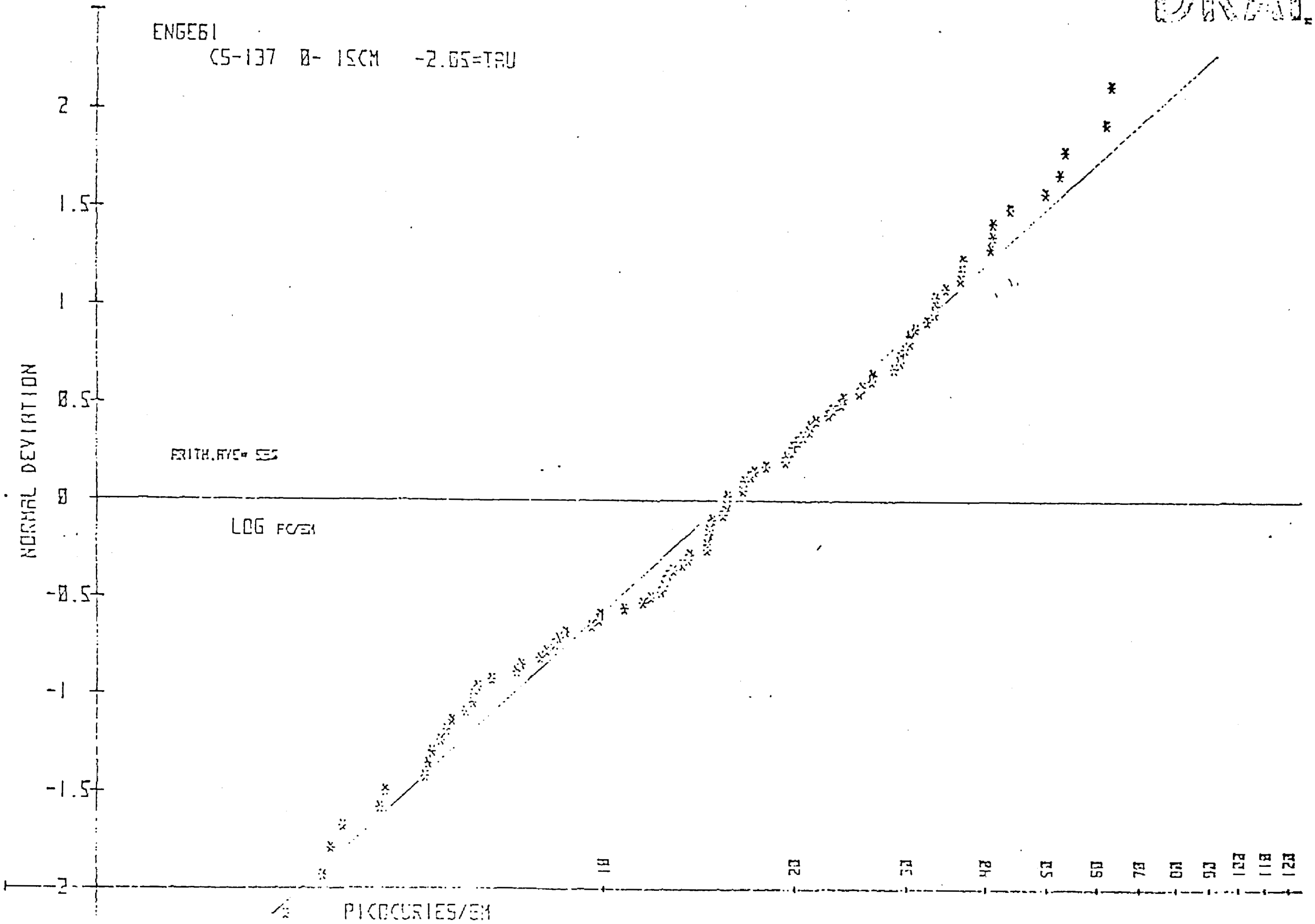

Fig. 5. ^{137}Cs, 0-15cm soil concentrations for Engebi (Janet), τ= -2

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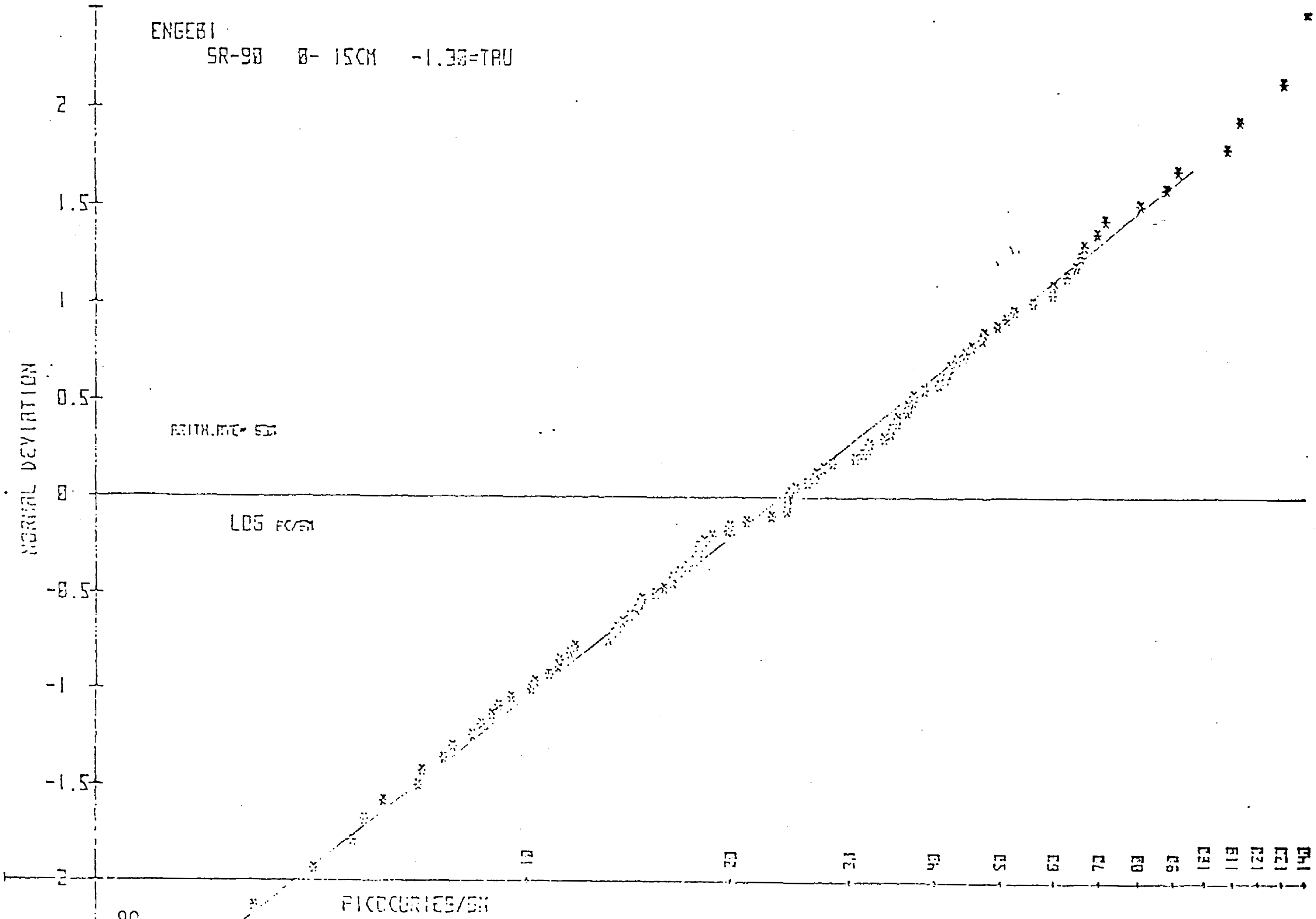

Fig. 6. ^{90}Sr, 0-15 cm soil concentrations for Engebi (Janet). x = - 1.3

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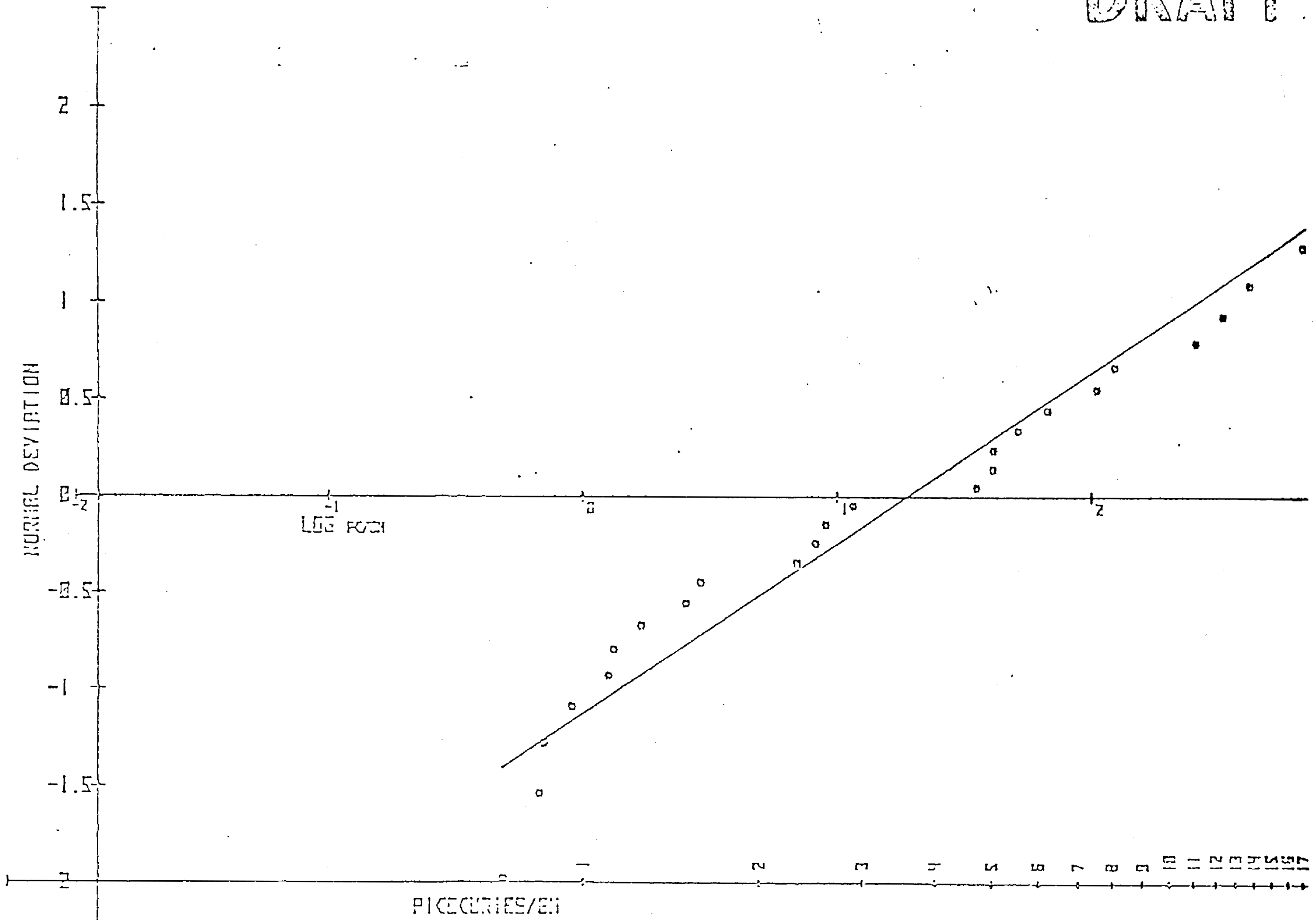

Fig. 7. ^{241}Am 0-15 cm soil concentrations for the NE quadrant, τ=0.

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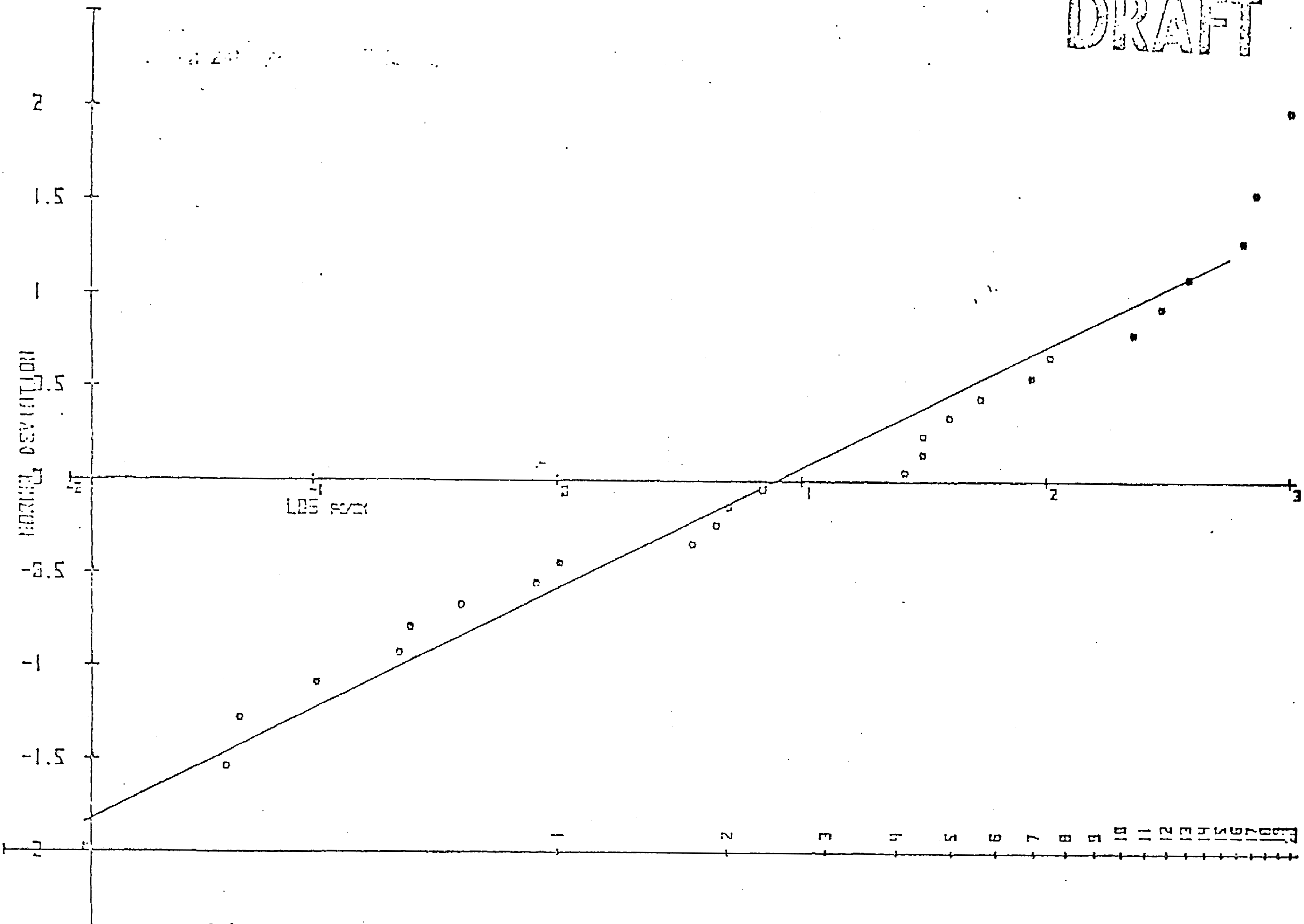

Fig. 8. 241Am, 0-15 cm soil concentrations for the NE quadrant of Engebi, τ=0.6

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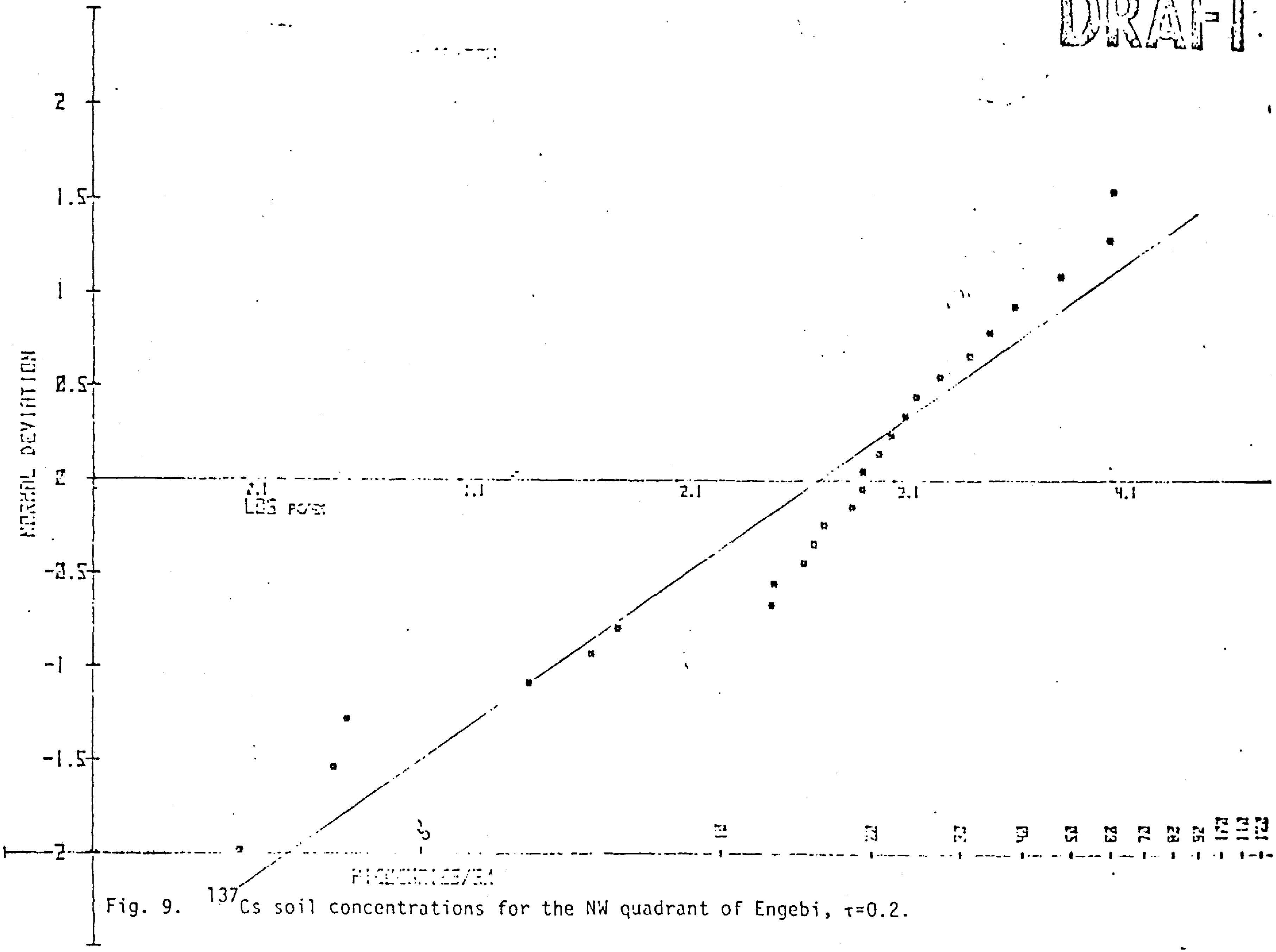

Fig. 9. ^{137}Cs soil concentrations for the NW quadrant of Engebi, τ=0.2.

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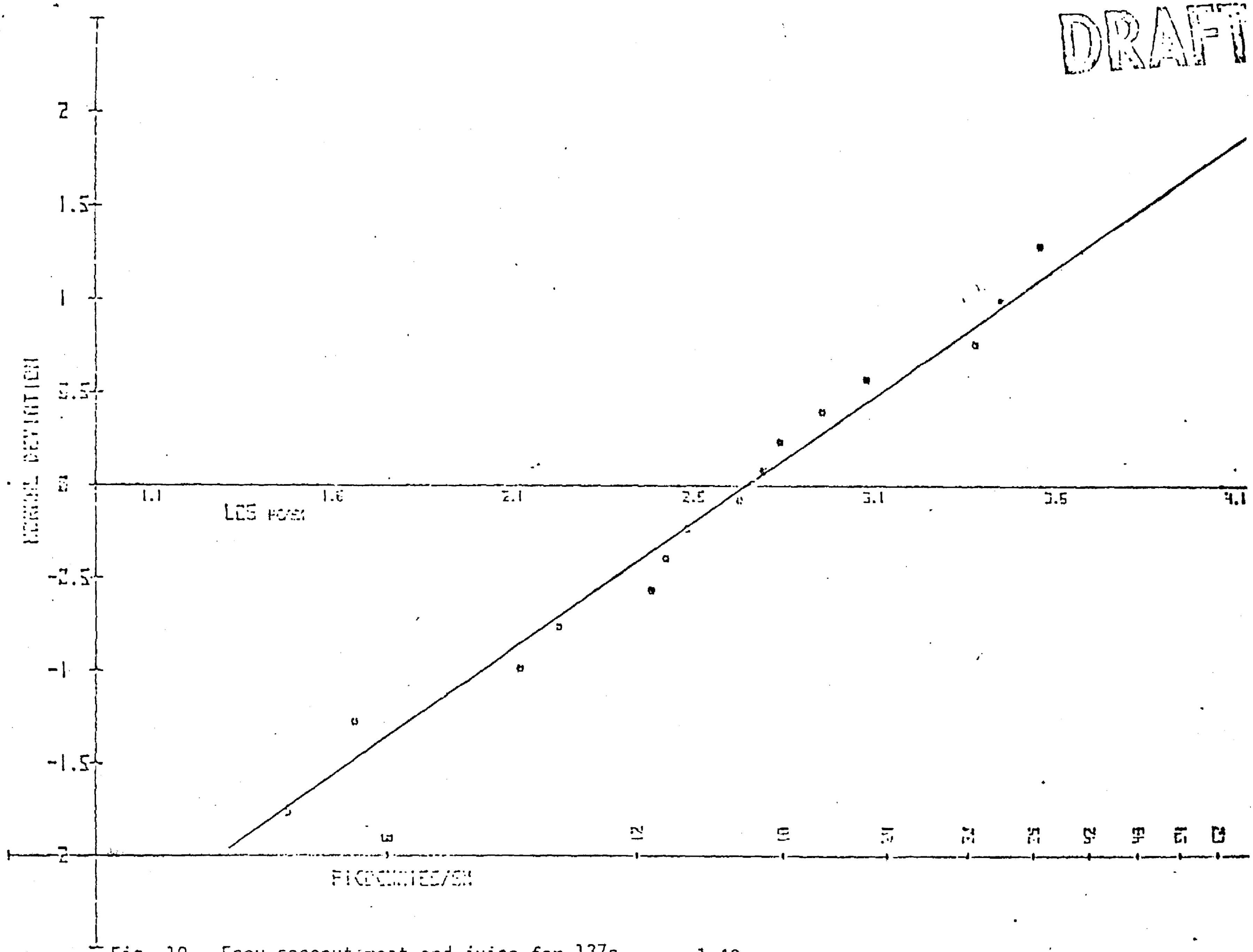

Fig. 10. Eneu coconut meat and juice for ^{137}Cs, τ= -1.40.