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RONGELAP REASSESSMENT PROJECT

REPORT

Corrected Edition*
March 1, 1989

*This reissue of May 25, 1990 contains material relating to the Congressional hearings of 16 Nov 89 and 4 May 90

Pursuant to the Compact of Free Association Act of 1985, Public Law 99-239, January 14, 1986 (99 Stat. 1783 et seq) and administered by the Republic of the Marshall Islands.

Rongelap Reassessment Project
1203 Shattuck Ave., Berkeley, CA 94709
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REPORT

RONGELAP REASSESSMENT PROJECT

CORRECTED EDITION*

March 1, 1989

TO: The President and Congress of the United States

FROM: Henry I. Kohn, Referee

Pursuant to the Compact of Free Association Act of 1985, Public Law 99-239, January 14, 1986 (99 Stat. 1783-84) and administered by the Republic of the Marshall Islands.

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PREFACE

This edition of the Report, which replaces that of July 22, 1988, has been corrected for typographical errors. In addition, for purposes of clarification, a paragraph has been added to each of pages 2, 3, 7, 23, 24, 62, 63 and 83; a sentence or phrase on pages 5, 15, 17, 27, 28, 33, 38, 40, 41, 44, 47, 65, 76, 77, 78, 79 and 92. These changes are in brackets to identify them.

None of these changes modifies the intent or meaning of the original Report.

In the Congressional Record of 31 Oct 88, p. E-3712, a resolution includes the statement that subsequent to the Reassessment Report's issuance (22 July 88), I have significantly changed my conclusions and positions.

I have not done so, as this edition of the Report will show. I hope that the minor changes and corrections I have made will clarify the text at certain points so that it will not be misinterpreted.

The main message of the Report can be had quickly by reading the Abstract [page 3] followed by pages 43-44, and supplemented by Note 16. The Note has been added to this reissue to cover material relating to the Congressional Hearings of 16 Nov 89 before the House Subcommittee on Insular & International Affairs (Committee on Interior & Insular Affairs), chaired by Mr. DeLugo; and that before the House Subcommittee on Interior & Related Agencies (Appropriations Committee), chaired by Mr. Yates (4 May 90).

ABSTRACT

The task has been to determine whether or not DOE's 1982 Report proved that Rongelap Island is safe for habitation. The island was contaminated in 1954 during the testing of nuclear weapons.

It should be borne in mind that the dosage under discussion is current dosage, e.g., from 1990 to 2020, and not that from exposure in 1954. The current [population]* dosage over a 30-year period is a matter of 3 rem [or less], whereas [that of 1954] was one of 190 rem in 2 days.

The evidence used by DOE plus additional and more recent information have been reviewed.

Rongelap Island is safe for habitation by adults provided that the diet is equivalent to that formerly used. I do not believe that such a diet would present any difficulty. [It comprises local plus imported foods.]

Measurement of plutonium excretion in the urine of Rongelap residents (1981) [by the Brookhaven National Laboratory] shows very great variation, [and it is quite inconsistent with studies by the Lawrence Livermore National Laboratory]. The matter is a potential cause of concern and should be studied [now] although it is not associated with overexposure.

The dose to infants and small children is another potential cause of concern. Preliminary findings from a diet survey indicate, however, that the dosage is not excessive. This study should be continued.

The whole-body counting for cesium should be resumed to establish a base line for later work at the time of resettlement.

In the course of planning for [Atoll] resettlement, the fact that Rongelap Island appears safe for resettlement now should not be lost sight of.

Planning for resettlement [of the Atoll] should consider the possible use of potassium-salt treatment of the soil and soil removal as studied at Bikini.

To obtain a brief summary of the key facts of dosage and the more general, but important human factors that will affect decision-making, the reader is referred to Section 4.5 (Dose Summary) and to Section 5 (Discussion and Recommendations.)

[The standards of safety in this Report -- as is to be expected -- are those employed currently in the U.S., where the radiation protection guide for the general population is 5 rem in 30 years (.17 rem/yr), whole body exposure (technically, the committed effective dose equivalent). The protective action guide is 0.2 rem/yr to the bone marrow (committed dose equivalent). These matters are discussed in Note 5.]

*Bracketed material has been added to this edition for clarification or correction.

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7. NOTES

1. INTRODUCTION

1.1 Task

Rongelap Atoll was contaminated with radioactive fallout in 1954 as a result of the Bravo thermonuclear test-shot at Bikini, 130 miles away. In 1978, to inform the people of the Northern Marshall Islands of the extent of residual contamination 24 years later, and of its potential effects upon their health, DOE (Department of Energy) surveyed the region and subsequently issued a specially prepared book report in Marshallese.

The book was entitled, The Meaning of Radiation for Those Atolls in the Northern Part of the Marshall Islands that were Surveyed in 1978, and was published in 1982. (We shall refer to it as DOE-1982.) The first part dealt in general with radiation and fallout, and how they might affect plants, animals and man. The situation at Rongelap was dealt with specifically on pages 38 - 39. (Note 1)

DOE's assessment of Rongelap Island was not accepted by the Rongelap people, so much so that in 1985 the residents abandoned their homes and moved to Majieto in Kwajalein Atoll.

The U. S. Congress, therefore, provided for an independent assessment of DOE's conclusions for Rongelap Island, in the Compact of Free Association Act of 1985 (U.S. Public Law 99-239, section 103(i); see Note 2). The functions of the present report are therefore as follows:

> "[The referee shall] review the data collected by the Department of Energy relating to the radiation levels and other conditions on Rongelap Island resulting from the thermonuclear test...The purpose...shall be to establish whether the data cited in support of the conclusions as to habitability of Rongelap Island as set forth in the [book] ...are adequate and whether such conclusions are supported by the data....If...the data are inadequate to support...habitabilty...the government of the Marshall islands shall contract...[for]...a complete survey...[and for recommendations of]...the steps needed to restore habitability..."

It should be noted that the law is quite specific in referring to Rongelap Island, not Atoll, and accordingly this Report concentrates on that Island, the chief residence of the Rongelap people. However, data and comments on other islands of the Atoll are included.

[The standards of safety in this Report -- as is to be expected -- are those employed currently in the U. S., where the radiation protection guide for the general population is 5 rem in 30 years (.17 rem/yr), whole body exposure (technically, the committed effective dose equivalent). The protective action guide is 0.2 rem/yr to the bone marrow (committed dose equivalent). These matters are discussed in Note 5.]

1.2 Procedure

The sections of DOE-1982 that deal with Rongelap and are now under review were discussed with DOE-1982's senior author, Dr. William Bair (Pacific Northwest Laboratories, Richland, WA 99352), and Dr. Bair has read, especially, the parts of the Report referring to them. It should be noted that DOE-1982 is a statement by DOE and is always referred to as such in this Report.

Dr. William Robison (Lawrence Livermore National Laboratory, Livermore CA 94550), who supplied the field data and the dose calculations for DOE-1982, has provided additional data for the present report, and has discussed his findings with me.

Relevant Rongelap studies that were supported by DOE at Brookhaven National Laboratory (Upton, New York 11973), were discussed with Dr. William H. Adams, (Medical Department), Dr. Robert Conard [Medical Department] and Mr. E. Lessard (Safety & Environmental Protection Division).

It was considered important and efficient to bring together all of the data that are now available rather than to restrict this report to the limited data on which DOE-1982 was based. With the concurrence of the Marshallese Government, therefore, additional information from DOE-supported laboratories, that became available after DOE-1982 had been written, was made available to us by Adams, Lessard and Robison. Also, we have taken a number of samples in the field and have had them analyzed independently, in accordance with the wishes of the Rongelap people.

Other sources of information in the international literature have been used and are cited in the text.

We have also discussed from time to time various matters relating to the Report, or the progress made in developing it, with Rongelap Senator Jeton Anjain, P.O. Box 1006, Majuro, Republic of the Marshall Islands, 96960.

The task has been greatly facilitated by Mr. Peter Oliver, Special Assistant for Compact Affairs, Republic of the Marshall Islands, P.O. Box 15, Majuro, 96960.

The Reassessment Report (the present document) was written by Henry I. Kohn in his capacity as Referee under contract with RepMar. The opinions and statements made are therefore his responsibility. The task, however, was greatly facilitated by discussions with members of an international panel of consultants, selected to represent a variety of overlapping specialties that would cover the problems under examination. Owing to time constraints, none of the consultants has read the final version of this Report. All have read the Preliminary Report (April 20, 1988), and I have discussed various parts of the present document with various consultants by correspondence and especially by telephone.

The following scientists participated in the Project.

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UTE BOIKAT, M.Sc., Ph.D. (radioecology), Executive of the Department of Public Health, Freie und Hansestadt Hamburg, Tesdorpfstr.8, D-2000 Hamburg 13, Federal Republic of Germany. ((011-49)40-44195334). Dr. Boikat has been a member of the consulting firm of Kollert, Donderer and Boikat of Bremen which assisted in some of the analytical work.

BERND FRANKE, M.Sc. (radioecology), Executive Director (Washington Office), Institute for Energy and Environmental Research, 6935 Laurel Ave., Takoma Park, MD 20912 (301-270-5500)*

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* The "Institute" is a private consulting office.

2. BACKGROUND -- THE RONGELAP EXPERIENCE

Rongelap Atoll is located about 2,500 miles southwest of Hawaii, at 12°N, 167°E (Fig. 2 #1). It comprises more than 50 low-lying islands and islets, total area 3.07 sq. miles, which bound a lagoon of 400 sq. miles. The largest and by far the most important island, Rongelap, has an area of 0.3 sq. miles.

The geological structure is that of a coral reef atoll resting on a submerged volcanic mass. The islands are made of reef debris, primarily of sand and gravel size, and reef organisms.

The atoll is typical in appearance, and the islands are covered with vegetation. However, a major factor limiting the kinds of plants that can be grown as staples is the long dry season.

The Marshall Islands Statistical Abstract of 1986, issued by the Republic, lists the population of the atoll as totalling 235. Previously, it was 165 in 1973, 189 in 1967, 264 in 1958. In 1954 at the time of the Bravo incident, 84 persons were evacuated. (These fluctuations reflect the need to work elsewhere.) Earlier records for Japanese and German periods of control are: 99 in 1945, 98 in 1935, 110 in 1920, 100 in 1906, 120 in 1860.

However, Mr. Peter Oliver, the Republic's Special Assistant for Compact Affairs, has informed me that the Rongelap Distribution Authority now makes per capita payments from its Nuclear Claims Fund to 1,578 individuals. Currently, these amount to $1480 per year to those exposed to fallout in 1954, and $480 to others. The Council has also determined that 2,277 individuals qualify for the benefits of the Section 177 Health Care Program as a result of their ties to Rongelap.

2.1 Bravo test -- 1954

The initial event occurred on March 1, 1954, when a 17-megaton-yield thermonuclear device was set off at Bikini Atoll, the Bravo test. The device was 1000 times as powerful as the bombs that destroyed Nagasaki and Hiroshima; its cloud rose 25 miles above the earth, and after 10 minutes had a diameter of 70 miles.

It had been planned that the "cloud" would be blown to the west and north (Fig. 2.1 #1). Unexpectedly for whatever reason (Note 3), it was blown to the east so that at about 5 hours after detonation fallout began at Rongelap Atoll, and during the ensuing 7 hours fell in such quantities as to suggest to Rongelapese, who had never seen snow, that it was snowing (Sharp & Chapman, 1957). Rather than avoiding contact, children played in the powdery, finely granular fallout, and no particular effort was made to separate it from food or clothing. No warning was or had been issued by the military.

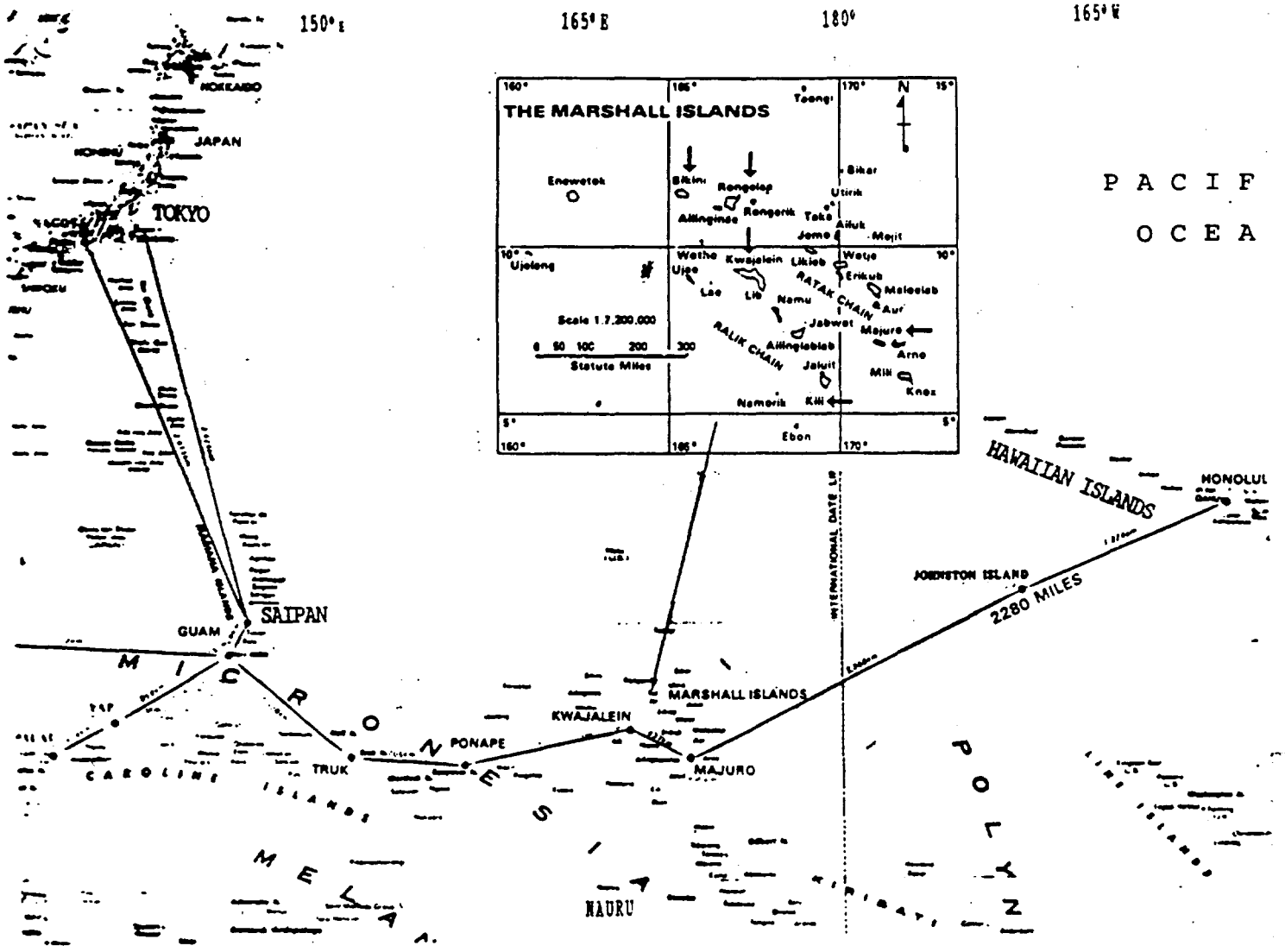

Fig. 2.1 Location of the MARSHALL ISLANDS

About 50 hours after the "shot", the Navy removed the 64 Rongelap residents from the Atoll to the medical base at Kwajalein (Sharp & Chapman, 1957; Cronkite et al, 1956) Also, eighteen visiting Rongelapese were removed from Sifo Island, Ailinginae Atoll, and 157 Utirik people from Utirik Atoll. It was immediately recognized that the surveillance and care of these people required far more professional staff than the base could supply, and a special medical team hurriedly organized for this purpose in the United States, utilizing naval and AEC personnel, reached the base 8 days after the detonation.

Consistent with a whole-body dose of 190 rem (over two days), two-thirds of the Rongelap group experienced nausea, 10% with vomiting and diarrhea, which cleared within three days or so, and all showed depressed white-blood-cell counts (Cronkite et al, 1956). As a result of the skin dose from physical contact with fallout, about 70% developed skin lesions of widely varying severity after a latency period of two to three weeks. Most of these were to heal successfully but a few developed significant scarring. There were no deaths within 60 days of exposure.

The most "significant" part of the initial exposure produced no immediate signs or symptoms. A half-dozen thyroid-seeking radionuclides entered the body through fallout-contamination of food and water. Over the course of the following weeks these iodine and tellurium radionuclides delivered doses that eventually caused thyroid hypofunction and the appearance of thyroid tumors.

The Bravo test posed new dosimetry problems, only vaguely sensed before. Owing to the gigantic energy-yield at ground level, great quantities of coralloid radioactive material were generated (Hiroshima and Nagasaki had involved high air-bursts): 142 radionuclides were involved whose radiations and rates of decay varied greatly, and whose eventual effects depended on the weather conditions and the living habits of the exposed population.

At the time of evacuation, the exposure rate in Rongelap village was 1.2 - 2.3 R/hour. The whole-body dose of "175 R in air" reported in 1956 was approximately correct. The dose estimate for the thyroid gland, however, was much too low because only iodine-131 had been considered in the calculation. As a result, the appearance of thyroid disease later on was quite unexpected.

An upwards revision of thyroid dose was reported in 1964 when iodine-133 and iodine-135 were included. (James, 1964). The revisions of 1984 (Lessard et al, 1985; Lessard, 1984a), based on a comprehensively planned attack on the problem (Bond et al, 1978), put the mean adult whole-body dose at 190 rem. The revised total dose to the thyroid gland, including contributions from all seven important radionuclides was greatly increased and varied significantly with age at exposure in 1954 -- from 5,200 rem for a one-year old to 1,600 rem at age 14, and 1,200 rem for the adult male. It was estimated that 95% of the thyroid dose was received during the first three post-exposure weeks, and 100% within three months (Note 4).

2.2 Return to Rongelap - 1957

The AEC (Atomic Energy Commission)[1/] decision that Rongelap had become safe was based on field data by the Radiation Ecology Laboratory, University of Washington College of Fisheries, and dose calculations by AEC staff. For 1957 the annual external gamma"dose" at Rongelap Island was estimated to be less than 0.5 roentgen, the maximum permissible for the general population, and it was expected to decline owing to physical decay. However, the AEC assessment was inadequate with respect to internal dosage resulting from contaminated food (Note 5 and Note 11, table 2).

In 1957, therefore, the Rongelap people returned to Rongelap Island. In March 1958 there were 81 persons there who had been exposed on Rongelap or Ailingnae, and approximately 100 others who had not.

To anticipate any late effects that might follow the acute exposures of 1954, the AEC commissioned Brookhaven National Laboratory's Medical Division to establish the Marshall Islands Medical Program, whose staff has visited the Rongelap people once or twice a year since 1957 (Note 4). Since Rongelap soil still contained low levels of radionuclides which might enter the body through the food chain, the program included equipment to measure radionuclides within the human body (whole-body counting). Since 1978 the counting program has been operated by Brookhaven's Safety & Environmental Protection Division.

2.3 Rongelap: 1957-1987

The medical findings were summarized or updated by R. A. Conard, who led the whole program for many years (Conard et al. 1958; 1975; 1980) and more recently by Adams et al (1984). The status of the dosimetry, originally included in the Conard reports, has been more recently reported on by Lessard et al (1984; 1985). In brief, on the basis of these reports, the following sequence of health-related events occurred over the past 30 years.

1957-63. Among the usual problems in the Marshall Islands were parasitism, chronic skin disease, diabetes adult-onset type II, and bad teeth in adults, and a variety of infant and childhood diseases including infant diarrhea.. The vast majority of skin reactions to radiation had disappeared without sequelae, except for scarring in the most heavily irradiated cases. No skin cancers were observed. Two possible examples of radiation effects occurred. First, it was reported that about twice as many abnormally terminated pregnancies occurred among the exposed parents as would be expected normally. Second, two boys showed markedly stunted growth, suggesting thyroid deficiency.

[1/] The AEC was the predecessor of DOE.

1964-75. Unquestionable damage to the thyroid gland, especially to those exposed below the age of 10, made its appearance. A reexamination of earlier estimates of dose to the thyroid gland led to their elevation by a factor of about 2 for adults, and 5 or more for children. The administration of thyroid hormone (interrupted on occasion) to the entire exposed population was begun in 1965 as a prophylactic measure against thyroid neoplasia (nodules, cancer), and also to correct for possible losses in thyroid function.

By the end of 1974 (Fig 2.3 # 1), the thyroid tumor record was as follows:

Age below 10 in 1954: 17 tumors in 19 persons examined, including 1 cancer.

Age 10-18 years in 1954: 2 tumors in 12 persons examined.

Age above 18 years in 1954 : 3 tumors in 33 persons examined, including 2 cancers.

Almost all persons with thyroid nodules were sent for surgical treatment to the Cleveland Metropolitan Hospital, Cleveland, Ohio. Each one was compensated at the rate of $25,000 per surgery.

The occurrence of thyroid disease as well as a case of acute leukemia worried the Rongelap people. The medical team was accused of having deceived the Rongelap people and of using them as guinea pigs. The Brookhaven medical services were boycotted during 1972, but they were accepted later in the year after a [relatively] favorable report on the matter by an international committee.

1976-79. More thyroid nodules appeared. The Rongelap people continued to be worried. They asked for an independent health review which was not granted. A group of Brookhaven scientists proposed a comprehensive dosimetry review (Bond et al, 1978), which DOE then funded (Lessard, 1984a; Lessard et al, 1984c; Lessard et al, 1985). Independently, DOE initiated a "Northern Marshall's Survey" based on an aerial survey by EG&G and some terrestrial work by Lawrence Livermore National Laboratory (Robison et al, 1980; Robison et al, 1982b; Tipton & Meibaum,1981).

1980-84. DOE summarized its survey results in 1982 with a report in Marshallese, embellished with colored illustrations. (This is the book, DOE-1982, under review in the present report. See Note 1.) DOE-1982 stated that the U. S. radiation guide was 5 rem in 30 years, and that the current whole-body dosage at Rongelap Island was 2.5 rem in 30 years. On some other Rongelap-Atoll islands not used for permanent residence the dose might be 2 to 5 times as much. The Rongelap people requested the Government to transfer them to another atoll. Significant parts of the anti-nuclear documentary film, Half-Life, were filmed at Rongelap. The film suggested that the people had been used as "guinea pigs".

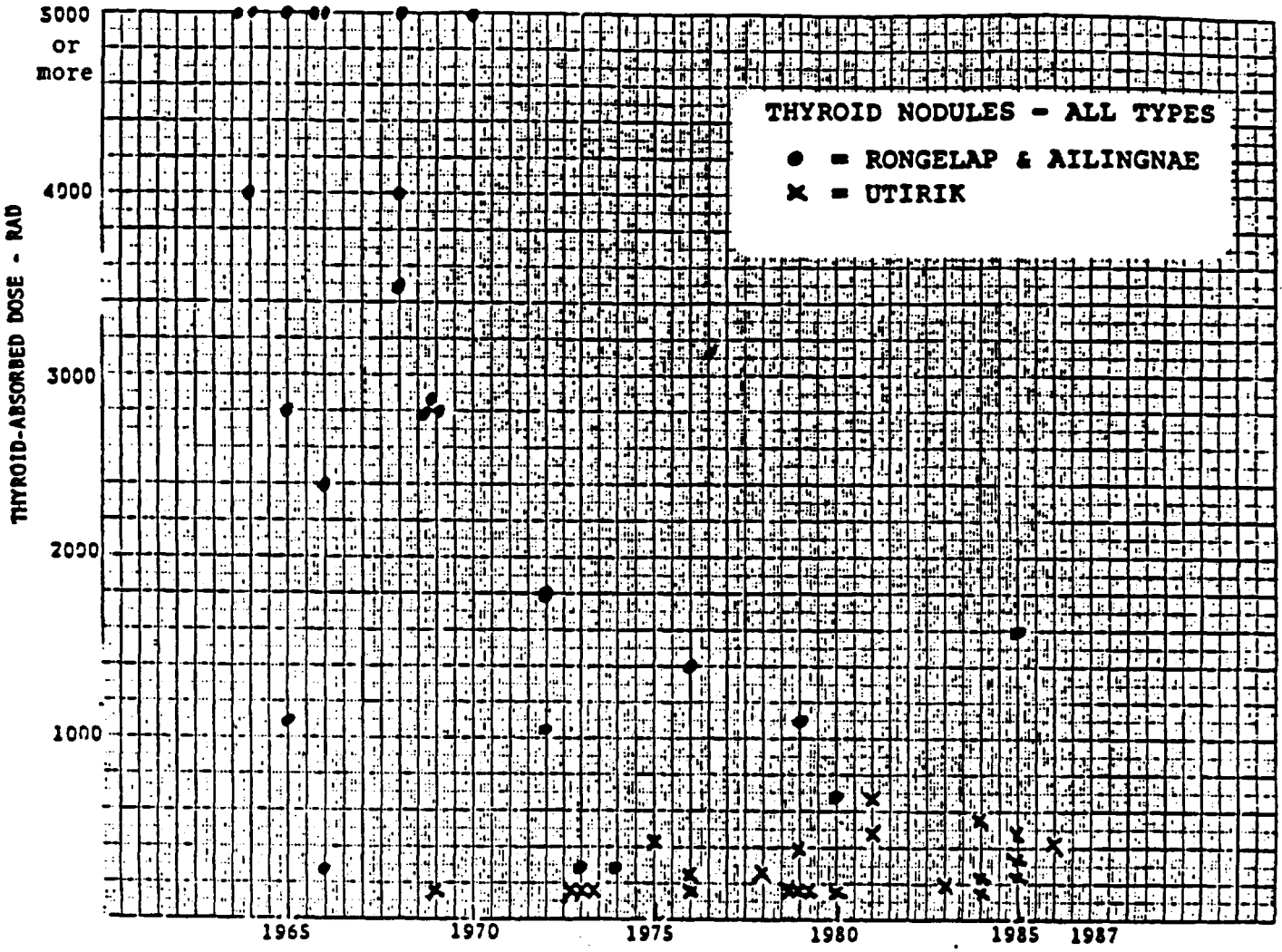

Figure 2.3 #1. Latency period for appearance of thyroid nodules related to thyroid dose received in 1954 at Rongelap & Ailingnae, and Utirik. Details on thyroid dosage are given in Table N.4 #2.

(Figure courtesy of W. H. Adams, Brookhaven National Laboratory)

1985. The Rongelap people abandoned Rongelap and sailed for Majieto Island in Kwajalein Atoll. The U. S. Congress passed the Compact of Free Association Act of 1985 (Public Law 99-239) of which Section 103(i) is the basis for the present inquiry (Note 2).

1987 The following points are of major interest for the present report.

(a) A clear distinction should be made between the late effects of the large acute exposure in 1954 (190 rem whole-body) and the possible (but as yet undetermined) effects of the much smaller chronic dose since resettlement in 1957-1978 (~ 3.5 rem or less). [(Note 11, pp. 74 & 75)]

(b) The original dose estimates for the 1954 exposure were much too low for the thyroid gland (Cronkite,1954; Dunning, 1957). The necessity for major correction later on weakened or destroyed Rongelap confidence in DOE. The annual radiation doses during the first years of resettlement may also have been underestimated, but the corrections would be very much smaller. [(Note 11, pp. 74 & 75)]

(c) The occurrence of thyroid tumors (~ 30%) 10 years or later after returning to Rongelap (Fig. 2.3 #1; Note 4B) has been a confusing experience for the Rongelap people. In addition, eight cases of hypothyroidism have been observed (Adams 1988).

(d) No significant increase in tumors outside of the thyroid gland was noted (Adams et al, 1984) in the 81 persons at risk. [An up-to-date summary is expected from Brookhaven early in 1989 and will deal specifically with (a) tumor data in the 1954-exposed and 1954-unexposed groups, and (b) tumor data as affected by the duration of residence on Rongelap Island after resettlement in 1957.]

(e) No obvious gross difference in survivorship between 1954-exposed and 1954-unexposed groups has occurred (Fig. 2.3 #2). Although statistically significant decreases in some blood-cell types have been noted (Adams et al, 1982), none has been clinically significant.

(f) Based on four parameters (longevity, thyroid nodules, carcinoma, blood counts), there is no evidence of effects from the chronic low-level exposure associated with length of residence on Rongelap since 1957 (Note 4). These studies are admittedly exploratory. However, the average dose over the period 1957-78 is quite small (3.5 rem or less), and will be accumulated at much lower rates in the future.

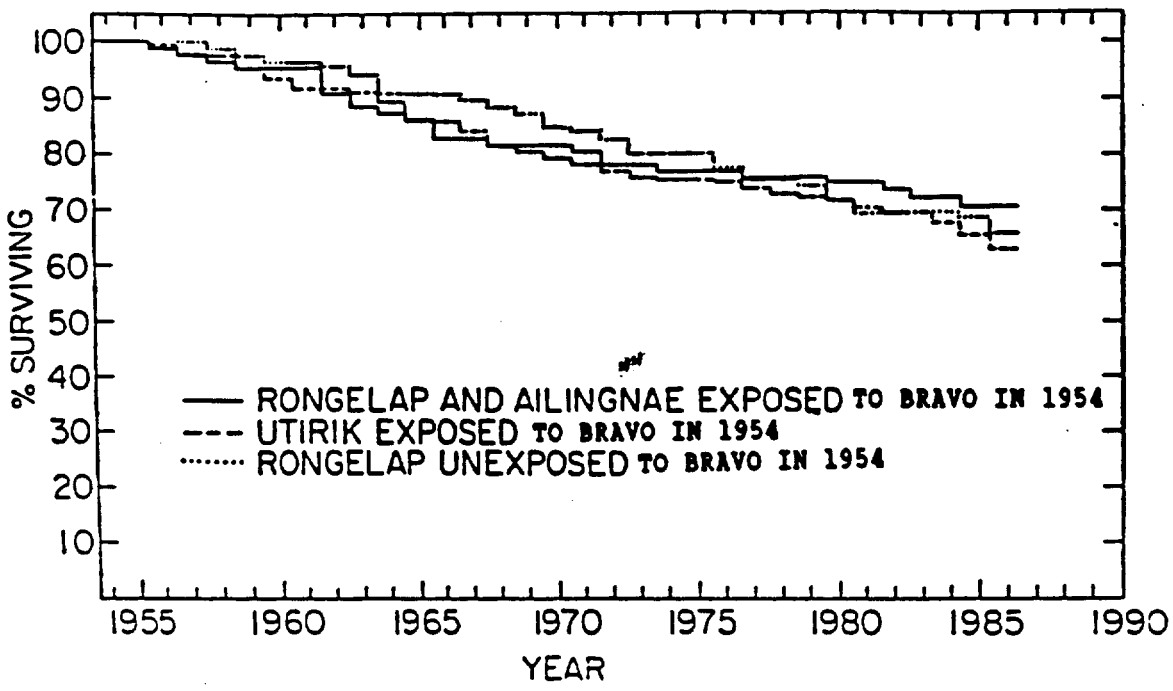

FIGURE 2.3 #2 Survival as a function of time after 1954.

The numbers exposed and whole-body doses were: Rongelap, 67 persons, 190 rem; Ailingnae, 19 persons, 110 rem; Utirik, 167 persons, 11 rem. The unexposed group of 86 Rongelapese was matched (age, sex) in 1957 to the Rongelap-Ailingnae group and has been followed for survival annually.

(Figure courtesy of W. H. Adams, Brookhaven National Laboratory.)

3. REASSESSMENT

With the foregoing as background, let us now attempt to answer the questions which the Congress has asked: Were the doses used by DOE-1982 correct (Robison 1982b)? Does it follow that Rongelap is habitable? If not, what should be done [Note 5]?

It should be noted that the technical position has changed since 1982. More data have been accumulated so that the original meager sampling has become more robust. In addition, we shall consider the findings of the Brookhaven National Laboratory, using an important method which DOE-1982 did not consider, and also our own findings.*

The data base employed by DOE-1982 comprised the results of the Northern Marshall Islands Survey of 1978 (September-November) which had been planned as an aerial reconnaissance to map external gamma-ray exposure rates (normalized to 1 meter above ground level) (Tipton & Meibaum,1981). Two helicopters were employed, operating from a major support vessel, the U.S.N.S. Wheeling.

Subsequently the Livermore Laboratory program was added to obtain soil, water, vegetation and fish samples at each atoll "as time and facilities might permit" (Robison et al, 1981, Part 1). The time spent at Rongelap Atoll permitted 7 days for 9 islands, of which the major one was Rongelap. Operating from a large ship that had to cruise at a considerable distance offshore, and whose primary function was aerial reconnaissance, restricted the terrestrial work significantly.

The radionuclides dealt with were five: cesium-137, which is distributed throughout the body; strontium-90, a bone seeker; and the very poorly absorbed plutonium-239.-240 and americium-241, which have very long half-lives and which are tightly bound by bone, liver and testes (Table 3 #1).

The Livermore group took soil samples from some 25 scattered locations on Rongelap Island whose averages (picocuries/gram) for 0-10 cm depth were: cesium-137, 12; strontium-90, 7.1; plutonium-239,-240, 2.6; americium-241, 0.9 (Table 3 #2). These 1978 levels were about twice those for Eneu, Bikini Atoll.

This soil contamination provided the basis for human exposure in two ways. Radiations that emanated from the ground or standing vegetation led to external dose. Radiations that emanated from food and water after entering the human body were responsible for internal dose.

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* B. Franke states that the enabling legislation calls for study of only the original findings and report. A second committee should consider subsequent findings, and a third group should execute its recommendations.

The total dose received was the sum of the external and internal doses. The external whole-body dose was estimated by measuring the exposure in air (e.g., at 1 meter above ground) and applying a factor based ultimately on measurements with phantoms to the meter reading. The internal dose was estimated by the Livermore group on the basis of an assumed diet and the analysis of the radionuclide contents of Rongelap food products in it.

The lagoon and its fish were found to be a trivial source of dose. Ground water (well water) was an unimportant source, since its activity was very low and, in any case, the people relied heavily on catchment of rain rather than wells (Noshkin et al 1981).

Before considering the data, the nonprofessional reader may wish to consult Note 6 which explains the radiological usage of such terms as exposure and dose, and the definition of their units. It may also be noted here that my use of the term whole-body dose (internal) usually signifies the committed effective dose equivalent; the tissue dose (internal) is usually the committed dose equivalent. DOE-1982 used integral doses calculated by the Livermore group, i.e., the annual dose (not committed dose) for each year was summed for the period of exposure.

TABLE 3. #1

SOURCES OF FALLOUT RADIATION

Radionuclide	Half-life[a/]	Principal Radiations[a/]			Fraction absorbed from gut in adults[e/]	Annual dose (rem) per pCi/g in tissue[f/]	
		[b/] α	[c/] β	[c,d/] γ		soft tissue	bone marrow
	Years	MeV	MeV	MeV			
Cesium-137 *	30	-	0.187	.66	1.0	.010 (muscle)	.009
Strontium-90	29	-	1.13	-	.3	-	.005
Plutonium * * -239	24,065	5.23	-	-	.001	1.93 (liver)	0.63
-240	6,537	5.24	-	-	.001	1.93 (liver)	0.63
Americium * * -241	432	5.57	-	-	.001	2.06 (liver)	0.68

[a/] ICRP Publication 38. (Radionuclide transformations)
[b/] Quality factor, 20.
[c/] Quality factor, 1.

[d/] X and gamma rays are omitted whose total contribution to dose would be less than 10%.

[e/] ICRP Publication 30. Supplement to Part 1. (1980), and ICRP Publications 48 and 51 for transuranics. The half-retention time in liver is 20 years, in skeleton 50 years for the transuranics.

[f/] Dose in 1 year for an activity of 1 pCi/g maintained for that year in the tissues which receive the highest dose when the radionuclide is ingested. (Reference, See Footnote [e/].)

* The half-life in the body is about 110 days in males, 85 days in female, and much less in pregnant women and children.

** The half-life in bone marrow and liver together averages about 35 years.

TABLE 3 #2

RONGELAP ISLAND: RADIONUCLIDE SOIL PROFILES[a/] (1978)

Depth (cm)	Average specific activity for dry soil (pCi/g)			
	Cesium-137	Strontium -90	Plutonium -239,-240	Americium -241
0-5	15	6.9	3.2	1.0
5-10	9	7.7	2.0	.78
10-15	5.4	6.7	1.1	.41
15-25	2.6	4.5	.35	.18
25-40	1.8	2.1	.07	.08
0-40	5.0	4.6	.89	.35
Number of profiles	27	20	18	17

[a/] The 1978 profiles are from Robison et al, 1982, Part 4, Appendix B.

4. DOSE

DOE-1982 reported doses for persons living on Rongelap Island for the period 1978-2008 (for the corresponding period 1990-2020, they would be 25% less):

(a) The "highest average amount of radiation the people might receive in any part of the body" was 2.5 rem (over 30 years). I take this to be Livermore's "integral dose" in which each year's delivery is summed for 30 years (Robison et al, 1982b, Table 17). I will compare it to the committed whole-body dose (rem) for 30 years (i.e., the committed effective dose equivalent for a standard man).

(b) The corresponding bone marrow average would be 3.3 rem (Robison et al, 1982b, Table 14). I take this to be the marrow "tissue dose" and it is approximately equal to the committed dose equivalent,

DOE-1982 stated that the doses are based on the condition of "local food only from Rongelap Island" (Note 1).* However, the doses in fact had been calculated by the Livermore team (Robison, 1982b) for the community type B diet (Naidu et al, 1980). That diet involves the use of imported foods brought in on a regular basis by supply ship to supplement local produce. Without such imports, the doses would be higher.

DOE-1982 used the Livermore findings, but failed to utilize those of Brookhaven National Laboratory. These included whole-body counting to determine cesium-137, a method superior to that which calcultates dose from the diet.

More recently, Brookhaven's results with the fission track method to determine plutonium in urine, and from it the committed effective dose equivalent, have yielded doses which disagree with those of the Lawrence Livermore Laboratory based on diet. This will be discussed.

[*Dr. Bair has since informed me that the quoted text should be interpreted to mean that the diet contained imported food and local food only from Rongelap Island. DOE-1982 inadvertently did not mention the imported food.]

4.1 External Dose

The 1978 aerial survey (Tipton & Meibaum, 1981) provided DOE with important information on exposure to fallout in the Northern Marshall Islands. As the survey proceeded south and east from Bikini Atoll, the seat of the Bravo shot, the external exposure rate fell (Table 4.1 #1). It was calculated for 1 meter above ground level.

At Rongelap Atoll (Figure 4.1 #1), the islands fell into four exposure groups (microroentgens per hour) from north to south: Naen, Yugui, Lomuilal (28-43 μR/h), Eniaetok, Kabelle, Gogan (10-27 μR/h); Busch, Borukka, Gabelle, Tufa (5-9 μR/h); Rongelap and Arbar (4.1-4.5 uR/h).

The external dose (whole-body), was calculated from exposure by my assuming 1 roentgen = 0.7 rem tissue dose (Kerr, 1980; U.N. 1982). For Rongelap Island the annual dose was .028 rem, well below the EPA guide of .170 rem/year; 8 other major islands were also below the guide (Table 4.1 #1).* The factor of 0.7 rem per roentgen was used to allow for the [possibly] smaller size of the Rongelap [population] and the many children. The conventional value for the 70 kg standard man is 0.61.

There is also a shallow dose to be considered, that due to beta rays which travel for short distances (< 1 cm) into those parts of the body that are near or in close contact with the soil and that are unshielded. Their contribution is considered to be negligible (Note 7).

These estimated external gamma-ray dose rates are maximal ones. Indoors the rate is reduced by about 50%. Likewise, the rate is reduced by about 50% in the immediate vicinity of houses owing to the coral gravel that is spread around them (Shingleton et al, 1987 and Robison et al, 1982b). This, of course, is important in the case of infants and small children.

Other annual contributions to external dosage which are <u>not</u> included come from cosmic radiation (.028 rem) and medical exposure.

In summary, the contribution of fallout to the total external radiation dose at Rongelap Island in 1978 was approximately .028 rem per year uncorrected for the shielding within or around buildings, which would decrease the rate by 50%. The 30-year whole-body dose would be .590 rem allowing for spontaneous decay, but not shielding. Environmental decay such as leaching of radionuclides from the soil would reduce this estimate still more, but was not allowed for.

[* Based on the annual doses in Table 4.1 #1, the Lukuen group of northern islands exceed the radiation protection guide (Note 5) on the basis of external dose alone and the Eniaetok group approaches this limit (.17 rem/yr). With the internal dose also taken into account, I would recommend that no islands be inhabited north of Borukka and Eniaetok.]

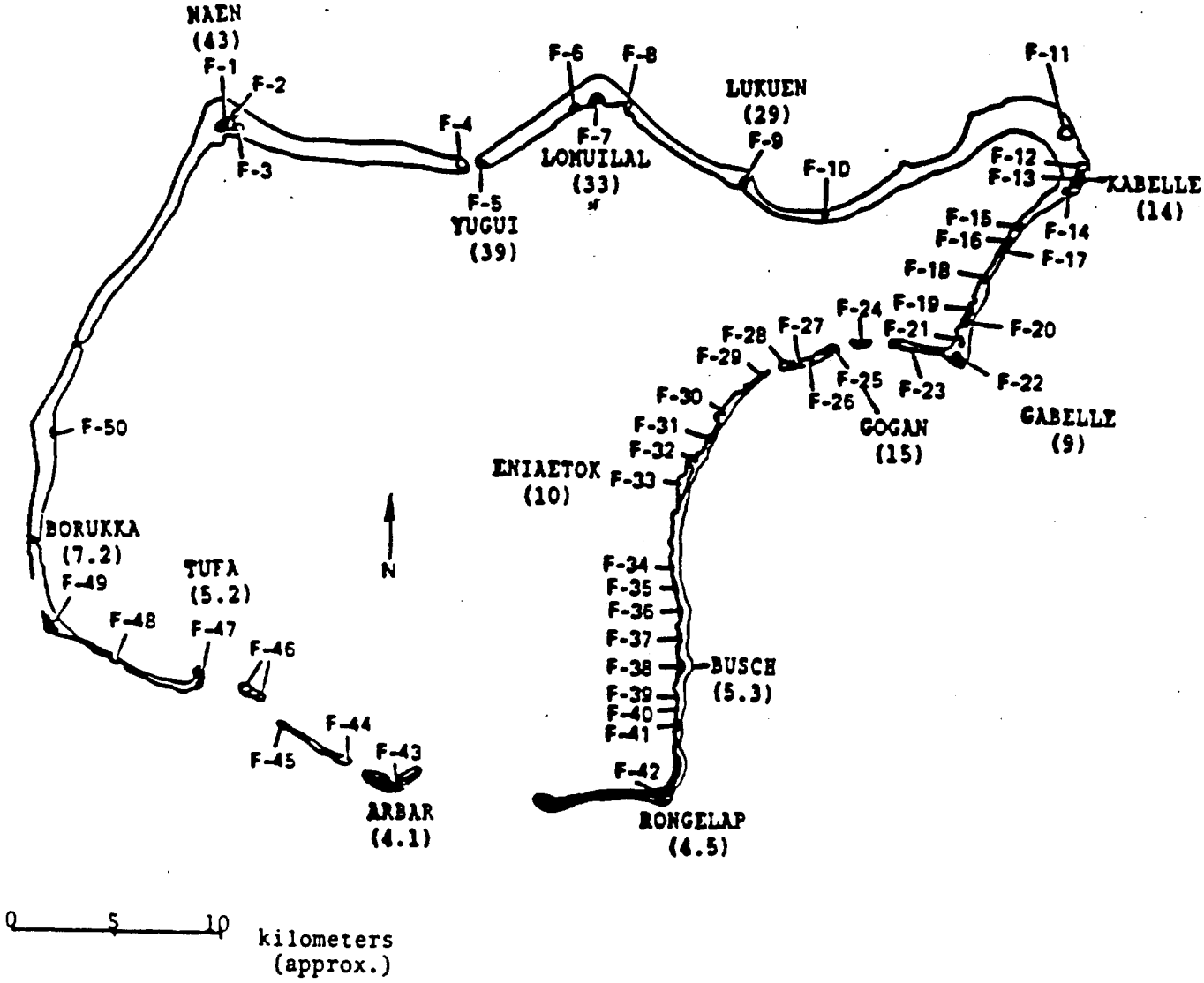

Figure 4.81 PRINCIPAL ISLANDS OF RONGELAP ATOLL

The numbers in parentheses are the external whole-body exposure-rates in microroentgens/hour, corrected for cosmic radiation, as determined in 1978 by aerial survey (Tipton & Meibaum, 1981).

TABLE 4.1 #1 AVERAGE EXTERNAL EXPOSURE AND EXTERNAL DOSE RATES (1978) (gamma ray) FOR ISLANDS AFFECTED BY BRAVO FALLOUT

(The 1990 doses will be approximately 75% of those for 1978.)

Atoll and Reference	Island	Year	a/ Exposure (gamma)	b/ Dose (whole-body)
			microroent-gens/hour	rem/year
Bikini Atoll				
Tipton & Meibaum (1981)	Eneu	1978	2.7	.017
	Bikini		35.0	.215
Shingleton et al (1987)	Eneu	1986	--	.018
	Bikini		--	.160
Rongelap Atoll				
Tipton & Meibaum (1981)	Rongelap	1978	4.5	.028
	Arbar		4.1	.025
	Busch, Tufa, Borukka, Gabelle		5-9	.031-.055
	Eniaetok, Kabelle, Gogan		10-27	.061-.166
	Lukuen, Naen, Yugui, Lomuilal		28-43	.172-.264
Paretzke (Note 8)	Rongelap	1987	4.1 (7)c,d/	.025
Greenhouse & Miltenberger (1977)	Rongelap	1977	3.6-4.5	.022-.028
Ailingnae Atoll				
Tipton & Meibaum (1981)	Sifo	1978	1.4	.009
Paretzke (Note 8)	Mogiri	1987d/	1.3 (1)	.008
	Enibuk		2.2 (1)	.013
Utirik Atoll				
Tipton & Meibaum (1981)	Utirik	1978	0.8	.005

a/ Measured at 1 meter above ground level, corrected for cosmic rays.

b/ Annual, whole-body dose (millirem/year) calculated as equal to 6.13 x 10^{-3} x μR/hour. For the epidermal dose, see Note 7.

c/ The average of 7 locations ranging from 2.2 to 4.6 μR/hour.

d/ Corrected for decay back to 1978. See Note 9.

4.2 Internal Dose - Lawrence Livermore National Laboratory

Lawrence Livermore attacked the problem by determining what went into the body by ingestion and inhalation (picocuries per day) [Table 4.2 #2]., and then applying appropriate factors to such input (exposure) to obtain the dose in rem. The particular ones I have used are given in Table 4.2 #1.

The major uncertainty of the "input" method lies in the diet--no one knows precisely what it is, although several attempts have been made to define it. DOE-1982 used the BNL community B diet, i.e., one involving a greater amount of food and also a greater input of contaminated food (Note 8). Naidu et al (1980) who originally described it commented that the diet represented prepared, not eaten food, and that in fact it was more than a person could eat. This results in overestimation of dose. The Lawrence Livermore group that used it for dose calculations concurred.

The 1978 specific activities measured by the Livermore team were made on 21 samples of coconut, 5 of Pandanus, 1 of breadfruit, 1 chicken, 2 pigs and 98 fish, on the whole a barely adequate number (Robison et al, 1981a, 1982b). In 1986, however, that Laboratory took for analysis more than 75 samples of coconut, more than 10 of breadfruit and some others; the results were in agreement with the earlier ones, and a summary of all data is shown in Table 4.2 #2, calculated for 1990. [(See also Table 4.2 #2, p. 26, in Preliminary Report.)]

Since the Rongelap people have expressed doubt about the reliability and honesty of Department of Energy scientists (e.g., those from Brookhaven and Livermore), a comparison trial was carried out in December 1987 in which samples collected at Rongelap and Ailinginae in the presence of Senator Anjain and others were divided among several laboratories for analysis (Livermore, Bremen, Neuherberg (Munich) and Berkeley). The results demonstrated agreement (Note 9).

Cesium. I am taking 3,400 pCi/d (in 1990) as the exposure due to cesium-137, based on a total for foods listed in Table 4.2 #2 plus a 10% allowance for a miscellaneous variety of others (Note 8, Table #1). The whole-body, red marrow and bone surface doses [30-year] are just about equal, 1.26 rem (based on the factors given in Table 4.2 #1).

Strontium. The strontium-90 estimates for 1990 are based on the 1978 samples; I have been unable to learn how much more work has been done since then. I am therefore taking 21.8 pCi/d based on field samples plus a 25% increment for other miscellaneous foods. The total exposure is 27.3 pCi/d. The 30-year doses are: whole-body, .025 rem; red marrow, .137 rem; bone surfaces, .300 rem. (Scaled back to 1978, they would be 33% more.)

Transuranics. Based on Table 4.2 #1 and the plutonium-239,-240 exposure of 0.293 pCi/d, the 30-year doses are: whole-body,.011 rem; red marrow, .017 rem; bone surfaces, .214 rem. The americium doses will be 35% of the plutonium-239,-240 ones. The total transuranic dosage is therefore .015 rem, whole-body.

Water. In the case of catchment water (Noshkin et al 1981), the radionuclide levels are no higher than 3% of the guides. In the case of ground water, the same is true except for strontium-90, whose level is about 25% of the guide (8 pCi/liter). (These levels have been scaled to 1990.)

Inhalation. It is the transuranics that are of consequence. The original estimates of respired dust were very much too high (Shinn et al 1980) and they have been reduced to make them more realistic (Robison 1988). The matter is discussed in Note 10. Taking the daily intake to be 0.006 pCi/d, the 30-year adult dose is .027 rem whole-body, .041 to the red marrow, and .005 rem to the bone surfaces.

Summary. The individual doses [for cesium and strontium] have been multiplied by 1.33 to scale them back from 1990 to 1978, the year in which DOE-1982's samples were collected. It should be recalled that the following estimates depend directly on the assumed diet.

Livermore Adult 30-year Dose
(type B community diet) for 1978-2008*

Source	Whole-body dose (rem)	Red marrow dose (rem)
Inhalation	.027	.041
Internal dose		
-cesium-137	1.673	1.673
-strontium-90	.033	.182
-transuranics	.015	.023
External dose	.590	.590
Totals	2.34 **	2.51***
DOE-1982	2.500	3.300

* To convert 1990 to 1978, multiply by 1.33 [for cesium and strontium.]
** Committed effective dose equivalent
*** Committed dose equivalent

TABLE 4.2 #1A

INGESTION

FACTORS TO CONVERT ADULT "INITIAL DAILY INTAKE (pCi/d)" TO COMMITTED

"WHOLE BODY" OR "TISSUE" DOSE (rem) FOR DIFFERENT PERIODS OF DAILY INTAKE [a]

Radionuclide & period	C.E.D.E.[b]	Red marrow	Lungs	Bone surfaces	Liver
CESIUM-137					
initial year	1.7 E-5[c]	1.7 E-5	Like C.E.D.E		
0-30 year	3.7 E-4	3.8 E-4			
30-70 year	2.2 E-4	2.4 E-4			
STRONTIUM-90					
initial year	4.7 E-5	2.4 E-4	1.8 E-6	5.3 E-4	1.8 E-6
0-30 year	9.2 E-4	5.0 E-3	3.6 E-5	1.1 E-2	3.6 E-5
30-70 year	5.6 E-4	3.0 E-3	2.2 E-5	6.6 E-3	2.2 E-5
PLUTONIUM-239.-240					
initial year	1.3 E-3	1.9 E-3	1.0 E-8	2.4 E-2	4.2 E-3
0-30 year	3.9 E-2	5.7 E-2	3.1 E-7	7.3 E-1	1.3 E-1
30-70 year	5.1 E-2	7.4 E-2	4.1 E-7	9.6 E-1	1.7 E-1
AMERICIUM-241					
initial year	1.3 E-3	Like plutonium			
0-30 year	3.9 E-2	5.7 E-2	1.6 E-6	7.3 E-1	1.3 E-1
30-70 year		Like plutonium			

[a] **It is assumed that the daily diet remains constant, but that the radionuclides in it decay spontaneously. The table provides dose factors in rem/picocuries/day. It is based on NRPB (1987) which provides factors in Sv/Bq (= 3.8 x rem/picocurie), and is consistent with ICRP recommendations (ICRP 1986, 1987). These factors allow for the fraction of radionuclide absorbed from the gut, its distribution and residence time in the body, the absorption and effectiveness of its radiation in the body, and its rate of physical decay.**

[b] Committed effective dose equivalent (whole-body dose). Other doses are committed dose equivalents (tissue dose). The C.E.D.E. is the sum of the dose equivalents to 11 tissues of the body of a standard man, each weighted by the risk of cancer resulting from a unit dose to that tissue as compared to the risk from a unit dose to the whole body.

[c] **E-5 signifies: x 10^{-5}.**

TABLE 4.2 #1B

INHALATION

FACTORS TO CONVERT ADULT "INITIAL DAILY INTAKE (pCi/d") TO COMMITTED

"WHOLE BODY" OR "TISSUE" DOSE (rem) FOR DIFFERENT PERIODS OF DAILY INTAKE [a]

Radionuclide & period	C.E.D.E.[b]	Red marrow	Lungs	Bone surfaces	Liver
CESIUM-137					
initial year	1.0 E-5[c]	9.9 E-6	1.1 E-5	9.4 E-6	1.0 E-5
0-30 year	2.2 E-4	2.0 E-5	2.2 E-4	2.0 E-4	2.2 E-4
30-70 year					
STRONTIUM-90					
initial year	7.7 E-5	4.2 E-4	4.6 E-6	9.2 E-4	3.1 E-6
0-30 year	1.6 E-3	8.7 E-3	9.5 E-5	1.9 E-2	6.4 E-5
30-70 year					
PLUTONIUM-239.-240 & AMERICIUM-241					
initial year	1.5 E-1	2.3 E-1	2.3 E-2	2.8 E-0	5. E-1
0-30 year	4.5 E-0	6.9 E-0	6.9 E-1	8.4 E-1	1.5 E-1
30-70 year	6.0 E-0	9.2 E-0	9.2 E-1	1.12 E-2	2.0 E-1

[a] It is assumed that the radionuclides in soil decay spontaneously. The table provides dose factors in rem/picocuries/day. It is based on NRPB (1987) which provides factors in Sv/Bq (= 3.8 x rem/picocurie), and is consistent with ICRP recommendations (ICRP 1986, 1987). These factors allow for the fraction of radionuclide absorbed, its distribution and residence time in the body, the absorption and effectiveness of its radiation in the body, and its rate of physical decay. See p. 24.

[b] Committed effective dose equivalent (whole-body dose). Other doses are committed dose equivalents (tissue dose). The C.E.D.E. is the sum of the dose equivalents to 11 tissues of the body of a standard man, each weighted by the risk resulting from a unit dose to that tissue as compared to the risk from a unit dose to the whole body.

[c] E-5 signifies: x 10^{-5}.

TABLE 4.2 #2

FOOD SPECIFIC ACTIVITY IN 1990 [a/]

(Multiply the cesium and strontium values by 1.33 to scale them for 1978.)

Item	gm/d	pCi/gm wet				pCi/day			
		Cs-137	Sr-90 x 10^{-2}	Pu-239,-240 x 10^{-4}	Amer-241 x 10^{-5}	Cs-137	Sr-90	Pu-239-240	Amer-241
Arrowroot	0	3.2							
Breadfruit	36	2.71	7.3	1.24	7.34	97.6	2.6	.045	.003
Banana	19	1.1	2.64	1.05	6.2	20.9	.502	.002	.001
Coconut									
Drinking meat	100	1.81	.39	.51	4.82	181	.39	.005	.005
Drink. fluid	514	1.07	.11	.27	2.52	550	.571	.014	.013
Copra	68	4.65	1.7	.56	6.32	316	1.16	.004	.004
Milk	125	4.65	1.7	.56	6.32	581	2.13	.007	.008
Sprouting	100	4.65	1.7	.56	6.3	465	1.70	.006	.006
Papaya	0								
Pumpkin	0								
Pandanus	96	8.63	11.8	.60	2.65	828	11.33	.006	.003
Fish	194	.0192	.065	2.40	4.22	3.73	.126	.047	.008
Poultry	3	1.95	.45	.1	85	5.85	.014	0	.003
Wild birds	9	?							
Domestic meat	0								
Pork	1.4	6.5	.27	.36	2.5	9.1	.004	0	0
Clams	15	.0012	.41	100	314	.02	.061	.15	.047
Crabs	0								
Octopus	20	.0106	.16	2.64	4.64	.212	.032	.005	.001
Turtle	.1								
Snails	12	?							
Coconut crab	1	2.71	118	19.4	62.4	2.71	1.18	.002	.0006
Lobster	.14								
Shellfish	-								
TOTALS	1310					3060	21.8	.293	.102

[a/] These data for the type B community diet (Naidu et al, 1980) were supplied through the courtesy of Dr. William L. Robison, Lawrence Livermore National Laboratory.

4.3 Internal Dose - Brookhaven National Laboratory

Cesium. It is a curious fact that Brookhaven's studies were not utilized by DOE-1982. Brookhaven had chosen whole-body counting, a definitive method independent of assumptions concerning diet, to follow cesium in the Rongelap population (Conard et al 1980; Lessard 1984 b,c; Miltenberger et al 1980), and one of primary importance in the present case where cesium accounts for 95% of the dose.

The cesium-137 body burden fell from about 670,000 pCi in 1958-65 to about 175,000 pCi in 1979. It is of interest that body burden fell by 75% in 20 years, whereas the half-life of cesium is 30 years. Perhaps a change in eating habits or a larger degree of environmental loss of the radionuclide than has been established were at work.

In any event, the Brookhaven estimates for whole-body dose (1978) are .027 rem, and for the ensuing 30-year period .245 rem (Note 11, Tables 1,2). The 30-year dose was calculated by extrapolating the curve for the previous dozen years.

A more conservative assumption would be that the dose will fall only as a result of spontaneous decay by cesium-137. In this case, the 30-year dose would be .56 rem for whole-body, red marrow and bone surfaces.

We do not have an independent field check on the accuracy of the whole-body field measurements. The point may be made, however, that it was this team that discovered the precipitous rise in body-burden of the Bikini settlers in 1977-78 and who therefore called for their removal from Bikini Atoll (Conard et al, 1980; Miltenberger et al, 1980).

Strontium. Strontium-90 daily excretion was determined by urine analysis and the committed effective dose equivalent calculated therefrom. Three autopsies have confirmed such calculations (Conard et al 1980, p. 115). The annual whole-body dose for 1978 was less than .001 rem (Note 11, Table 2); the subsequent 30-year committed effective dose based on spontaneous decay alone whould be .015 rem. The corresponding tissue doses are: red marrow, .079 rem; bone surfaces, .179 rem.

Transuranics. Although only 104 of some 270 determinations have been looked at, it is clear that the results cannot be used as they stand now. A full discussion is presented in Note 12; here we deal briefly with the conclusions.

Plutonium-239 was measured in urine samples, collected in 1981 at Rongelap, using the fission track method (ORAU, 1987). The data appear to be bimodally distributed over a range extending from 1×10^{-5} pCi/d (the practical limit of detection) up to 5×10^{-3} pCi/d. Neither sex nor age appears to play a primary role in determining this result.

The oral intake associated with the maximum urinary output would be 38 pCi/d of plutonium-239, or 76 pCi/d of the three transuranics (plutonium-239,-240; americium-241). It would seem impossible to eat this much; the minimum quantity would be 5.6 kg of clams every day (Table 4.2 #2). The 30-year whole-body dose from 76 pCi/d would be 2.96 rem.

On the other hand, the median excretion of about 1 x 10^{-4} pCi/d would require eating 1.2 pCi/d of all three transuranics. This would be about 3 times the currently estimated oral input used by Livermore, based on the community type B diet, and presumably would be possible. The 30-year whole-body dose would be .045 rem. It is curious and may be of some significance that the median of such an extended distribution should be within a factor of three of the diet method's single estimate.

Summary. In summarizing the Brookhaven results, two estimates have been made to cover the uncertainties surrounding the transuranic determinations, one based on the median, the other based on the range from minimum to maximum.

Source	Brookhaven 30-year (1978-2008)* Adult doses Whole-body** (rem)	Red marrow*** (rem)
Cesium-137:	.560	.560
Strontium-90:	.015	.079
Transuranics		
- median	.045	.068
- range	.005 - 2.96	.008 - 4.33
External dose:	.59	.59
Total:	1.21	1.30
- range	1.17 - 4.13****	1.24 - [5.56]

* Not including inhalation
** Committed effective dose equivalent
*** Committed dose equivalent.
**** The estimate falls below the 5 rem guide for 30 years even when the maximum transuranic estimate is used - one which would appear to be dietetically impossible.

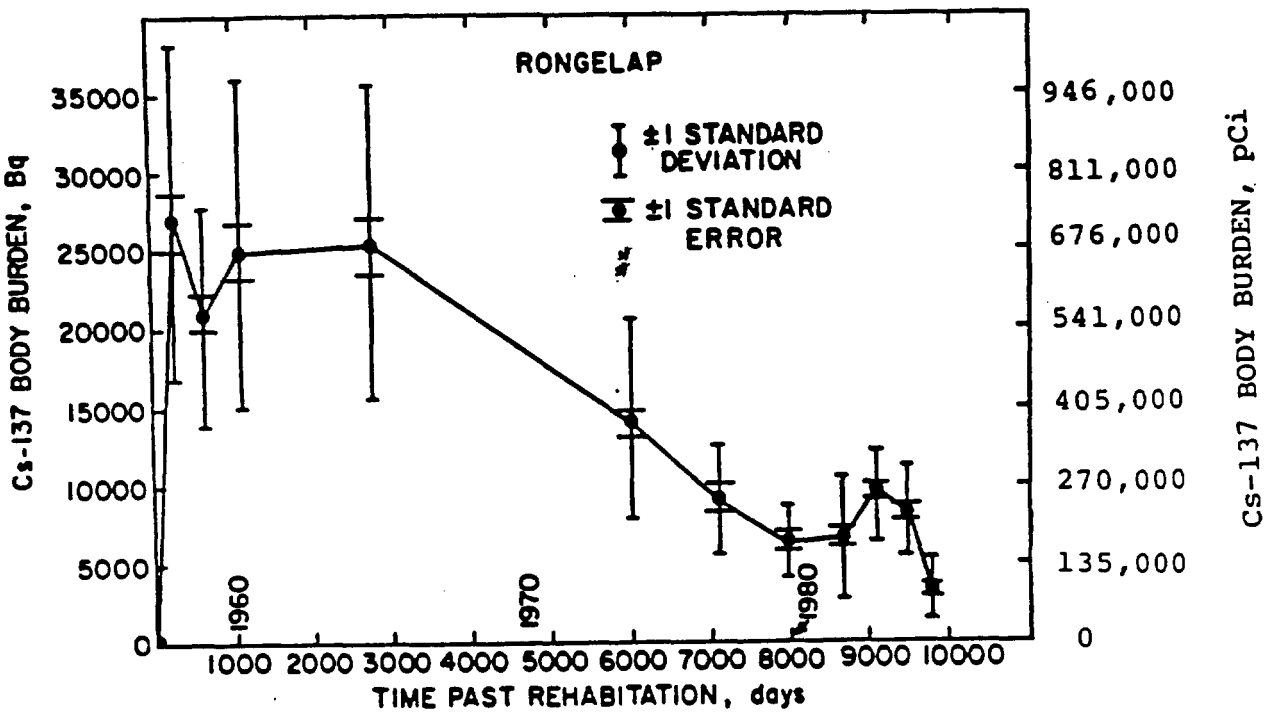

Figure 4.3 #1. Adult cesium-137 body burden as a function of time since resettlement of Rongelap Island in 1957.

The maintenance of the body content depends on the radionuclide intake from the diet. The physical half-life is 30 years; the physiological half-life is 110 days in men, 80 days in women, and less in youths and children. (1 Bequerel = 27 picocuries; 1 nanocurie = 1,000 picocuries) The maintenance of the specific activity of 1 pCi/g in soft tissue for 1 year gives rise to a dose of .01 rem.

(Figure courtesy of E.T. Lessard, Brookhaven National Laboratory.)

4.4 Infant Dosage

The doses that have been under consideration are for adults. In the case of children and infants, the doses might be different owing to variations in (1) physical and physiological processes and (2) dust and diet.

Physical and physiological factors. These variables affect the conversion factors in Tables 4.2 #1A & #1B. For example, the smaller size of children can diminish the fraction of gamma ray energy absorbed in the body; the residence time of the radionuclide in the body may be less than in adults; the fraction absorbed from the gut might be much more. Furthermore, a long-lived radionuclide deposited in the body at age 6 months will be diluted by growth so that its "picocuries per gram of tissue", on which a dose depends, will fall significantly with time.

Table 4.4 #1, based on the United Kingdom NRPB report (1987b), and consistent with the recommendations of the ICRP (International Commission on Radiological Protection), shows that the corrections for children are well on their way to disappearing by age 10 y, but are important in the first year or so of life. The correction for cesium-137 is an increase of not more than 20%, but that for strontium is about 3.6-fold. For the transuranics, it is 2.4-fold for inhalation during the first year, but for ingestion it is 22-fold for months 0-6, and 2.1-fold thereafter in that year.

These factors are for committed doses which in the case of children aged 10 and less are calculated to age 70 years rather than for the standardized period of 50 years in adults. For radionuclides with short physiological half-lives such as cesium-137 (less than 110 days), this is of no consequence. But for the transuranics with half-lives in liver and bone marrow of 20 and 50 years, respectively, the extra residence time adds to the 50-year committed dose.

In general it would be expected that the smaller intake of children and infants will compensate for the increased size of their dose-factors compared to the adult ones in Tables 4.2 #1A & #1B.

Since there are almost no directly pertinent Rongelap data on such inputs, we have approached the problem in two ways. First, we have made some calculations aimed at setting upper bounds. Second, we have attempted to obtain information from the Marshall Islands on infant and small child diets.

Table 4.4 #1

CHILDREN: FACTORS TO CONVERT ANNUAL OR 30-YEAR CONSTANT INTAKE(pCi/d) TO DOSE (rem)

(The factors for adults in Tables 4.2 #1A & #1B are to be multiplied by the relative values in this table)

Nuclide and route		Age at Exposure ≥ 20 yr[a/]	10 yr[b/]	1 yr[b/]	0-6 mo[b/]	30-year exposure[c/]
Cs-137	Ingestion	1	1	1.1	1.1	1.02
	Inhalation	1	1	1.2	1.2	1.03
Sr-90	Ingestion	1	1.4	3.6	3.6	1.54
	Inhalation	1	1.4	3.7	3.7	1.56
PU-239 [d/]	Ingestion	1	1.3	2.1	22.	1.63
	Inhalation	1	1.3	2.4	2.4	1.35

[a/] Adult. The adult dose commitment is for 50 years.

[b/] For children the commitment is until age 70.

[c/] 30 years of constant "adult" intake, beginning at age 0. Since the intake of children in fact is much smaller than of adults, the true value will be much closer to 1.

[d/] Also plutonium-240 and americium-241.

Cesium-137 in mothers' milk. The cesium content of mothers' milk was determined on samples from three Bikini women in 1979, nine months after leaving Bikini where they had been resident for 3-8 years (Miltenberger et al, 1981). The mean body burden of cesium-137 was .13 μCi (.09 - .18); the specific activity of the milk averaged .40 pCi/ml (.26 - .53); the mean specific activity of milk was therefore 3.3×10^{-6} times the body burden.

In 1977 on Rongelap the mean body burden of cesium-137 in women was .251 μCi. Applying the Bikini factor gives .83 pCi/ml for the specific activity of cesium-137 in Rongelap milk. Taking milk consumption to be 2 liters per day, the committed dose generated in months 0 - 12 would be

$$(2{,}000 \times .83) \times (1.1 \times 1.7 \times 10^{-5}) = .030 \text{ rem.}$$

Transuranics. We have no data for the consumption by children of plutonium-239,240 and americium-241 and therefore estimate their dosage as follows:

(a) For ingestion, suppose that infants and children eat as much of the transuranics as do adults. Taking the worst case of no supply ships for the entire year, so that only locally produced foods are consumed, Livermore now estimates an adult intake of 1.8 pCi/d (Ref. Robison).

For intake during the period 0-12 months of age the estimated committed effective dose equivalent would be:

$$(1.8) \times [(2.1 + 22)/2] \times (1.3 \times 10^{-3}) = .028 \text{ rem (1st y, ingestion)}$$

Of this committed dose, not more than .019 rem would in fact be received during the first year.

(b) To this would be added the dose from inhalation (Section 4.2). Taking .024 pCi/d as the adult exposure, which would be a liberal allowance for the infant, the committed whole-body dose would be:

$$(.024) \times (2.4 \times .15) = .009 \text{ rem} \qquad \text{(0-1 year, inhalation)}$$

On this somewhat special basis, the committed effective transuranic doses would be 0.037 rem (1st year). The dose absorbed during the first year presumably would be no more than .025 rem.

Diet. We have also attempted through the assistance of the Peace Corps to find out quantitatively what infants and small children eat. (Such information will be of value to the professional nutritionists in the Marshall Islands as well as to ourselves.) The Corps volunteers, all of whom speak Marshallese, carried out inquiries on their own islands of residence where they are familiar with the local scene and people, and have lived for at least one year. The diets were ascertained by living with a family for one day on two separate occasions and recording what was eaten by the child (Note 13).

At present we have only the returns from 5 islands of 4 atolls, comprising 21 children, 7 months to 4 years of age (but chiefly below 1 year). The principal finding, as might have been expected, is that children are breast fed until well past 6 months of age, in fact often into the [second] year.

A second important finding appears to be that additional foods during the weaning period are often, if not usually, imported. The diet, however, varies greatly from family to family, as well as from day to day (to judge by these two-day samplings).

I have used Table 4.2 #2 and related material in calculating the daily intake of cesium-137, from the individual diet reports. The two reports for each child were averaged, and then an average obtained for the island. In the summary below, the island mean is followed by the range, followed by the number of children, in parentheses.

1.	Ine Island, Arno:	128 pCi/d (0-210; 3)
2.	Buoz Island, Ailinglaplap:	113 pCi/d (0-215; 5)
3.	Kaven Island, Maloelap:	212 pCi/d (58-343; 3)
4.	Woja Island, Ailinglaplap:	405 pCi/d (7-995; 9)
5.	Wotje Island, Wotje:	500 pCi/d (215-785; 2)

The maximum individual daily intake of cesium-137 indicated by these samples was not a constant one, but may be used to estimate what is probably an upper bound for daily consumption. For 1000 pCi/d of cesium-137, the dose would be (1990):

$$(1000) \times (1.1 \times 1.7 \times 10^{-8}) = .019 \text{ rem (committed first year dose)}$$

Scaled to 1978, it would be .025 rem. The strontium-90 dose would be less than 5% of this.

It is not claimed that these results are definitive. Nontheless, I believe that these data do provide at the very least significant orientation to the problem. Accurate data are very hard to obtain, according to the volunteers, and the investment in time -- about 2 days per child -- has been a very large one, indeed. One difficulty encountered was getting the mothers to understand what kind of information was wanted and why. No brief interrogatory visits could obtain reliable data. The study is still going on, and it is hoped that more information will be available by October.

Summary. A maximum type of internal dose estimate for age 0-12 months (1978) can be made by adding the three doses just developed:

Cesium-137 in breast milk (2 liters/d)	.03 rem
Transuranics (intake equal to that of adults):	.04 rem
Peace Corps cesium-137 estimates:*	.025 rem
Total:	.095 rem per year.

The estimate is therefore about .095 rem/year. However, it must be recalled that infants do not drink 2 liters of breast milk per day -- a better average might be 1 liter; the transuranic dose during the first year (not committed dose) would be closer to .025 rem; the daily average of non-milk cesium intake could be materially less than that stated. A maximum total of .05 rem seems more likely at present.

Until we have a more extensive appraisal of what the infant and small child diet is, it would be wise to withhold final judgement. The information in hand, however, does provide specific orientation to the methodology of the problem and the magnitude of the doses involved.

*

4.5 Dose Summary

The dosage problem as developed in this Report breaks down into three parts: the adult dose, the uncertainty introduced into the adult dose by the transuranics; the infant dose.

(a) Adult dose. For the 30-year period 1990-2020, the one of current interest, the following tabulation shows that all three estimates of the adult dose [based on the community type B diet] meet the 5 rem guide.

Rongelap: 30-year Adult Exposure (1990-2020)

Source	Whole-body (rem)	Red marrow (rem)
Livermore data	1.80*	1.88**
Brookhaven data****	.91* (.88 - [3.8])	.98** (.93 - [5.3])
DOE-1982 Report***	1.9	2.9

* Committed effective dose equivalent
** Committed dose equivalent
*** Integral doses
**** The median transuranic dose was employed.

The Brookhaven doses are about half the others; cesium-137 was measured with the whole-body counter, the preferred method for its determination. [The "total dose" is based on the median plutonium dose, the "range" on the lowest and highest individual doses.]

DOE-1982 stated that the diet on which its reported doses were based consisted only of local foods from Rongelap Island [but see footnote, p. 23]. That statement is incorrect. Lawrence Livermore calculated the cited dose on the basis of the community type B diet, and that diet (for comparability) has been used for the calculation of all doses above.

The cancer mortality risk for 500 persons settled on Rongelap Island and receiving 1.9 rem over the next 30 years would be:

$$500 \times 1.9 \times 2.5 \times 10^{-4} = .24 \text{ cases}$$

The risk factor used here is 2.5 times that advocated in the National Academy of Science (1972) report. It is lower than what is being used for the Japanese survivors (Shimuzu et al 1987; Preston & Pierce 1987), but they experienced high-dose and high-dose-rate exposure whereas the Rongelap exposure would be low and at an extremely low dose-rate.

The risk factor for first generation genetic defects is smaller than that for cancer mortality (National Academy of Sciences, 1972; NCRP, 1987a), being approximately 1×10^{-4}. Furthermore, since no genetic effects have been recorded as yet for the Japanese (Radiation Effects Research Foundation, 1987), it is unlikely that any would be found here.

(b) Transuranics. The Brookhaven dose estimates [are not only different from those of Lawrence Livermore, but] vary significantly, reflecting transuranic data which may vary by a factor of 1,000. Could this be "real"? Probably not. To supply the transuranic oral input necessary to maintain the maximum urinary output recorded, it would be necessary to eat 5 kg of clams every day -- or even larger amounts of other foods.

Obviously, something is radically wrong, technically or physiologically. Contamination is one possibility (urine collection in the Marshalls is difficult). Or conceivably, an inborn error of metabolism allows certain individuals in the general population to absorb 100 times as much from the gut as that which the ICRP recognizes as normal.

It is therefore essential, as emphasized in the Preliminary Report, that the problem be studied immediately. As a start, additional urines should be collected repeatedly from the same individuals under rigorously controlled conditions to determine the reproducibility of results, and which simple changes in life style might affect them.

(c) Infant dose. The question of infant and childhood dosage has been raised, and is a sensitive issue. The maximum internal dose for months 0-12 appears to be 0.1 rem. More information should become available by October. According to the ICRP tables, the dose per unit intake is 2 - 3 times higher for small children than for adults, but children eat less so that the two factors tend to cancel one another out. In any case, the observations thus far should not give rise to alarm, but they must be followed up.

(d) The foregoing comments apply to the future. But what about the influence of the past? The Rongelap residents exposed to the Bravo shot received an acute dose of 190 rem in 1954; during 1957-1978 they received a chronic dose of 3 rem. My opinion is that the addition to these past doses of something like 3 rem during the next 30 years will not appreciably increase detectable health and genetic risks in a way that should preclude return to Rongelap Island.

5. DISCUSSION AND RECOMMENDATIONS

5.1 Comment

Section 4.5 summarizes the basic results of this report. They must be viewed from two angles.

First, from a technical point of view, they provide a reasonable basis for assessing the Rongelap dosage problem. It seems clear that under the ordinary conditions of Rongelap life, there is no significant radiation danger associated with residence on Rongelap Island for adults. The implicit assumption in this statement is that the diet will be equivalent to that of the past. To what extent that will be true after resettlement can only be learned by monitoring the inhabitants with whole-body counting equipment, as done by Brookhaven, supplemented as necessary by urine analysis. Any other method such as that used by the Livermore groups must assume a diet in order to calculate the dose.

In the case of infants during the first six months, while they are breast-fed, it will be the mother's diet that ultimately determines the dose. However, knowing the mother's body burden by whole-body counting will make possible a prediction of her milk's specific activity. Or direct measurements can be made on the milk itself. Presumably, a "safe" mother should be associated with a "safe" baby.

On general grounds one can estimate the dosage to infants and children. Whole-body counting can be done only if the child will be quiet. My interest in enlisting the help of Peace Corps Volunteers (who speak Marshallese) was to see if the data obtained within the home would make it obvious that the children were receiving obviously excessive exposure. The result has been negative, at least thus far.

These negative findings with respect to radiation hazards are unpopular ones, at least for some of the Marshallese (and their advisors), and understandably so. Their history of irradiation without warning, and the subsequent development of thyroid disease (although originally told nothing would happen) initiated a distrust of the Federal Government which has never left them, and feelings of uncertainty as to the nature of their environment.

The second point of view is therefore that of the Rongelap person who does not have a grasp of technical matters, but who for one reason or another distrusts the establishment with which he or his representatives must deal. This situation is often if not always complicated by the fact that the concept of "objective" judgement is a foreign one. The judge is either for them or against them, but he cannot give a divided opinion.

During the course of this work, I have had criticism from Senator Anjain and from two of the consultants who regard themselves as working for him. It would be fruitless to answer their comments one by one (two letters from them were attached to the Preliminary Report). Here I attach a letter from Senator Anjain of June 25, 1988, in order to present his views and reactions to this project (Note 15). The letter is best judged by comparing it to the contents of this Report.

5.2 Recommendations

However the program is set up, I recommend that it cover the following items.

(1) Reinstitute whole-body counting for cesium-137 now to establish a base line of comparison to be used when the people return to Rongelap. We know, of course, that their counts have not been excessive.

(2) Study the plutonium excretion in urine now [before return]* as a research project to determine the reproducibility of the fission track method and how environmental factors might influence the results, [and especially why the Brookhaven results differ so much from those obtained by Lawrence Livermore].

(3) Extend the study [before return]* of infant diets and those of small children. This will be much more time consuming than foreign consultants might suppose.

(4) Develop a plan to control contamination to the extent necessary to make the Rongelap people feel comfortable with their Atoll. Two methods developed at Bikini Atoll might be adapted for use here -- soil removal or soil treatment with potassium salt. The plan would be a graded one in which the northern islands would receive more treatment than Rongelap itself, which would receive little, if any.

(5) The prelude to such planning would include some contamination surveys on the important islands where food is produced.

(6) For the present, at least, I recommend no food gathering on islands north of Borukka and Eniaetok.

(7) The fact that Rongelap [Island]* appears suitable for resettlement now should not be lost sight of. The Rongelap people should ask themselves what further evidence do they want, or what steps taken, to make them feel comfortable about this. Will they ever feel comfortable about it? [It is essential that they be satisfied before they return.]*

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*Bracketed material added to this edition is for clarification.

REFERENCES

Adams, W.H., J.A. Harper, R.S. Rittmaster, P.M. Heotis, W.A. Scott. (1982). Medical status of Marshallese accidentally exposed to 1954 Bravo fallout radiation: January 1980 through December 1982. BNL 51761 (Biology & Medicine-TIC 4500) (Available from National Technical Information Service.)

Adams, W.H. (1985) Letter Report to U. S. Department of Energy.

Adams, W.H. (1987) Personal communication to H. I. Kohn.

Adams, W.H., J.R. Engle, J.A. Harper, R.S. Rittmaster, P.M. Heotis, W.A. Scott (1984). Medical status of Marshallese accidentally exposed to 1954 Bravo fallout radiation: January 1983 through December 1984. BNL 51958, Medical Dept., Brookhaven National Laboratory, Upton, NY 11973

Bikini Atoll Rehabilitation Committee, (1987). Report No. 5, Status March 31, 1987. 1203 Shattuck Ave., Berkeley CA 94709

Bond, V.P. et al. (1978). Surveillance of facilities and sites, dose reassessment for populations on Rongelap and Utirik following exposure to fallout. DOE Contract # EY-76-C-02-0016, 189# 6K-121

Christy, M., R.W. Leggett, E.E. Dunning, K.F. Eckerman (1984). Age dependent dose conversion factors for selected bone-seeking radionuclides. ORNL/TM, 8929. Oak Ridge National Laboratory, Oak Ridge TN 37830

Conard, R.A., L.M. Meyer, J.E. Rall, A. Lowery, S.A. Bach, B. Cannon, E.I. Carter, M. Eicher, H. Hechter (1958). March 1957 medical survey of Rongelap and Utirik people three years after exposure to radioactive fallout. BNL 501. Brookhaven National Laboratory, Upton, NY 11973

Conard, R.A., L.M. Meyer, W.W. Sutow, A. Lowrey, B. Cannon, W.C. Moloney A.C. Watne, R. E. Carter, A. Hicking, R. Hammerstrom, B. Bender, I. Lanwi, E. Riklon, J. Anjain. Medical survey of the people of Rongelap and Utirik Islands nine and ten years after exposure to fallout radiation (Mar. 1963 and Mar. 1964). BNL 908 (T-371) Medical Division, Brookhaven National Laboratory, Upton NY 11973

Conard, R.A., K.D. Knudsen, B.M. Cobysn, et al (1975). A twenty-year review of medical findings in a Marshallese population accidentally exposed to radioactive fallout. BNL 50424, Brookhaven National Laboratory, Upton NY 11973

Conard, R.A. et al (1980). Review of medical findings in a Marshallese population twenty-six years after accidental exposure to radioactive fallout. BNL 51261 (Biology & Medical TID-4500) Medical Dept., Brookhaven National Laboratory, Upton, NY 11973

Cronkite, E.P., V.P. Bond, C.L. Dunham, editors (1956). Ionizing radiation: a report on the Marshallese and Americans accidentally exposed to radiation from fallout and a discussion of radiation injury in the human being. U.S. Atomic Energy Commission, Washington, D. C. TID-5358 (Superintendent of Documents, Washington, D.C.)

Dunning, G.M. (editor) (1957). Radioactive contamination of certain areas in the Pacific Ocean from nuclear tests. U. S. Atomic Energy Commission. (Superintendent of Documents, Washington, D.C.)

Eisenbud, M. (1987). Personal communication to Henry I. Kohn for inclusion in the Rongelap Reassessment Report, dated Dec. 13, 1987. M. Eisenbud, 711 Bayberry Drive, Chapel Hill, N.C. 27514.

Federal Radiation Council (1960). Background material for the development of radiation protection standards. Report No. 1. May 13, 1960. Washington, D.C.

Federal Radiation Council (1960). Radiation protection guidance for Federal agencies. Federal Register, May 18, 1960, pp. 4102-4103.

Federal Radiation Council (1965). Radiation protection guidance for Federal agencies. Federal Register, May 22, 1965, pp. 6953-6956.

Federal Register (1987). Radiation protection guidance to federal agencies for occupational exposure. Federal Register 52:2822.

Greenhouse, N.A., R. P. Miltenberger (1977). External radiation survey and dose predictions for Rongelap, Utirik, Rongerik, Ailuk, and Wotje Atolls. BNL 50797. Brookhaven National Laboratory, Upton, NY 11973

Hoenes, G.R., J.K. Soldat (1977). Age specific radiation dose commitment factors for 1-year chronic intake. Nuclear Regulatory Commission - 0172. Office of Standards Development, USNRC, Washington, D.C.

ICRP (1979). International Commission on Radiological Protection. Limits for intakes of radionuclides by workers. ICRP Publication 30, Part 1. Also Supplement to Part 1. Pergamon Press, NY

ICRP (1984). Principles for limiting exposure of the public to natural sources of radiation. ICRP Publication 39. Pergamon Press, NY

ICRP (1985). Quantitative bases for developing a unified index of harm. ICRP Publication 45. Pergamon Press, NY

ICRP (1986). The metabolism of plutonium and related elements. ICRP Publication 48. Pergamon Press, NY

ICRP (1987). Data for use in protection against external radiation. ICRP Publication 51. Pergamon Press, NY

[ICRU (1979) Publication 31]

James, R.A. (1964). Estimate of radiation dose to the thyroids of the Rongelap children following the Bravo event. UCRL 12273. Lawrence Livermore National Laboratory, Livermore CA 94550

Kato, H., W.J. Schull, A. Awa, M. Akiyama, M. Otake. (1987). Dose response analyses among atomic bomb survivors exposed to low-level radiation. Health Physics 52: 645-52

Kerr, G.D. (1980) A review of organ doses from isotropic fields of gamma rays. Health Physics 39, pp. 3-20.

Lessard, E.T. (1988) Personal communication to Henry I. Kohn.

Lessard, E.T. (1984a) Letter Report to Roger Ray, DOE Operations Office, P.O. Box 14100, Las Vegas, NV 89114

Lessard, E.T., R.P. Miltenberger, S.H. Cohn, S.V. Musolino, R.A. Conard (1984c). Protracted exposure to fallout: the Rongelap and Utirik experience. Health Physics 46, 511-547

Lessard, E.T., A.B. Brill, W.H. Adams (1985). Thyroid cancer in the Marshallese: Relative risk of radioiodine and external radiation exposure. BNL 37232. Medical Dept., Brookhaven National Laboratory, Upton NY 11973

Lessard, E.T., R. Miltenberger, R. Conard, S. Musolino, J. Naidu, A. Moorthy, C. Schopfer (1985). Thyroid absorbed dose for people at Rongelap, Utirik, and Sifo on March 1, 1954. BNL 51882. Brookhaven National Laboratory, Upton, NY 11973

Lessard, E.T, X. Yihua, K.W. Skrable, G.E. Chabot, C.S. French, T.R. Labone, J.R. Johnson, D.R. Fisher, R. Belanger, J.L. Lipsztein. (1987). Interpretation of bioassay measurements. NUREG/CR-4884; BNL-NUREG-52063. Safety and Environmental Protection Division, Brookhaven National Laboratory, Upton, NY 11973

Miltenberger, R.P., N.A. Greenhouse, E.T. Lessard (1980). Whole body counting results from 1974 to 1979 for Bikini Island residents. Health Physics 39: 395-407.

Miltenberger, R.P., E.T. Lessard, J. Steimers, N.A. Greenhouse (1981) ^{137}Cs in human milk and dose equivalent assessment. Personal communication of unpublished report. Brookhaven National Laboratory, Upton, NY 11973

Moss, W.D., G.L. Tietjen (1988). Twenty-sixth Hanford Life Sciences Symposium, (October 1987): Reassessment of human and beagle dog plutonium excretion data in: Modelling for scaling to man. (J.A. Mahaffey and J.A. McWhinney, co-chairmen). To be published as a special issue of the Journal of Health Physics. [The factors used were obtained from Dr. Lessard; see p. 78.]

Naidu, J.R., N.A. Greenhouse, G. Knight, E.C. Craighead. (1980). Marshall Islands: A study of diet and living patterns. BNL 51313. Safety and Environmental Protection Division, Brookhaven National Laboratory, Upton. NY 11973

National Academy of Sciences (1972). The effects on populations of exposure to low levels of ionizing radiation. Report of the Advisory Committee on the Biological Effects of Ionizing Radiations, Division of Medical Sciences, National Academy of Sciences, Washington D.C. 20006

National Academy of Sciences (1980). The effects on populations of exposure to low levels of ionizing radiation. Report of the Advisory Committee on the Biological Effects of Ionizing Radiations, Division of Medical Sciences, National Academy of Sciences, Washington D.C. 20006

NCRP (1957). National Council on Radiation Protection and Measurements Permissible dose from external sources of ionizing radiations. Insert to National Bureau of Standards Handbook 59, National Council of Radiation Protection and Measurements. 7910 Woodmont Av., Bethesda, MD 20814

NCRP (1987a) Genetic effects from internally deposited radionuclides. NCRP Report No. 89. National Council of Radiation Protection and Measurements. 7910 Woodmont Av., Bethesda MD 20814

NCRP (1987b) Recommendations on limits for exposure to ionizing radiation, NCRP Report No. 91. June 1, 1987. National Council on Radiation Protection and Measurements. 7910 Woodmont Av., Bethesda, MD 20814

NCRP (1987c) Ionizing radiation exposure of the population of the United States. NCRP Report No. 93, National Council on Radiation Protection and Measurements, 7910 Woodmont Av., Bethesda MD 20814

National Radiological Protection Board (1987A). Interim guidance on the implications of recent revisions of risk estimates and the ICRP 1987 Como statement. NRPB-GS9. Chilton, Didcot, Oxon OX11 ORQ, United Kingdom

National Radiological Protection Board (1987B). Committed doses to selected organs and committed effective doses from intakes of radionuclides. NRPB-GS7. Chilton, Didcot, Oxon OX11, ORQ, United Kingdom. August 1987

Noshkin, V.E., R.J. Eagle, K.M. Wong, T.A. Jokela, W.L. Robison (1981). Radionuclide concentrations and dose assessment of cistern water and groundwater at the Marshall Islands. UCRL-52853, Part 2. Lawrence Livermore National Laboratories, Livermore, CA 94550

Oak Ridge Associated Universities (ORAU) (1987). Current Status of bioassay procedures to detect and quantify previous exposures to radioactive materials. Report to the National Cancer Institute. Medical & Health Sciences Division, ORAU, Oak Ridge, Tenn. 37831

Preston, D.L., D.A. Pierce (1987). The effect of changes in dosimetry on cancer mortality risk estimates in the atomic bomb survivors. Radiation Effects Research Foundation Technical Report RERF TR 9-87.

Radiation Effects Research Foundation (1988). Annual Report for 1986-87. Hiroshima-Nagasaki, Japan

Robison, W.L. (1983) National Academy of Sciences conference.

Robison, W.L. (1988) Personal communication to H. I. Kohn. These data should be published by LLNL in 1988.

Robison, W.L., V.E. Noshkin, W.A. Phillips, R.J. Eagle (1980). The Northern Marshall Islands radiological survey: radionuclide concentrations in fish and clams and estimated doses via the marine pathway. UCRL-52853, Part 3. Lawrence Livermore National Laboratory, Livermore CA 94550

Robison, W.L., C.L. Conrado, R.J. Eagle, M.L. Stuart (1981). The Northern Marshall Islands radiological survey: Sampling and analysis summary. UCRL 52853, Part 1. Lawrence Livermore National Laboratory, Livermore CA 94550

Robison, W.L., M.E. Mount, W. A. Phillips, M.L. Stuart, S.E. Thompson, C.L. Conrado, A.C. Stoker (1982a). An updated radiological dose assessment of Bikini and Eneu Islands at Bikini Atoll. UCRL 53225, Lawrence Livermore National Laboratory, Livermore CA 94550

Robison, W.L., M.E. Mount, W.A. Phillips, C.A. Conrado, M.L. Stuart, C.E. Stoiker (1982b). The northern Marshall Islands radiological survey: terrestrial food chain and total doses. UCRL 52853, Part 4. Lawrence Livermore National Laboratory, Livermore CA 94550

Sharp, R., W.H. Chapman (1957). Exposure of Marshall Islanders and American military personnel to fallout. Operation Castle-Project 4.1 addendum. Armed Forces Special Weapons Project. Sandia Base, Albuquerque, NM. Document WT-938

Shimizu, Y., H. Kato, W.J. Schull, S.L. Preston, S. Fujita, D.Pierce (1987). Life Span study report 11, Part 1. Comparison of risk coefficients for site-specific cancer mortality based on the DS86 and T65DR shielded kerma and organ doses. Radiation Effects Research Foundation RERF TR 12087

Shingleton, K.L., J. L. Cate, M.G. Trent, W.L. Robison (1987). Bikini Atoll ionizing radiation survey, May 1985-May 1986. UCRL-53798. Lawrence Livermore National Laboratory, Livermore CA 94550

Shinn, J.E.,D.N. Homan, Robison,W.L. (1980). Resuspension studies at Bikini Atoll. UCID-18538, Lawrence Livermore National Laboratory, Livermore CA 94550

Tipton,W.J., R.A. Meibaum (1981). An aerial radiological and photographic survey of eleven atolls and two islands within the northern Marshall Islands. EG&G Energy Measurements Group, Document EFF-1183-1758 (Available from the National Technical Information Service, Springfield VA 22161.)

United Nations Scientific Committee on the Effects of Atomic Radiations (1982). [UNSCEAR] Report to the General Assembly with annexes. Annex A P 124 and P 127. (Also see Table 7)

UNSCEAR, (1977).

UNSCEAR, (1988).

U. S. Congress. Compact of Free Association Act of 1985, U.S. Public Law 99-239, Section 103(i)

U. S. Department of Energy. (1982). The meaning of radiation for those atolls in the Northern Part of the Marshall Islands that were surveyed in 1978. Washington, D.C.

N.1

The following is quoted from "The Meaning of Radiation for Those Atolls in the Northern Part of the Marshall Islands That Were Surveyed in 1978", U. S. Department of Energy, Washington, D.C., November 1982, page 39:

Information That Has Been Obtained from the Measurements Made in 1978

If 233 people live on Rongelap Island and eat local food only from Rongelap Island

Scientists estimate that the largest amount of radiation a person might receive in one year from radioactive atoms that came from the U S bomb tests is 400 millirem But usually the largest amount a person might receive would be less than this This amount of radiation decreases every year however it decreases very slowly

The highest average amount of radiation people might receive in the coming 30 years is 2500 millirem in any part of the body and 3300 millirem in just the bone marrow

In the coming 30 years scientists estimate that 10 people may die from cancers caused by things other than radiation from the atomic bomb tests In addition to this from 0 1 to 0 6 people may die in the future from cancers caused by radiation received in the coming 30 years from the atomic bomb tests

In the coming 30 years scientists estimate that 60 children could be born with health defects caused by things other than radiation from the atomic bomb tests In addition to this 0 007 to 0 1 children may eventually be born with health defects caused by radiation their parents receive in the coming 30 years from the atomic bomb tests

If people live on Eneaetok and not on Rongelap Island and eat local food only from Eneaetok the amount of radiation they receive would be about the same

If people go to Naen from Rongelap Island and eat food from Naen they might receive about five times more radiation while they are there

If people go to Namen or Melu from Rongelap Island and eat food from those two islands they could receive about two times more radiation while they are there

department or agency of the United States or by contract with a United States firm) shall continue to provide special medical care and logistical support thereto for the remaining 174 members of the population of Rongelap and Utrik who were exposed to radiation resulting from the 1954 United States thermonuclear "Bravo" test, pursuant to Public Laws 95-134 and 96-205. Such medical care and its accompanying logistical support shall total $22,500,000 over the first 11 years of the Compact.

91 Stat. 1159.
94 Stat. 84.

(2) AGRICULTURAL AND FOOD PROGRAMS.—Notwithstanding any other provision of law, upon the request of the Government of the Marshall Islands, for the first five years after the effective date of the Compact, the President (either through an appropriate department or agency of the United States or by contract with a United States firm) shall provide technical and other assistance—

President of U.S.

(A) without reimbursement, to continue the planting and agricultural maintenance program on Enewetak;

(B) without reimbursement, to continue the food programs of the Bikini and Enewetak people described in section 1(d) of Article II of the Subsidiary Agreement for the Implementation of Section 177 of the Compact and for continued waterborne transportation of agricultural products to Enewetak including operations and maintenance of the vessel used for such purposes.

Post, p. 1812.

(3) PAYMENTS.—Payments under this subsection shall be provided to such extent or in such amounts as are necessary for services and other assistance provided pursuant to this subsection. It is the sense of Congress that after the periods of time specified in paragraphs (1) and (2) of this subsection, consideration will be given to such additional funding for these programs as may be necessary.

(i) RONGELAP.—(1) Because Rongelap was directly affected by fallout from a 1954 United States thermonuclear test and because the Rongelap people remain unconvinced that it is safe to continue to live on Rongelap Island, it is the intent of Congress to take such steps (if any) as may be necessary to overcome the effects of such fallout on the habitability of Rongelap Island, and to restore Rongelap Island, if necessary, so that it can be safely inhabited. Accordingly, it is the expectation of the Congress that the Government of the Marshall Islands shall use such portion of the funds specified in Article II, section 1(e) of the subsidiary agreement for the implementation of section 177 of the Compact as are necessary for the purpose of contracting with a qualified scientist or group of scientists to review the data collected by the Department of Energy relating to radiation levels and other conditions on Rongelap Island resulting from the thermonuclear test. It is the expectation of the Congress that the Government of the Marshall Islands, after consultation with the people of Rongelap, shall select the party to review such data, and shall contract for such review and for submission of a report to the President of the United States and the Congress as to the results thereof.

Hazardous materials.
Contracts.

Post, p. 1812.

Report.

(2) The purpose of the review referred to in paragraph (1) of this subsection shall be to establish whether the data cited in support of the conclusions as to the habitability of Rongelap Island, as set forth in the Department of Energy report entitled: "The Meaning of Radiation for Those Atolls in the Northern Part of the Marshall Islands That Were Surveyed in 1978", dated November 1982, are

Report.

adequate and whether such conclusions are fully supported by the data. If the party reviewing the data concludes that such conclusions as to habitability are fully supported by adequate data, the report to the President of the United States and the Congress shall so state. If the party reviewing the data concludes that the data are inadequate to support such conclusions as to habitability or that such conclusions as to habitability are not fully supported by the data, the Government of the Marshall Islands shall contract with an appropriate scientist or group of scientists to undertake a complete survey of radiation and other effects of the nuclear testing program relating to the habitability of Rongelap Island. Such sums as are necessary for such survey and report concerning the results thereof and as to steps needed to restore the habitability of Rongelap Island are authorized to be made available to the Government of the Marshall Islands.

(3) It is the intent of Congress that such steps (if any) as are necessary to restore the habitability of Rongelap Island and return the Rongelap people to their homeland will be taken by the United States in consultation with the Government of the Marshall Islands and, in accordance with its authority under the Constitution of the Marshall Islands, the Rongelap local government council.

Hazardous materials.

(j) FOUR ATOLL HEALTH CARE PROGRAM.—(1) Services provided by the United States Public Health Service or any other United States agency pursuant to section 1(a) of Article II of the Agreement for the Implementation of Section 177 of the Compact (hereafter in this subsection referred to as the "Section 177 Agreement") shall be only for services to the people of the Atolls of Bikini, Enewetak, Rongelap, and Utrik who were affected by the consequences of the United States nuclear testing program, pursuant to the program described in Public Law 95-134 and Public Law 96-205 and their descendants (and any other persons identified as having been so affected if such identification occurs in the manner described in such public laws). Nothing in this subsection shall be construed as prejudicial to the views or policies of the Government of the Marshall Islands as to the persons affected by the consequences of the United States nuclear testing program.

Ante, p. 1781.

91 Stat. 1159.
94 Stat. 84.

(2) At the end of the first year after the effective date of the Compact and at the end of each year thereafter, the providing agency or agencies shall return to the Government of the Marshall Islands any unexpended funds to be returned to the Fund Manager (as described in Article I of the Section 177 Agreement) to be covered into the Fund to be available for future use.

(3) The Fund Manager shall retain the funds returned by the Government of the Marshall Islands pursuant to paragraph (2) of this subsection, shall invest and manage such funds, and at the end of 15 years after the effective date of the Compact, shall make from the total amount so retained and the proceeds thereof annual disbursements sufficient to continue to make payments for the provision of health services as specified in paragraph (1) of this subsection to such extent as may be provided in contracts between the Government of the Marshall Islands and appropriate United States providers of such health services.

Hazardous materials.

(k) ENJEBI COMMUNITY TRUST FUND.—Notwithstanding any other provision of law, the Secretary of the Treasury shall establish on the books of the Treasury of the United States a fund having the status specified in Article V of the subsidiary agreement for the implementation of Section 177 of the Compact, to be known as the

Post, p. 1812.

N-3 The following comments relate to the timing of the evacuation of the Rongelap people.

(a) According to C. L. Dunham, Director of the AEC Division of Biology and Medicine, (Cronkite et al, 1956), "unexpected changes in the wind structure deposited radioactive materials on inhabited atolls and on ships of Joint Task Force 7, which was conducting the tests. Radiation surveys of the areas revealed radiation levels above permissible levels: therefore evacuation was ordered, and was carried out as quickly as possible with the facilities available to the Joint Task Force".

(b) According to Merril Eisenbud (personal communication, see references) a scientific member of the Task Force, "There are many unanswered questions about the circumstances of the 1954 fallout. It is strange that no formal investigation was ever conducted. There have been reports that the device was exploded despite an adverse meterological forecast. It has not been explained why an evacuation capability was not standing by, as had been recommended, or why there was not immediate action to evaluate the matter when the Task Force learned (seven hours after the explosion) that the AEC Health & Safety Laboratory recording instrument on Rongerik was off scale. There was also an unexplained interval of many days before the fallout was announced to the public".

(c) Since the Rongelapese had been evacuated prior to previous tests, it is not clear why the usual procedure was changed. In February 1954, Dr. Bertell has told me, Magistrate John Anjain of Rongelap was told about the Bravo test, but was not given the date. He said that "there are no orders from Washington to evacuate the people".

(d) Rongelap was evacuated on March 3, 1954, approximately 50-55 hours after the shot.

N-4

This note deals with the mission of the medical program at Rongelap (letter from W.H. Adams, M.D.), some medical findings at the time of the relocation of the Rongelap people in 1985 (letter from Dr. Adams to Mr. Roger Ray), and a detailed summary of the thyroid dosage from exposure to fallout in 1954.

NOTE 4: INTRODUCTION - THE MISSION OF THE MEDICAL PROGRAM.

BROOKHAVEN NATIONAL LABORATORY
ASSOCIATED UNIVERSITIES, INC.
Upton, Long Island, New York 11973

Medical Department

(516) 282-
FTS 666-

April 28, 1988

Henry Kohn, M.D.
Rongelap Reassessment Project
1203 Shattuck Ave.
Berkeley, California 94709

Dear Dr. Kohn,

Let me state briefly what the Brookhaven National Laboratory Marshall Islands Medical Program is and what it is not.

The medical program is mandated by Congress under Public Law 95-134 to provide for diagnosis and treatment of radiation-related disease among the populations of Rongelap and Utirik exposed to Bravo fallout radiation in 1954. The U.S. Department of Energy fulfills this mandate by contracting with the medical department, Brookhaven National Laboratory, to provide said care. The Department of Energy has permitted, by providing the necessary operating funds, an extension of the program to cover many aspects of health care unrelated to radiation exposure and to offer medical services to a great number of unexposed persons. No funds are made available for research because Congress did not intend the medical program to carry out research; clinical care of the injured parties is the program's sole purpose. Therefore, all activities of the medical program have a clinical goal, that being improvement of the health of the population identified in PL 95-134. The ability to disseminate the capabilities of the medical program among the general Marshallese population represents the natural tendency of any health care organization. It is to the great credit of U.S. Department of Energy personnel responsible for carrying out the Congressional mandate that this expansion of coverage has been warmly supported.

Sincerely yours,

W.H. Adams

William H. Adams, M.D.
Director, Marshall Islands
Medical Program

5000662

N-4A

The following letter is from Dr. W. H. Adams of Brookhaven National National Laboratory to Dr. Roger Ray of DOE.

2108

July 18, 1985

Mr. Roger Ray
Deputy for Pacific Operations
Nevada Operations Office
Department of Energy
P.O. Box 14100
Las Vegas, NV 89114

Dear Roger:

In view of the recent evacuation of Rongelap, which appears to have been precipitated by concern about harmful residual radioactivity on the atoll, we have reviewed our medical records to see if there is any clinical evidence that supports this conclusion and course of action.

Since 1957 an unexposed population of Marshallese of Rongelap ancestry has been examined periodically by the Brookhaven medical team. This population (the Comparison group) is similar in age and sex distribution to the exposed people of Rongelap. The reason for examination of the unexposed group has been to obtain baseline incidences of diseases in the general Marshallese population as an aid in detection of previously unidentified radiation hazards which might affect the exposed group.

Collected data on the unexposed people are sufficient to assess the effect of residence on Rongelap (since 1957) on longevity, thyroid neoplasia, and blood counts. We have done a retrospective analysis of their medical records; 133 of the group are living and 54 are deceased. We have arbitrarily selected for analysis the following divisions of years of residence on Rongelap:

Short-term	-	<3 years (average, 1.0 years)
Intermediate	-	4 - 14 years (average, 7.5 years)
Long-term	-	>15 years (average, 20.9 years)

The place of residence for a given year is defined as the place where an individual received his medical examination. Since there is considerable migration of Marshallese among the atolls, the site of examination may not always be the same as the site of residence. Overall, however, there should be a good correlation between the two.

Effects on Longevity

There is no evidence that prolonged residence on Rongelap since 1957 has resulted in a shortening of life expectancy:

Residence Category	Number of Deaths	Mean age at Death
Short-term	20	61.4 years
Intermediate	27	66.6 years
Long-term	5 *	70.0 years
Total	52*	Average 64.9 years

* Does not include 2 accidental deaths.

Effects on Thyroid Neoplasia

There is no evidence that prolonged residence on Rongelap since 1957 has resulted in an increase in thyroid neoplasia. Nine unexposed persons in the Comparison group have had surgery for thyroid nodules:

Residence Category	Number of Persons	Mean Age in 1985 (yr)	Number with Thyroid Nodules Removed	Number of Thyroid Cancers
Short-term	58	47.1	4 (7%)	1
Intermediate	46	46.4	3 (7%)	0
Long-term	29	46.9	2 (7%)	1
Total	133		9	2

These figures apply to the 133 unexposed persons in the Comparison group who are living. All of the 9 persons who had thyroid nodules removed are still alive.

Effects on Blood Counts (1985 data)

There is no detectable effect of residence on Rongelap on blood counts:

Residence Category	Number Tested	Neutrophils/ul ±SD	Lymphocytes/ul ±SD	Platelets/ulx10^3 ±SD
Short-term	24	4851±2089	2754±1006	279±111
Intermediate	40	3838± 992	2835± 908	292± 59
Long-term	26	4366±1551	2612± 787	262± 51

A test of equality of means showed no statistically significant differences among the three categories. Note that the number of blood tests performed (90) is less than the number of persons in the Comparison group. This is because not all were seen in the March-April, 1985, survey.

We have also considered thyroid nodules and current blood cell counts as they may relate to early residence on Rongelap, since a greater radiation risk would have existed during the early years after the 1954 fallout. Thirty-four persons in the Comparison group resided in Rongelap for 4-6 years commencing with the return to the atoll in 1957. Only 1 nodule, an "occult carcinoma",, has occurred in this subgroup (3.0%), whereas the other 8 nodules, including the two true thyroid carcinomas, occurred in the other 99 persons in the Comparison group (8.1%). There was also no difference in blood cell counts:

Time of Residence	Number Tested (1985)	Neutrophils/ul ±SD	Lymphocytes/ul ±SD	Platelets/ulx10^3 ±SD
Early	29	4032±1543	2713±836	267±57
Late	77	4349±1599	2756±951	284±80

If you wish us to examine any other parameters do not hesitate to ask.

Sincerely yours,

William H. Adams, M.D.

WHA/elr

TABLE N.4B #1 THYROID DOSE FROM INDIVIDUAL RADIONUCLIDES IN FALLOUT TO THE ADULT MALE [a,b]

Source	Half-life	Per cent physical decay in 3 weeks	Dose rads
Internal exposure			
Iodine-135	6.6 h	100%	190 rad
Iodine-134	53.2 min	100%	3
Iodine-133	21 h	100%	550
Iodine-132	2.3 h	100%	7
Iodine-131	8.04 d	84%	130
Tellurium-131	30 h + 8.04 d	79%	120
Tellurium-131m	25 min + 8.04 d	84%	13
External exposure			190
Total dose			1203

[a/] Lessard et al, (1985)

[b/] Exposure to the fallout on Rongelap Island occurred for about 45 hours. The fallout fell for about 7 hours.

TABLE N-4 B #2 Total Thyroid Absorbed-Dose Estimate (1954)

Age	Rongelap Island			Sifo Island			Utirik Island		
	Internal	External	Total	Internal	External	Total	Internal	External	Total
Average Estimate, rad[a]									
Adult Male	1000	190	1200	280	110	400	150	11	160
Adult Female	1100	190	1300	290	110	410	160	11	170
Fourteen-Year-Old	1400	190	1600	410	110	530	220	11	230
Twelve-Year-Old	1600	190	1800	450	110	570	240	11	250
Nine-Year-Old	2000	190	2200	540	110	660	300	11	310
Six-Year-Old	2400	190	2600	640	110	760	340	11	350
One-Year-Old	5000	190	5200	1300	110	1400	670	11	680
Newborn	250	190	440	-	-	-	48	11	59
In Utero, 3rd tri.	680	190	870	-	-	-	98	11	110
In Utero, 2nd tri.	-	-	-	490	110	610	260	11	270
Maximum Estimate, rad									
Adult Male	4000	190	4200	1120	110	1200	600	11	610
Adult Female	4400	190	4600	1160	110	1300	640	11	650
Fourteen-Year-Old	5600	190	5800	1600	110	1700	880	11	890
Twelve-Year-Old	6400	190	6600	1800	110	1900	960	11	970
Nine-Year-Old	8000	190	8200	2200	110	2300	1200	11	1200
Six-Year-Old	9600	190	9800	2600	110	2700	1400	11	1400
One-Year-Old	20000	190	20000	5200	110	5300	2700	11	2700
Newborn	1000	190	1200	-	-	-	190	11	200
In Utero, 3rd tri.	2700	190	2900	-	-	-	390	11	400
In Utero, 2nd tri.	-	-	-	2000	110	2100	1000	11	1000

[a]Multiply by 0.01 to obtain Gy.

Source: Lessard et al, 1985, p.61

N-5

The sequence of safety recommendations and guides has run as follows.

(a) In 1954 the National Bureau of Standards Handbook 59 presented the recommendations of the NCRP. The maximum permissible dose to the bone marrow (and hence to the entire body) was 0.3 rem per week.

(b) In January, 1957, the whole-body dose for the general population was lowered to .5 rem per year by the NCRP. This was published as an insert into the Bureau's Handbook 59. The AEC also published this and other recommendations in Appendix 10, p. 400 of its 22nd Semiannual Report to the Congress.

(c) In 1960, the Federal Radiation Council defined two guides for the general population. (Federal Register, May 22, 1965, pp. 6953-55)

The "radiation protection guide" for the general population under normal circumstances was .170 rem per year.

The "protective action guide (category 3)" was defined to cover the long-term harm by cesium-137 and strontium-90 acting through the food web after the first year of a contaminating event. The FRC recognized the great diversity of such situations. It concluded that protective action must be determined on a case-by-case basis when the annual dose to the bone marrow after the first year would exceed 0.5 rem to individuals or 0.2 rem to a suitable sample of the population.

[Such an evaluation involves cost-benefit analysis. Suppose that the excess bone-marrow dose over a 10-year period is estimated to be 15%. Would this be sufficient to warrant a population giving up the use of its homes and land? Obviously, the excess dose would be trivial from the point of view of harm, whereas the personal loss measured in terms of social values would be considerable. To emphasize the need for judgement of this kind, the Federal Radiation Council instituted the term protective action guide rather than standard.]

(d) In 1979, ICRP Publication 30 subsequently modified for the transuranics in Publication 48, 1986, provided annual limits for the intake of radionuclides by workers. Divided by 30, they are equal to a committed effective dose equivalent per year of .170 rem.

[(e) Dr. Alan Richardson of EPA (Guides & Criteria Branch) has informed me (2/8/89) that representatives of EPA, the Food & Drug Administration and the Department of Agriculture have begun to discuss possible revisions in the general population guides, and that a paper for public discussion should be ready sometime next winter.]

For the nonprofessional reader, the following is an explanation of the specific radiological meaning of the terms, exposure and dose. Very simply, the medical analogy would be this. A patient takes a spoonful of heart medicine -- radiologically considered, that is his exposure.

Of the swallowed medicine, three-quarters are eliminated but one-quarter passes from the intestine into the circulation and is absorbed by the heart -- that one-quarter is the dose. It would be expressed per gram of heart tissue.

For exposure to radiation per se, the unit is the roentgen (R), measured in air. For radionuclides (atoms which spontaneously decay and emit radiation), the units are the bequerel (Bq), equal to 1 atomic disintegration per second, or the curie (Ci), 3.7×10^{10} disintegrations per second. The microcurie (μCi) and the picocurie (pCi) are respectively 1 millionth of a curie, and 1 millionth of a microcurie (27 pCi equal 1 Bq).

The units of dose are the rad (for any type of ionizing radiation: 100 ergs absorbed per gram of tissue); and the rem (dose equivalent in biological effect to 1 rad of standard radiation). The particular point to remember about radiation dose is that it is per gram of tissue. A whole-body dose of 100 rad means that every gram (on average) received 100 rad; it does not mean that the entire body received 100 rad to be distributed throughout the tissues.

Both exposure and dose are referred to as resulting from external or internal sources. An external exposure or external dose is the result of a radiation source outside of the body, e.g., fallout-contaminated soil. An internal dose would result from a source inside of the body, e.g., radioactive iodine due to the use of fallout-contaminated drinking water.

In the case of radionuclides, we shall use the term "whole-body dose" in the technical sense of "committed effective dose equivalent". Committed means the dose delivered to the body over the next 50 years from the amount of radionuclide under discussion (e.g., the amount I eat today). Effective signifies corresponding to whole-body exposure (e.g., 1 rem to the entire lungs corresponds to .12 rem whole-body). Dose equivalent in rem signifies that whatever kind of radiation is being used, its dose in rem gives the same effect as that of any other type of radiation expressed in rem.

The "tissue dose" is the committed dose equivalent.

[The radiation guides, couched in terms of rem, are given in Note 5.]

N-7 The external gamma-ray exposures of Table 4.1 #1 affect all of the tissues of the body. In addition, beta rays (cesium-137 and strontium-90) emanate from soil, but have only a limited range in air and very poor penetration into the body; they might affect the body's surface in those regions which are closest to or are actually touching the ground. Shoes and clothing provide complete or almost complete protection.

External beta-ray dose is considered to be unimportant on the basis of the following. For gamma rays, the Rongelap Island/Eneu Island external-dose ratio is 1.7 (Table 4.1 #1. The beta-ray dose ratio at .007 mm depth (basal cell layer, skin) should be approximately the same. Therefore, by extrapolation from the determinations at Eneu (Shingleton et al, 1987) the Rongelap basal-cell dose would be 46 mrem/y, and at 1 cm depth practically zero (ICRP 51, Table 26). Since the radiation protection guide for skin is 5 rem/y (NCRP 1987b), the skin dose is a trivial one.

Diet. The major uncertainty in estimating the dose is the diet - no one knows precisely what it is. Two efforts have been made to delineate it. The first by Naidu et al (1980) (BNL 51313) was based on living experiences over the years on various Northern Marshallese Atolls and clearly demonstrated the effects of living patterns on diet. Rongelap fell into their B class, one in which there was a low availability of local foods (excepting fish), overpopulation, and a good supply of imported foods (supply boat comes in regularly, say, every three weeks). Naidu et al reported the quantities of food prepared, but emphasized that they did not know how much was eaten. In any event, Robison and DOE-1982 used this estimate as the maximum level of consumption for a population.

The MLSC diet was elaborated by M. Pritchard of the Micronesian Legal Services Corporation in 1979 when he visited the Enewetak people for 2.5 weeks [then on Ujilang Atoll] (Robison et al, 1982a). His diets assumed that the supply ship came regularly, making it possible for the people to eat relatively large amounts of imported foods (rice, flour, sugar, canned goods, etc.), or that the ship did not come at all. Robison selected the adult female subgroup of the population for calculation because its consumption was greatest. DOE-1982 took this calculation for the minimal level of contaminated-food consumption [in certain calculations].

For the MLSC diet (supply ship on schedule) it has been found that cesium-137 accounts for about 95% of the whole-body dose and 85% of the bone marrow dose. Strontium-90 accounts for 5% and 15%, respectively, and the transuranics for less than 1% during the first 70 years. When the supply ship is on schedule, coconut accounts for 80% or so of the radionuclide intake.

In summary, then, DOE-1982 used the Naidu type B commuunity diet for its dose calculations. When it wished to indicate a range, it used both the type B community (high) and the MLSC diet (low). The diets are given in Table N-8 #1.

One additional fact about the preparation of fish. The skin and bones of fish may have 50-100 times the strontium-90 specific activity of the meat. Also, the contents of the intestinal tract may be high. What is the effect of all this on dosage? First, Noshkin et al (1981) found the strontium-90 specific activities of all tissues to be below 1 pCi/g. Robison et al (personal communication, 1988), have confirmed this for mullet caught off the reef of Bikini Island (contamination levels 5-10 times those at Rongelap Island). Roast mullet and stewed mullet were tested. For stew, neither the meat, nor broth, nor skin and bones exceeded .01 pCi per gram (Table N 8.# 2). The cooking was done by Marshallese in the customary way (the intestines were discarded).

TABLE N- 8 #1 DAILY FOOD CONSUMPTION -- TWO DIETS [a/]

Food	Community B (adult) grams/day	MLSC Diet (adult female) grams/day
Arrowroot	0	3.9
Breadfruit	36	27.2
Banana	19	0.02
Coconut		
Drinking meat	100	--
Drinking fluid	514	--
Copra	68	--
Milk	125	--
Sprouting	100	--
Coconut "fluid"	--	142
Coconut "meat"	--	63.3
Papaya	0	6.6
Pumpkin	0	1.2
Pandanus	96	9.2
Fish	194	41.5
Eggs	--	10.7
Poultry	3	--
Wild birds	9	4.2
Domestic meat	--	21.2
Pork	1.4	--
Clams	15	8.9
Crabs	--	3.1
Octopus	20	4.5
Turtle	.1	4.3
Snails	12	--
Coconut crab	1	--
Lobster	.14	--
Shellfish	--	5.1
Total	1313.64	356.92

a/ Imported foods are not included in the lists. The data are from Tables 4 and 11 in Robison et al, UCRL 52853 (1982b). Imported staples include rice (especially), sugar, flour, canned meat, canned drinks, and baby foods.

5000672

TABLE N-8 #2

STRONTIUM-90 DISTRIBUTION IN MULLET; FRESH, ROASTED, AND AS A STEW[a/]

	Strontium-90, pCi/g wet weight		
	Roast mullet	Mullet stew	Fresh mullet[b/]
Muscle (meat)	9.5 E-4	--	5.2 E-4
Bones	5.4 E-2	4.2 E-2	1.8 E-2
Duplicate bones	6.0 E-2	--	--
Skin	8.0 E-2	--	2.7 E-2
Broth	--	4.5 E-4	--
Skin + meat	--	1.8 E-3	--

[a/] The table was supplied by Dr. W. L. Robison of the Lawrence Livermore National Laboratory.

[b/] From V. Noshkin et al, UCID-20754, 1986, "Concentrations of Radionuclides in Fish Collected from Bikini Atoll between 1977 and 1984".

N-9

To determine whether or not the determination of specific activity of soil and plants made by the Livermore Laboratory was analytically correct, a field trip took place in December 1987 during which samples were collected at 7 locations running the length of Rongelap Island and on 3 islands of Ailinginae Atoll. The samples were collected under the supervision of Dr. H. Paretzke by Livermore technicians and Rongelap men. Senator Anjain and other Rongelap citizens were present. The results show that the Livermore technique is an acceptable one.

At each location, the external exposure rate was measured. The mean for seven locations on Rongelap [Island] was 3.4 (2.2-4.6) μRh. Corrected back to 1978, it becomes 4.3 μR/h, in excellent agreement with previous determinations (Table 4.1 #1).

The samples of soil and vegetation were frozen and shipped back to the Livermore Laboratory where they were divided so that one-half of each was sent to Dr. Paretzke in Neuherberg (Munich), the other being retained for analyses in this county by Dr. Robison (Livermore) and Dr. Kohn (Berkeley). Dr. Paretzke shared his samples with Dr. Boikat (Bremen).

Each laboratory prepared its own material for analysis and then analyzed it without knowledge of the results from elsewhere.

In general, the various laboratory results agreed well with one another for field sampling (Table N 9# 1-4).

The radionuclide levels on Ailinginae Atoll were found to be no more than one-third those on Rongelap Island.

Among the radionuclides themselves, the extremely low levels of the transuranics in vegetation and meat compared to soil demonstrate the operation of biological selection against these elements (5,000 to 10,000-fold). This effect is amplified by further negative selection in the gut; absorption in adults is about 0.1% compared to 100% for cesium. During the first month of life, however, absorption from the gut might be 10 to 100 times greater than in adults.

The radionuclide levels are also in general agreement with the most recent summary of the Lawrence Livermore Laboratory (Table 4.2 #2).

These comparisons are of more than routine importance, since many Rongelap people have stated that DOE laboratory results cannot be trusted and that the DOE scientists are liars.

TABLE N-9 #1

CESIUM-137 COMPARISONS (1987)

Item	Island [a] (No. samples)	LLNL [b]	P & B [c]
		pCi/g	pCi/g
Drinking coconut meat	A (3) [d]	.47	.60
	R (6)	4.5	3.4
Drinking coconut juice	A (3)	.22	.19
	R (6)	1.25	1.45
Soil: 0-10 cm	A (3)	3.31	2.43
	R (7)	11.5	8.7
10-20 cm	A (1)	.48	.30
	R (1)	1.30	.97
Lime meat	R (2)	2.2	1.9
Coconut crab muscle	A (2)	1.09	.96
Breadfruit	R (1)	3.8	4.38
Arrowroot	R (1)	17.1	20.7
Pandanus	R (1)	21.3	26.2
Pig muscle	R (1)	14.7	13.9
Chicken muscle	R (1)	6.2	6.3

[a] A is Ailinginae, R is Rongelap [Island].

[b] Lawrence Livermore National Laboratory

[c] Dr. Paretzke (Munich) and Dr. Boikat (Bremen)

[d] 1 each from Mogiri, Enibuk and Gerea-Knox

TABLE N-9 #2

STRONTIUM-90 COMPARISONS (1987)

Item	Island (No. samples)	P & B [a/] #	HIK [b/]
		pCi/g	pCi/g
Drinking coconut meat	R (1)	.0054	.0061
Breadfruit meat	R (1)	.035	.052
Soil: 0-10 cm	R (1)	6.2	10.1
Arrowroot	R (1)	.068	.076
Coconut crab muscle	A (1)		.35

[a/] Dr. Paretzke (Munich) and Dr. Boikat (Bremen)
[b/] Dr. Kohn (Berkeley)

TABLE N-9 #3

PLUTONIUM-239,-240 COMPARISONS (1987)

Item	Island (No. samples)	P & B [a]	HIK [b]
		pCi/g	pCi/g
Drinking coconut meat	R (2)	.000016 < .0032	.000069
Soil: 0-10 cm	R (1)	2.46	7.7
Arrowroot	R (1)	.0046	.00065
Breadfruit meat	R (1)		.000018
Pig muscle	R (1)		.00001
Chicken muscle	R (1)		.00011

TABLE N-9 #4

AMERICIUM-241 COMPARISONS (1987)

Item	Island (No. samples)	LLNL [c,d]	P & B [d]	HIK [e]
		pCi/g	pCi/g	pCi/g
Drinking coconut meat	A (2)			.00002
	R (6)			.00005
Soil: 0-10 cm	A (3)	0.69	< .33	.61
	R (7)	1.43	1.19	1.54
10-20 cm	A (1)	.19	< .12	.19
	R (1)	.074	< .11	.076
Breadfruit	R (1)			.000013
Arrowroot	R (1)			.00038
Pandanus	R (1)			.000025

[a] Dr. Paretzke (Munich) and Dr. Boikat (Bremen)
[b] Dr. Kohn (Berkeley)
[c] Lawrence Livermore National Laboratory
[d] Gamma counting.
[e] Alpha counting

N-10

INHALATION DOSE

The inhalation of dust can vary tremendously depending on activity. On Bikini Island ploughing an open field in the dry season would represent the high end of the spectrum; resting quietly at home or sailing on the lagoon would be near the low end. Robison (Ref. UCRL 53805, p. 9) has revised his earlier excessive estimate based on 5 hours per day of ploughing. As an average now throughout the year, he takes 1 hour per day plus 23 hours under normal conditions, resulting in a daily intake at Bikini of .017 pCi of plutonium-239,-240 and .0071 pCi/d of americium-241, totalling .024 pCi/d.

To obtain the Rongelap dose, it was assumed that the distribution of particle sizes and of radionuclides was practically the same on Bikini and Rongelap Islands. Therefore, the inhalation dose on Rongelap would be to that on Bikini as the transuranic specific activity of Rongelap soil (0-5 cm) was to that of Bikini Island. The plutonium level on Rongelap was 29% of that on Bikini, and the americium level 12% (Robison 1982a, pp. 8, 12, 44, 56; 1982b, pp. 12, 14, 47, B10, B13).

The daily transuranic exposures for adults on Rongelap were therefore:

plutonium-239,-240,	29% of .017 pCi	= .005	pCi/d
americium-241,	12% of .00071 pCi	= .0009	pCi/d
Total		.006	pCi/d

The adult 30-year inhalation doses are estimated to be (Table 4.2 #1B):

Tissue	Plutonium-239,-240 (rem)	Americium-241 (rem)
Whole-body	.023	.004
Red marrow	.035	.006
Bone surfaces	.004	.0007

For the infant (to be on the safe side) we have assumed exposure to be the same as for an adult. Therefore, taking the total daily transuranic exposure as .006 pCi/d, we find the whole-body dose for the first year to be (Table 4.4 #1):

N-11

BROOKHAVEN RESULTS - Cesium-137 and Strontium-90

The whole-body counter measures the quantity and the energy of the gamma ray photons that have been emitted by cesium-137, or other radionuclides, and that escape from the body. In principle, the machine is calibrated by measuring the escape of gamma rays from a phantom which has been loaded with the radionuclides in question. Obviously, the whole-body counter comes closest to giving a direct measurement of the body-content.

The Brookhaven Laboratory team has visited Rongelap periodically since the time of resettlement in 1957 in order to perform whole-body counts for cesium-137, and some other radionuclides, for which the results are summarized in Tables N.11 #1 and #2. The actual data are shown in Table 1, and the annual estimates of body burden based on curves fitted to the data of Table 1 are shown in Table 2. These tables have been provided through the courtesy of Dr. E. T. Lessard.

TABLE N.11 #1

AVERAGE RADIONUCLIDE CONTENT AND TIME SINCE REHABILITATION FOR RONGELAP ADULTS

	Adult Males (>15a)		Adult Females (>15a)		Adults (>15a)			
	Body Burden Bq	Number of Individuals	Body Burden Bq	Number of Individuals	Body Burden Bq	Number of Individuals	Time Post Rehabitation Days	Year
^{60}Co	$1.1x10^{0}$	(A)	$6.3x10^{-1}$	(A)	$9.3x10^{-1}$	(A)	0	1957
	$3.7x10^{2}$	37	$2.9x10^{2}$	37	$3.3x10^{2}$	74	1370	1961
	$9.3x10^{1}$	45	$7.4x10^{1}$	45	$8.1x10^{1}$	90	2831	1965
^{65}Zn	$1.9x10^{3}$	4(B)	(C)	(C)	(C)	(C)	0	1957
	$2.3x10^{4}$	17	$6.4x10^{3}$	8	$1.8x10^{4}$	25	244	1958
	$1.6x10^{4}$	30	$1.4x10^{4}$	12	$1.5x10^{4}$	42	304	1958
	$2.3x10^{4}$	32	$1.9x10^{4}$	27	$2.1x10^{4}$	59	639	1959
	$3.5x10^{3}$	38	$3.1x10^{3}$	23	$3.4x10^{3}$	61	1370	1961
^{55}Fe	$1.6x10^{4}$	28	$1.5x10^{4}$	32	$1.5x10^{4}$	60	4626	1970
^{90}Sr	$7.0x10^{0}$	(A)	$5.2x10^{0}$	(A)	$6.3x10^{0}$	(A)	0	1957
	$1.7x10^{1}$	11	$1.1x10^{1}$	4	$1.4x10^{1}$	15	304	1958
	$4.7x10^{1}$	24	$2.9x10^{1}$	16	$4.1x10^{1}$	40	639	1959
	$6.3x10^{1}$	9	$2.5x10^{1}$	4	$5.1x10^{1}$	13	1370	1961
	$3.0x10^{2}$	13	$1.8x10^{2}$	15	$2.4x10^{2}$	28	1696	1962
	$2.1x10^{2}$	12	$1.9x10^{2}$	13	$1.9x10^{2}$	25	2100	1963
	$2.1x10^{2}$	11	$2.0x10^{2}$	7	$2.1x10^{2}$	18	2466	1964
	$7.7x10^{1}$	12	$1.6x10^{2}$	12	$1.3x10^{2}$	24	3561	1967
	$1.5x10^{2}$	11	$1.2x10^{2}$	11	$1.3x10^{2}$	22	3927	1968
	$1.6x10^{2}$	11	$1.3x10^{2}$	13	$1.5x10^{2}$	24	4292	1969
	$5.5x10^{1}$	9	$1.5x10^{2}$	11	$1.1x10^{2}$	20	4657	1970
	$1.4x10^{2}$	8	$1.2x10^{2}$	7	$1.3x10^{2}$	15	5022	1971
	$9.6x10^{1}$	5	$8.7x10^{1}$	7	$9.6x10^{1}$	12	5388	1972
	$3.2x10^{2}$	4	$2.1x10^{2}$	7	$2.5x10^{2}$	13	5753	1973
	$1.7x10^{2}$	10	$8.5x10^{1}$	4	$1.5x10^{2}$	14	6118	1974
	$2.5x10^{2}$	26	(C)	(C)	(C)	(C)	7579	1978
	$3.7x10^{1}$	25	$2.8x10^{1}$	19	$3.3x10^{1}$	44	8057	1979
^{137}Cs	$5.2x10^{2}$	(A)	$3.1x10^{2}$	(A)	$4.1x10^{2}$	(A)	0	1957
	$2.9x20^{4}$	38	$1.9x10^{4}$	13	$2.7x10^{4}$	51	304	1958
	$2.9x10^{4}$	47	$1.5x10^{4}$	49	$2.1x10^{4}$	96	639	1959
	$3.5x10^{4}$	37	$1.7x10^{4}$	37	$2.5x10^{4}$	74	1370	1961
	$3.5x10^{4}$	44	$1.8x10^{4}$	45	$2.5x10^{4}$	89	2831	1965
	$1.8x10^{4}$	22	$1.1x10^{4}$	24	$1.4x10^{4}$	46	6118	1974
	$1.1x10^{4}$	30	$7.0x10^{3}$	21	$9.3x10^{3}$	51	7213	1977
	$6.7x10^{3}$	19	$5.6x10^{3}$	18	$6.3x10^{3}$	37	8057	1979
	$6.7x10^{3}$	36	$7.0x10^{3}$	30	$6.7x10^{3}$	66	8813	1981
	$1.0x10^{4}$	29	$7.8x10^{3}$	18	$9.4x10^{3}$	47	9180	1982
	$8.9x10^{3}$	23	$7.8x10^{3}$	29	$8.3x10^{3}$	52	9540	1983
	$3.9x10^{3}$	43	$3.4x10^{3}$	35	$3.7x10^{3}$	78	9910	1984

A = Number of individuals not recorded.
B = Measured at Argonne National Laboratory.
C = No females measured.

(This table was supplied by Dr. E. T. Lessard, Brookhaven National Laboratory)
(1 bequerel = 27 picocuries)

TABLE N.11 # 2

BROOKHAVEN DATA FOR INTERNAL DOSE & EXTERNAL EXPOSURE

Rongelap Adult Committed Effective Dose Equivalent,[1] Average Value Committed Each Year

Year Post BRAVO	Year	^{60}Co (mrem y^{-1})	^{137}Cs (mrem y^{-1})	^{65}Zn (mrem y^{-1})	^{90}Sr (mrem y^{-1})	^{55}Fe (mrem y^{-1})	Average Annual External Exposure Rate (mR/year [2])	
3	1957	19.8	199	151	4.32	10.9	290	
4	1958	8.35	181	33.8	3.97	8.44	210	
5	1959	3.53	164	7.56	3.64	6.51	170	
6	1960	1.49	149	1.69	3.34	5.02	140	
7	1961	0.63	136	0.38	3.06	3.88	120	
8	1962	0.27	123	0.08	2.81	2.99	100	
9	1963	0.11	112	0.02 195	2.58	2.31	90	
10	1964	0.05	102		2.37	1.78	80	
11	1965	0.02 34	92.4		2.17	1.38	73	
12	1966		83.9		1.99	1.06	66	
13	1967		76.2		1.83	0.82	61	
14	1968		69.2		1.68	0.63	56	
15	1969		62.9		1.54	0.49	52	
16	1970		57.2		1.41	0.38	49	
17	1971		51.9		1.29	0.29	46	
18	1972		47.2		1.19	0.22	43	
19	1973		42.9		1.09	0.17	41	
20	1974		38.9		1.00	0.13	38	
21	1975		35.4		0.92	0.10	36	
22	1976		32.1		0.84	0.08	35	
23	1977		29.2		0.77	0.06	33	
24	1978		26.5 1911		0.71 45	0.05 47.6	32	1302 millirem
25	1979		24.1		0.65	0.04	30	
26	1980		21.9		0.60	0.03	29	
27	1981		19.9		0.55	0.02	28	
28	1982		18.1		0.50	0.02	27	
29	1983		16.4		0.46	0 01	26	
30	1984		14.9		0.42	0.01	25	
31	1985		13.5		0.39	0.01 .14	24	
32	1986		12.3		0.36		23	
33	1987		11.2		0.33		23	
34	1988		10.2		0.30		22	
35	1989		9.22		0.28		21	
36	1990		8.38		0.25		21	
37	1991		7.61		0.23		20	
38	1992		6.92		0.21		19	
39	1993		6.28		0.20		19	
40	1994		5.71		0.18		18	
41	1995		5.19		0.16		18	
42	1996		4.71		0.15		17	
43	1997		4.28		0.14		17	
44	1998		3.89		0.13		16	
45	1999		3.53		0.12		16	
46	2000		3.21		0.11		15	
47	2001		2.92		0.10		15	
48	2002		2.65		0.09		15	
49	2003		2.41		0.08		14	
50	2004		2.19		0.08		14	
51	2005		1.99		0.07		14	
52	2006		1.80		0.06		14	
53	2007		1.64		0.06		13	
54	2008		1.49 245		0.05 7		13	410 millirem
55	2009		1.35		0.05		13	

[1] Multiply by 10^{-5} to convert to Sv.

[2] Multiply by 0.7 to obtain mrem (whole-body).

Σ to 1978 = 2233 + 1302 = 3535
Σ 1979-2008 = 252 + 410 = 662

5000681

This table was supplied by Dr. E. T. Lessard of the Brookhaven National Laboratory.

Note 12

PLUTONIUM ANALYSIS

In the case of radionuclides that emit beta rays (strontium-90) or alpha particles (transuranics), and whose range in tissue is at most a centimeter down to some micrometers, two methods have been used for assay.

(a) Knowing the daily urinary excretion, the body content of radionuclide is calculated from knowledge of its metabolism. The method has worked for strontium-90 (e.g., 3 Rongelap cases at autopsy confirmed urinary analysis (Ref. Conard 1980, Appendix, p. 115), but not so far with plutonium where extremely small quantities are involved.

(b) The dose can also be calculated from the diet. The primary obstacle here is that the diet is difficult to ascertain accurately. The Livermore results are based on this method.

For Rongelap, diet and urine methods are in frank disagreement. The Livermore diet method finds the daily intake of [transuranics] to be about 0.4 pCi/d (Section 4.2; plutonium-239 is about 50% of the transuranic mixtures).

On the other hand, the current analysis of urine at Brookhaven gives plutonium-239 excretion values which range from less than 1×10^{-5} to about 5×10^{-3} pCi/d. These correspond to a range of intake from less than .07 pCi/d to about 38 pCi/day.

The doses (30-year, whole-body) calculated from these estimates for plutonium-239 are as follows:

Livermore: [.008 rem]

Brookhaven: .003 rem - 1.48 rem

The total dose for the three transuranics (two plutoniums plus americium) would be twice these figures.

The problems implicit in this comparison require some detailed discussion.

Brookhaven results. Historically, we may begin with Conard's twenty-year Rongelap review of 1975 (Ref. BNL 50424) in which the results of urine analysis for 10 Rongelap persons were reported (Appendix 12, p. 147). One result seemed much too high; the average of the other nine was 58×10^{-3} pCi/liter/d, twice the maximum found in the current series. Conard did not discuss this result, but it was reviewed by an ad hoc group which suggested contamination as a likely cause of the high values (Lessard 1984).

Urines were again collected on a much larger scale in 1981. The PARALS method was applied, but abandoned owing to inherent contamination with polonium. The fission track method was then adopted and a method to separate plutonium for such analysis worked out. It should be recognized that the very small quantities of plutonium involved make the operation of the method a very difficult task (ORAU, 1987). The cost per sample is about $1,000.

Some 270 samples of urine have been analyzed. Owing to a reorganization at Brookhaven, the work for this project was stopped (no funds), and the results were neither tabulated nor analyzed. For the Rongelap Preliminary Report of April 26, 1988, the Brookhaven Laboratory gave Dr. Lessard, the former manager of the program, two days of free time and he reported on some details.

Since then, starting in June a summer student, Mr. George Taylor,* has been extracting data from the notebooks and should be able to tabulate a summary by the end of summer. Meanwhile, Mr. Taylor has sent me some results for the first 104 cases, which are displayed in Table N.12 #1.

(a) As noted above, the range of excretion is very large -- from less than 1 x 10^{-5} pCi/d to 5 x 10^{-3} pCi/d. The significance of this range is not known.

(b) The distribution of the data appears to be logarithmic and bimodal. Thus it may be suggested that two populations are at risk. The populations might differ physiologically (one absorbs transuranics much more readily than the other); environmentally (diet, contamination of samples); or technically (a change in technique or technician). Of these, contamination might be the most likely; it is very difficult to collect good urine samples in the Marshalls. But any or all of these variables may have played a role.

(c) The results are not primarily dependent on sex or age, although these factors may play a role.

(d) The youngest group appears to have a somewhat higher excretion rate than the oldest one, at least in males. This could be due to a more rapid metabolic turnover of the radionuclides. Tritium and iodine, for example, have half-residence times in infants of 3 days and 30 days respectively, but in adults 10 days and 100 days (Hoenes, et al 1977). The long-term compartments of plutonium have an average half-time in the body of about 35 years, which could be much less in infants and children. The higher outputs of the children might therefore represent faster metabolism rather than greater intake.

Although the arithmetic in the foregoing calculations may be correct, we may ask, "Are they consistent with what we know?" As a matter of judgment, I think the answer is, "No.". The maximum urinary output of plutonium-239 corresponds to 76 pCi/d input for the three transuranic elements. Looking over the data in Table 4.2 #1, it is difficult to see how anyone could eat sufficient food to accomplish this. Clams have the highest specific activity of the transuranics -- 131 x 10^{-4} pCi/g -- a specific activity that is about 50 times greater than the nearest competitor. One would therefore have to eat 5.8 kilograms per day, every day in the year, to satisfy the predictions of the Brookhaven analyses.

[* Department of Nuclear Engineering, Texas A & M College of Engineering, College Station, Texas 77843. c/o Prof. John Poston.]

Dose calculations. The Moss (Moss 1988) factors in Table N.12 #2, supplied through the courtesy of Dr. E. T. Lessard of Brookhaven, permit the calculation of plutonium-239 oral intake from urinary excretion, or vice versa. The factors vary about 3-fold in the present case where the periods of exposure are from about 5 to 25 years.

Of the 104 cases in Table N.12 # 1, all had lived on Rongelap since birth or for at least 7 years with four exceptions. One other exception was the case of a 12 year-old female who first arrived in 1980; her output of 2.34 [x 10^{-4}] pCi/d was practically identical to that of an 11 year-old (2.18 [x 10^{-4}] pCi/d) who had always lived on the island.

For orientation, let us use a factor of 1.5 x 10^{-4}, corresponding to about 7 years of plutonium exposure. Then for the maximum urinary output, the intake would be 38 pCi/d [(5 x 10^{-3}) / (1.5 x 10^{-4})].

The corresponding [maximum] whole-body dose (30 year) would be 1.5 rem for plutonium-239, and 3 rem for the three transuranics. (The corresponding Livermore diet estimate would be .014 rem.) Three rem of course, is relatively a sizable dose. However, it is of interest that when combined with the rest of the Brookhaven estimates, the total dose of [4] rem does not exceed the 5 rem limit. For exposure from birth to age 30 years, the [estimated plutonium maximum] dose would be 1.63 times greater [or 4.9 rem]. (Table 4.4 #1). [I emphasize again, however, that the maximum transuranic estimate is an unrealistic one.]

TABLE N.12 #1

RONGELAP: PLUTONIUM-239 URINARY EXCRETION (1981)[a,b]

Age	No.	Below detectible limit	1 - 9 x 10^{-5} pCi/d	1 - 9 x 10^{-4} pCi/d	1 - 5 x 10^{-3} pCi/d
Males					
5 - 10 y	24	6 (25%)	*	17 (71%)	1
10 - 20 y	27	9 (33%)	7 (25%)	9 (33%)	2
21+ y	17	12 (71%)	1	3 (18%)	1
TOTAL MALES	68 (100%)	27 (40%)	8 (12%)	29 (43%)	4 (6%)
Females					
5 - 10 y	9	2 (22%)		4 (44%)	3 (33%)
10 - 20 y	10	4 (40%)		5 (50%)	1 (10%)
21+ y	17	8 (47%)	1	6 (35%)	2 (18%)
TOTAL FEMALES	36 (100%)	14 (39%)	1 (3%)	15 (42%)	6 (17%)
TOTALS	104 (100%)	[41] (40%)	9 (9%)	44 (42%)	[10] (9%)

[a] 1981 collection, determined by fission track method at Brookhaven National Laboratory. All subjects had been in continuous residence (or practically so) for their life span or for more than 7 years. The urine volumes were standardized to 700 ml for age 10 and below; 1 liter for females above 10; 1.2 liters for males 10 - 16, and 1.4 liters for males over 16 (per day).

[b] Analyses on another 160 or so subjects are now being taken from the records for tabulation and analysis. We are indebted to the Radiological Sciences Research Division for this material, and to Messrs. Lessard and Taylor.

TABLE N.12 #2

PLUTONIUM-239: FRACTION OF ORAL DAILY INTAKE EXCRETED IN URINE [a/][b/]

It is assumed that the daily intake is constant over the period specified. F_1 = .001 [absorbed from gut].

Duration of exposure (years)	Jones (old)	Moss (new)
1	3.62×10^{-5}	5.42×10^{-5}
5	6.2×10^{-5}	--
10	8.61×10^{-5}	1.71×10^{-4}
20	1.31×10^{-4}	2.3×10^{-4}
29	1.67×10^{-4}	2.92×10^{-4}

[a/] The table's data were supplied by Dr. E. T. Lessard of the Brookhaven National Laboratory. I have used the Moss factors (Moss, 1988).

[b/] The intake can be calculated by dividing the urinary excretion by the factors given. For example, after 20 years of intake, the daily excretion is found to be 3×10^{-5} picocuries. Then the intake is: $(3 \times 10^{-5}) / 2.3 \times 10^{-4} = .13$ picocuries/day.

[This page has been added tp the reprinting of the Report to show that the Jones factors from England and the Moss factors from Los Alamos are within approximately a factor of two of the Leggett & Eckerman factors from Oak Ridge; see page 80.]

OAK RIDGE NATIONAL LABORATORY
OPERATED BY MARTIN MARIETTA ENERGY SYSTEMS, INC.
FOR THE U.S. DEPARTMENT OF ENERGY

POST OFFICE BOX 2008
OAK RIDGE, TENNESSEE 37831

May 24, 1990

Dr. Henry I. Kohn
1203 Shattuck Ave.
Berkeley, Ca 94709

Dear Henry:

Please find tabulated below the urinary excretion rates (d^{-1}) per unit intake rate (d^{-1}) for continuous ingestion of Pu. For example the values represent the pCi/d excreted in urine per pCi/d ingested. The excretion rates are based on the soluble form ($f_1 = 10^{-3}$) and the urinary excretion function tabulated by Leggett and Eckerman (*Health Phys. 52, 3, 337-346, 1987*). This excretion function is consistent with all source of information on Pu excretion.

Urinary Excretion Rate (d^{-1}) per unit rate of ingestion (d^{-1})	
Time (y)	Excretion rate
1	2.23×10^{-5}
2	2.88×10^{-5}
5	4.62×10^{-5}
10	7.05×10^{-5}
15	1.02×10^{-4}
20	1.30×10^{-4}
25	1.57×10^{-4}
30	1.68×10^{-4}

If you have any questions please give me a call.

Sincerely

Keith F. Eckerman
Group Leader,
Metabolism and Dosimetry Research Group

KFE:rrw

NOTE 13. PEACE CORPS

Through the essential help of Mr. Jack Maykoski (Peace Corps Headquarters, P.O. Box 5, Majuro, Marshall Islands 96960) and Mr. Peter Oliver, Special Assistant for Compact Affairs of the Government (P.O. Box 15, Majuro 96960), a number of Volunteers are making diet surveys of their islands. The study is still in progress, but some results have been reported at this time for inclusion in this report by: Mike Flaherty, Buoj Island, Ailinglaplap Atoll; Judi Hinshaw, Woja Island, Ailinglaplap Atoll; Hali Robinette, Ine Island, Arno Atoll, Serena Weihl, Kayen Island, Maloelap Atoll; Ellen Opie, Wotje Island, Wotje Atoll.

The Volunteers have standardized measuring equipment and reporting sheets. Data are gathered by staying with a family for one day on two separate occasions. The task is not an easy one, and we are greatly indebted to these workers for taking on an extra and difficult duty.

NOTE 14

RISK FACTORS

The recent revisions in dosimetry for Japanese bomb survivors have indicated that the risk factor for cancer mortality of 1×10^{-4} should be raised 2 - 10-fold (Shimizu et al 1987; Preston and Pierce 1987). The Japanese experience, however, was based on high dose, high dose-rate exposure, whereas the Rongelap experience under discussion is very low dose and very low dose-rate. The difference in dose-rate involves a factor downwards of 3 - 10-fold, and as a result the two changes cancel one another. To be on the safe side, however, I have chosen to raise the old BEIR factor from 1 to 2.5×10^{-4}. The matter is presently under discussion by the United Nations Scientific Committee on the Effects of Atomic Radiations, which is preparing a report for the International Committee on Radiation Protection.

Note 15: Senator Anjain's letter

The letter from Senator Anjain speaks for itself. It should be compared with the body of the text of the present Report.

I would, however, like to comment on one point, namely, my failure to transmit Dr. Bertell's letter to the Congress immediately on receiving it. The reason was this: I did not consider her report good enough to be transmitted by me as part of my work as Referee. I may add that Dr. Bertell had testified before the Congress at the April 26, 1988, hearing, at the invitation of Senator Anjain.

Her letter (as did her testimony) dealt with two major topics. First, an attempt to show that somehow living on Rongelap per se affected the blood cell counts. I enclose my letter to Dr. Muckle, a pathologist she consulted about this work. Dr. Muckle agreed that when all of the data were reviewed, no tangible results were evident.

Second, the survey of child health led to suggestions that something was radically wrong and that radiation would be the presumptive cause, owing to currently living on Rongelap. I do not consider the data convincing. No mention is made of the usual levels of infant and child health in the Marshalls, and how difficult it would be against such a background to establish radiation as a cause. On this score I quote from the Report of the Task Force on Health (December 17, 1985), chaired by Mrs. Carmen Bigler, RepMar Secretary of Interior and Outer Island Affairs:

> "The task force believes that the central problem facing the health care system is a reversal of priorities;...an appropriate medical system must provide <u>first</u> the essentials of health through public health education, immunization, clean water, sanitation, family planning, community-based dispensary system, and infectious disease control."

For more specific information, I suggest reading "Current Living Conditions of Children in the Marshall Islands", a Report of general information for submission to UNICEF, Republic of the Marshall Islands, June 1984.

[In this corrected edition one other matter should not be passed over. I wish to comment specifically on the accusations relating to Mr. Dunster, made in the letter, pages 86 and 87, based on statements made by the Environmental Policy Institute (EPI) of Washington, D.C. EPI stated that Dunster as Health Physics Manager of the Windscale reactor in 1957 collaborated with colleagues in the U. K. Atomic Energy Authority to withhold critical information from the public regarding that accident. However, Mr. Dunster attests that (a) he never held such a post at Windscale; (b) at the time of the accident he worked at Risley, 150 miles distant; (c) he had nothing to do with the official report by the (now) Lord Penney; (d) he was surprised 20 years later to learn that critical information had been withheld by order of the Prime Minister. More than five months have elapsed since I wrote to EPI and to Senator Anjain about their false statements, but neither one has acknowledged receipt of my letter.]

RONGELAP ATOLL LOCAL GOVERNMENT
Republic of the Marshall Islands

Senator Jeton Anjain
Mayor Willie Mwekto

MAJURO OFFICE:
P.O. Box 1006
Majuro, Marshall Island 96960
Telephone: 3285

June 27, 1988

Henry I. Kohn, M.D.
Rongelap Reassessment Project
1203 Shattuck Avenue
Berkeley, CA 94709

Dear Dr. Kohn:

On April 25, Mayor Mwekto and I wrote you regarding the Rongelap Reassessment Project Preliminary Study saying you had performed "a great service on behalf" the Rongelap people. Today, I write you with a very different message. The manner in which this study is now being conducted is unacceptable. This study with each passing day, has less and less credibility in our eyes.

Congress mandated this study to be <u>independent</u>. We asked Congress for a review of DOE's 1982 Radiation Study -- independent of DOE -- and the Compact sets forth the terms and conditions of that "independent" review. Based on a review of actions of the "Kohn (independent) Study" taken to date, it is now evident that the "independence" of this study has been compromised.

Since the hearing before the Appropriations Committee in late April, this study has been changed. It's tone and direction have been altered. It's purpose now appears to be different than it was when the study was initiated.

I am writing you at this time in the hopes that actions can still be taken to restore credibility and integrity to this vital report.

In 1984, I and others testified before Congressman Seiberling regarding the 1982 DOE report and the general circumstances on Rongelap Atoll. Subsequently, I met privately with the Chairman to discuss the matter. Seiberling recognized that something must be done.

Congress mandated the independent study in section 103(i) of the Compact. A statement regarding the <u>purpose</u> of the study is found in Public Law 99-239 which says, in part:

> Because Rongelap was directly affected by fallout from a 1954 United States thermonuclear test and because the Rongelap people remain unconvinced that is safe to continue to live on Rongelap Island, it is the intent of Congress to take such steps (if any) as may be necessary to overcome the effects of such fallout on the habitability of Rongelap Island, and to restore Rongelap Island, if necessary so that it can be safely inhabited.

The fears that swept through our people were justified in the eyes of Congress. The 1982 DOE report and revelations contained in it terrified our people. More information was needed and Congress established a process by which it would be obtained.

Your Preliminary Study, as the Mayor and I said to you in April, "for the first time, contains important and significant revelations about the radiation contamination to which we have been exposed."

The disclosures in 1982 made it evident that DOE was not truthful with the Rongelap people from 1957 to 1982 regarding the level of atoll contamination. As alarming as the 1982 DOE Report was, the Rongelap people didn't believe that DOE told the full story regarding atoll contamination or health impacts.

Your study has substantiated our concerns. DOE did not tell the truth and we now know it.

Since the April 26 hearing at which time your Preliminary Study was released, the nature of your undertaking has changed. Many things you have done or are in the process of doing are not understood. The manner in which this study is now being conducted is unacceptable.

The following is a list of major problems with the study:

(1) <u>DOE Plutonium Studies Withheld.</u> When DOE's Harry Brown testified before the Appropriations Committee, he indicated that DOE had published a study in 1986 concerning plutonium and the Rongelap people. He further stated that the study was provided to you and your consultants. It was not. You were provided information and data from DOE which was not shared with your consultant working on this very issue. Despite repeated requests for these documents and materials, they remains unavailable.

(2) <u>Bertell Report Completed, But Withheld From Congress.</u> On June 1, Dr. Bertell completed her report evaluating medical and health data, including impacts on the children of Rongelap.

She submitted it to you with the request that you immediately forward it to Congress as the deadline for action was only a few days away. This was not done. Despite the fact that the impacts on children was the primary reason for extending your report by several months, you did not submit this new material to the Yates Committee. The Bertell report concludes, among other things, that the data from blood samples taken from the Rongelapese was never analysed, that the control group used in DOE studies was abnormal, and that the impacts on children and mothers indicate serious problems. DOE says it's safe and you advise us to return to Rongelap. We do not understand. Mostly, we don't understand why this report is being withheld beyond critical deadlines in Congress.

(3) Kohn Study Consultant Participated in Cover-up of Nuclear Radiation Accident. You selected Dr. John Dunster as one of your consultants. I have just learned of Dr. Dunster's personal and direct role in covering up the October, 1957 "Windscale" accident in Britian. Documents declassified early this year finally reveal the nature and extent of the willful withholding of information from the affected British people, both at the time of the accident and over the years since it occurred. That you would select such a person to participate in the Rongelap Reassessment Project is unthinkable.

(4) Independence of Rongelap Reassessment Project Undermined -- DOE Now Controls Release of Documents. Following the April hearing, and the disclosure that the DOE undertook a special review of the plutonium problem only two years ago, requests for information by one of your study consultants were referred to DOE. In early May, Mr. Franke sent written requests to you for the materials referenced at the hearing, and to Brookhaven National Laboratories, for additional materials relating to the plutonium problem. You wrote to Mr. Franke on May 7, stating, "the material you want should be obtained from Harry Brown (DOE). I am sorry that I have forgotten to send you his address." On May 9, Edward T. Lessard writes, "please forward your request to Mr. Harry Brown."

Requests for this information were then immediately sent to Brown, but as of today, none of the information has been received.

This study is not supposed to be "cleared" by DOE. It was supposed to be independent of DOE. Is this the independence we were promised?

(5) Study Work Plan Altered. The Study mandated by Congress was to review the DOE data in the 1982 report and to determine its accuracy. Early in the study, you were highly critical of a work plan advanced by consultants who recommended gathering new data. Now however, you are embarking on such

actions. As I understand it, you have recently decided to undertake certain nutritional studies. In furtherance of this effort, instead of having trained nutritional experts, you have recruited untrained peace corp volunteers to do this work.

Throughout the study, I have been reminded that the purpose of the study is to review the 1982 report. To have untrained volunteers gathering new health-nutrition data at this point in the process is not understood.

(6) Kohn Study Needs to Add Section on DOE Omissions. As a result of your study, we have learned that DOE and its laboratories have urine and blood samples from Rongelap citizens which have either not been measured, or, if measured, not analyzed. My people have participated in medical testing with the understanding that these samples would be fully analyzed. There is now considerable evidence that at least some of these samples have never been evaluated. To be punctured with needles drawing blood or filling little cups with our urine -- to find out that DOE then fails to fully evaluate these samples -- is insulting. Your study needs to indicate this problem.

I returned to Washington from the Marshall Islands expecting to find answers to problems, not more problems. But, what have I learned? I have learned that:

* DOE is now controlling all or part of this study;

* DOE plutonium reports and other materials have not been released by DOE;

* Brookhaven National Laboratories has not released bioassay reports or other requested materials;

* The children's medical study was completed, submitted to you, but not forwarded to Congress;

* One of the study consultants, recruited by you, actively participated in a cover-up of a nuclear accident and further, participated in the willful withholding of information to the affected citizens;

* Unqualified peace corps volunteers have been retained or recruited to undertake "fast" nutritional studies of the Rongelap people;

* The scope and purpose of the study appear to have been altered with a new purpose beyond that of examining and evaluating the accuracy of the DOE data in the 1982 report and now the direction of the study is no longer clear.

Dr. Kohn, the people of Rongelap are the reason for this study. We are the central figures. Or, stated another way, we are the clients. We were sent back to Rongelap Atoll in 1957 and over the years we were repeatedly told that it was safe to live, to gather and consume food -- from all the islands.

We are the most exposed group of people in the Marshalls to radiation.

We are the subject of and the reason for this study.

Yet, when you completed your study, no effort has been made to communicate with our people. No briefings were held. We didn't know your study would be preliminary and that it would be extended for several months. You never told us. This delay has removed us from congressional consideration during this current budget cycle.

Last December, you sent a video message to the people of Rongelap. You indicated that you'd keep the Rongelap people informed. This is not being done.

Over these many months, disclosure after disclosure has come forth. Most involve what DOE didn't do, what they didn't say, what they didn't analyze, and what they didn't tell us. The 1982 DOE report is riddled with errors.

Congress established a two-part process. First, review the report to determine if it was accurate. Second, if not, then a comprehensive review should be undertaken.

DOE was not accurate. The comprehensive report is justified. We urge you to make that recommendation, and to make it in clear and unmistakable terms.

Correct the deficiencies in your study. Make it credible in our eyes. Let it become a stepping-stone in a process to properly restore and rehabilitate Rongelap Atoll.

Dr. Kohn, let me state it this way. Had the 1982 DOE report not been issued, obviously we would still be living on Rongelap Atoll. However, on the basis of the Kohn Report and its revelations, we would be packing our belongings and preparing to leave today.

The Rongelap people today live in deplorable circumstances. Above all, we seek resolution of this matter. We have become pacific nomads, not out of choice, but out of fear. In your hands is a decision to take steps toward resolution or to prolong this agony.

We are human beings and we seek only simply dignity and truth.

Sincerely,

Mayor Willie Mwekto

Senator Jeton Anjain

[The charge that I reversed myself after the first edition of the Report was made by Mr. Weiman, based on Weiman's interview with Mr. John Rudolph of DOE. I spoke to Mr. Rudolph about this and he stated it was a lie that he had said I had reversed myself. When Mr. Weiman and Senator Anjain were subsequently asked by me about this, neither would state why they had not asked me about reversal. H.I.K.]

cc: Rongelap Atoll Local Government

Henry I. Kohn, MD, PhD
RONGELAP REASSESSMENT PROJECT

June 28, 1988

Dr. T. J. Muckle
Director of Laboratories
Chedoke Hospital Division
Box 2000, Station A
Hamilton, Ontario L8N 3Z5

Dear Dr. Muckle,

I have done some more thinking about the blood-cell counts of the Rongelap people, a matter which Dr. Rosalie Bertell asked you to comment on.

You will recall that 82 Rongelap people were exposed to fallout in 1954, were then moved to Majuro Atoll where they remained until 1957, and were then moved back to Rongelap.

During this period (1954-57), non-exposed Rongelap people were also living on Majuro and their blood counts are therefore of interest as controls. In addition, blood counts on the Majuro people themselves and on people living on Rita (an island in Majuro Atoll) are also of interest as controls.

The enclosed table shows blood cell counts for these control groups during the period 1954-57 (before return). You will note that the monocyte count of the Rongelap controls was low prior to return, but after return rose to the normal range. Radiation, therefore, had nothing to do with this change. The monocyte count was also somewhat low in the other two control groups.

You also commented on a difference in lymphocyte count between the first years on Rongelap and 1982-86. Please look again at the data including the Majuro controls in 1982-86. They show a similar change, but were never on Rongelap.

Looking over all of the results in this table leads me to suggest that the fourth paragraph of your letter (which has been quoted by Dr. Bertell) is not warranted now. I refer to the sentence, "I think what may be shown here is the effect of long-continued exposure, which may indeed be quite different from the late effects of acute but transient exposure."

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When reviewed with a bit of perspective, including bearing local conditions in mind, and the fact that 1982-86 counting techniques differed from earlier ones, I don't believe one can say that this collection of counts establishes anything specific in a positive sense.

What do you think now?

I feel somewhat hesitant to involve you in all of this, since it takes time. However, I excuse myself with the thought that you were involved already.

Sincerely yours,

Henry I. Kohn

Henry I. Kohn

cc: Dr. Rosalie Bertell

Over for Blood Count Table

WHITE BLOOD CELL COUNTS IN UNEXPOSED CONTROL GROUPS [a/]

Date	Group[b/]	Cells per mm^3			Platelets per mm^3 x 10^{-3}
		Neutrophils	Lymphocytes	Monocytes	
3'54	"Majuro" (115)	4800	4100	200	310
9'54	"Rita" (82)	5200	3700	180	290
3'56	"Rita" (57)	[4400]	[3600]	150	275
3'57	"Rongelap" (86)	While living on Majuro, before return: 3400	2900	70	280
3'58	"Rongelap" (80)	After return to Rongelap Island in 1957: 3600	3700	110	320
3'59	(75)	5200	4100	240	310
3'61	(-72)?	4200	3100	120	300
3'62	(70)?	4200	2900	190	350
3'63	(70)?	3900	3100	250	310
3'64	(70)?	4800	3500	240	370
'82-'86	(70)	4200	2800	330	--
'82-'86	"Majuro" (61)	3900	2800	320	--

[a/] Brookhaven National Laboratory reports: BNL 384 (T-71), 412 (T-80), 501 (T-119), 534 (T-135), 609 (T-179), 727 (T-260), 780 (T-296), 908 (T-371), and the 1982-86 statistics from BNL Medical Division averaged by Dr. R. Bertell. The reports are available from the Technical Service Information Bureau. The earlier Brookhaven statistics were supplied by Brookhaven National Laboratory.

[b/] All of these groups were unexposed to the fallout of 1954. The Majuro and Rita groups were living on those islands of Majuro Atoll. The Rongelap group was living on Majuro until 1957 when almost all of its members returned to Rongelap. The number examined per year is given in parentheses.

[The statistics are the average of males and females.]

NOTE 16 CONGRESSIONAL HEARINGS

Henry I. Kohn, 1
16 Nov 89

[House Subcommittee on Insular & International Affairs, room 1324, Longworth House Office Building, 16 Nov 89.]

I am Henry I. Kohn, appointed by RepMar to review the DOE-1982 Report on the habitability of Rongelap Island. This was done in accordance with the Compact of Free Association Act, Public Law 99-239, section 103[i]. In addition to DOE-1982, my Reassessment Reports considered other pertinent information available at the time of writing them [Preliminary Report, April '88; Report, July '88; Corrected Report, March '89].

I have now been asked to comment on the Proposal by the Rongelap people - that they be given $6.6 million to set up an expert committee which in the course of 1.5 years would make a comprehensive health and radiologic investigation of themselves and their Atoll. The results would be used by a succeeding expert committee to evolve and execute a plan to make Rongelap Atoll "safe" for habitation.

Let us consider some of the reasons given in the Proposal. [Proposed Workplan For A Phase 2 Comprehensive Study, P & D Technologies, 1989].

[1] The DOE-1982 Report was wrong in its dosimetric conclusion that Rongelap Island is "safe".

[2] A complete detailed health evaluation should have been made for every Rpongelap citizen (e.g. including chromosome analysis and urinary plutonium analysis). Special attention should have been given to infants and small children.

[3] The radiation dose should have been estimated for each citizen individually.

[4] Additional soil contamination data from all islands is needed for proper dosimetry.

[5] The Bramlitt soil-decontamination process for plutonium should be field-tested.

[6] Radiation-sensitive socio-economic factors should have been defined and evaluated.

My general conclusion is that such a vast plan is unnecessary, and that it could not be accomplished in 1.5 years; it would result in delaying the return to Rongelap Island.

First. The Congress specified that the habitability of Rongelap Island - not Atoll - was to be examined. The immediate crucial issue, therefore, is to estimate dosage from residence on that island for now and for the future.

Second. The Reassessment Project found that the dose due to residence on Rongelap Island was within the permissible range [less than 5 rem in 30 years] whether based on the data supplied by the Brookhaven or the Lawrence Livermore National Laboratory. The two

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laboratories used two different methods to estimate dose - diet [Livermore]. and "whole-body counting" plus biochemical analysis [Brookhaven]. Their agreement now obviates the necessity for immediate comprehensive dietary studies.

Third. Although within the practical permissible range, particularly striking were the original differences between Brookhaven and Livermore dose estimates for plutonium. Brookhaven has attacked the problem, and the results to date on 67 urines make it clear that urine-sample contamination was the major cause of the disagreement. I would dare to predict that the present interlaboratory agreement will hold for the remaining 169 samples whose analysis should be completed by July 1990.* This group includes samples from Utirik.

Fourth. Although the Reassessment Project concluded that infants and small children would not be overexposed on return to Rongelap Island, it recommended that further studies be done to provide assurance on this point. Livermore report UCRL 53917 (1989) provides this assurance for cesium-137 and strontium-90, which account for more than 90% of the dose. Further work on plutonium, however, has not been reported.

Fifth. I do not see the immediate radiological need for cytogenetic (chromosomal) examination of every citizen, since at current dose rates of about 3 rem or less in 30 years the cytogenetic technic is much too insensitive. On the other hand, for psychological reasons it might be worthwhile to check individuals who were tested in 1964.

Sixth. I do not agree that there is an immediate radiologic need to study exhaustively the health of every Rongelap citizen. The extent and timing of such a program should be coordinated with health planning by RepMar, discussed in 1984 by RepMar's report to UNICEF and in 1985 by RepMar's Secretary of Interior & Outer Island Affairs. It should also be coordinated with the health care project by Brookhaven and, I believe, the environmental monitoring projected by Livermore.

Seventh. I agree that additional planning and some field studies will needed before deciding on a course of decontamination for the northern islands of the Atoll. That, however, is a separate question from dealing with Rongelap Island now. I suggest that people could return to Rongelap Island and while living there develop such plans. I do not consider the Bramlitt process suitable for use at Rongelap Atoll. Socio-economic factors presumably would be included along with the enviromental ones in the planning.

Eight. Whether or not the Congress should appropriate money directly for such projects is not for me to judge.

Henry I. Kohn, MD. PhD

TESTIMONY FOR CONGRESSIONAL COMMITTEE HEARINGS
4.19.89

I am Henry I. Kohn, Referee, Rongelap Reassessment Project, whose preliminary (4.20.88) and final Reports (7.22.88; 3.1.89 re-edited) were submitted to the Congress and to the President of the United States pursuant to the Compact of Free Association Act of 1985. Here, it is only necessary to state their major conclusions concerning the habitability of Rongelap Island, which was abandoned several years ago by its residents for fear of being poisoned by the current radiation levels.

There are two central questions.

(1) Two Government Laboratories (Lawrence Livermore, Brookhaven) have obtained discordant results with respect to plutonium dosage by two different methodologies. I believe that one Laboratory was in error primarily owing to the great difficulties of urine sampling, and I am told that the crucial testing of this matter should be completed by the end of 1989. I anticipate that the results will permit adult resettlement of Rongelap Island. I may add that the importation of food to support the resettled population will be as necessary in the future as it has been in the past.

(2) The radionuclide dosage to infants and small children has come into question by the Rongelap People. I believe that additional data-collection on diets would settle this point in a matter of months. My estimates based on Peace Corps data indicated that this is not a problem scientifically.

The tests to meet the requirements of (1) and (2) above should be done and communicated to the Rongelap People in such a way as to be impressive and convincing. By this I do not imply spending millions. I do imply that the tests be aimed directly at the two central questions and be done thoroughly.

Furthermore, direct steps should be taken to inform interested citizens of what is being done to solve their problems -- discussion should not be limited to one or two political leaders and their paid consultants. National Laboratory scientists, DOE personnel and Rongelap officials must be willing to participate in such efforts in an appropriate way.

go to page 2.

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In addition, although other islands in the Atoll are outside the assigned scope of this project, I have taken the liberty of emphasizing that studies and planning for them be kept quite separate from those for Rongelap Island itself, so that return to Rongelap Island will not be delayed. An additional project would center on several larger islands which were more heavily contaminated than Rongelap Island, but which are not customarily inhabited. There are, of course, many smaller islands, but these are of secondary interest since they preumably lack water and have never been a significant source of food.

* Henry I. Kohn
April 11, 1989

Copies of this testimony for the hearings of April 19 & 20, 1989, have been sent to:

(1) Ms. Kathy Johnson, Staff, House Appropriations Subcommittee on Interior, B-308 Rayburn Office Building, Washington DC 20515

(2) Ms. Sue Masica, Staff, Senate Committee on Appropriation (Interior Subcommittee), 825 Senate Office Building, Washington DC 20510

(3) Mr. Allen Staymen, Staff, Senate Committee on Energy and Natural Resources, Washington DC 20510

Note 16 continued -
Congressional
Hearings.

Henry I. Kohn, MD, PhD

May 23, 1990

Congressman Sidney Yates
House Committee on Appropriations
Subcommittee on Interior and Related Agencies
308 House Office Building
Washington, D.C. 20515

Attn: Ms. Kathleen Johnson *

Dear Congressman Yates:

I am responding to your invitation to comment on the written testimony of Senator Anjain and his consultant Bernd Franke, representing the Rongelap people at the hearing of 4 May 90.

As you know, DOE in 1982 announced that Rongelap Island met the U.S. radiological standards, and that it was habitable. The compact of Free Association Act of 1985 requested tht these conclusions be reviewed critically. I received that contract in August 1987.

From the start, there has been contention between Senator Anjain, or his consultants, and myself.

(a) I have centered my attention on Rongelap Island, as stated in the Act. They have considered the whole Atoll and wish to deal with matters that I consider outside the scope of "habitability". (They have stated their objectives operationally in a proposed $6.6 milllion study plan, presented to the Congress.)

(b). In judging DOE-1982, I have used all data available.* They have argued that only those data should be used that were available when DOE-1982 was written, circa 1981.

The net result has been a great deal of criticism, technical and otherwise, from Anjain et al, directed at the Rongelap Reassessment Project or myself. In what follows, I shall not answer their testimony point by point. I will attempt to provide a more general picture, so that differences can be seen in perspective, by grouping the various topics under three headings: Dosage, Miscellaneous, and Recommendations.

* With the permission of the Secretary's Office, R.M.I.

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DOSAGE

DOE-1982 reported a 30-year dose of 2.5 rem for Rongelap Island, half the protective action guide applied in the U.S. and elsewhere. This figure was in doubt, however, because of uncertain plutonium dosage (noted by me). Subsequent work is demonstrating that, in fact, plutonium contributes very little to the total dose. Currently, the best estimate of total dose, based on whole-body counting, would be about 1.2 rem.

Two caveats apply. First, the final word on plutonium reassessment will be reported on by Brookhaven later in June. Second, dosage depends upon diet; the diet of the future, therefore, should be equivalent (imported plus local foods) to that of the past. The U.S. has been giving large amounts of food to the Rongelap people, but this is scheduled to stop in 1991.

What then? If the USDA assistance ceases, the people could eat two or three or four times as much local (Island) food, which would raise the dose 2 or 3 or 4 times. But there is not that much local food to be eaten -- Rongelap Island or even the Atoll has never been self-sufficient for sizeable populations. The population would have to shrink.

Several other points should be mentioned. DOE-1982 did not specifically deal with infants and children. My Report sets outside limits for them, but additional work providing additional reassurance should be done.

Anjain et al argue that the established protection guides do not apply to the Rongelap people, since all of them have been exposed in the past. However, all 1600 members of the community were not exposed. Furthermore, the addition in the future of 1-2 rem per 30 years to an initial dose in 1954 of 200 rem, or a chronic dose over 1957-1985 of 3-4 rem, would be of no practical importance. The work of the BEIR V committee will not materially affect this statement.

MISCELLANEOUS

The Enewetak Comparison Anjain et al point to Enewetak Atoll as a model for the treatment of Rongelap. They claim that all of Enewetak Atoll was decontaminated -- including Enewetak Island. That being so, Rongelap Island should be decontaminated. Furthermore, they claim that no settlement was allowed on Enewetak Island until all work on the Atoll was completed.

I am puzzled by these statements. The resettlement of Enewetak Island occurred well before the decontamination of the Atoll's northern islands had been accomplished. Furthermore, no decontamination of the Island was done. There was, however, a "cleanup" to rid the Island of worn out equipment and trash, accumulated when Enewetak served as a logistical supply center for the testing program.

Intellectual Honesty Senator Anjain et al have frequently stated their mistrust -- if not contempt-- for DOE personnel (including scientists) and for myself. I therefore arranged and paid for Dr. Paretzke (Munich), a well-known German scientist, to visit Rongelap Island and Ailinginae Atoll in the presence of Senator Anjain to collect samples of soil, vegetation and meat, and to have them analyzed by two German laboratories, Lawrence Livermore Laboratory (DOE), and by an independent one in Berkeley. Dr. Paretzke concluded that the results showed inter-laboratory agreement and also confirmed previous work by Livermore.

Plutonium Mr. Franke recommends using the Durbin excretion functions, officially recommended by the ICRP in the calculation of plutonium dosage. Dr. Durbin has assured me that these functions should not be used in the present circumstances, nor did ICRP publication No. 54 recommend them for this purpose. Instead of the Moss function used by me, one could use the Jones function or that of Leggettt & Eckerman. Dr. Eckerman has told me that the 30-year dose might be twice what I have estimated, which on the basis of current Brookhaven analyses of urine remains trivial.

Plan C I have never heard of Plan C. The comments about it do not make sense to me.

National Academy of Sciences Review Panel I am quite willing to cooperate with such a panel.

Speera Panel I agree that all work relating to health, safety, ecology, etc., should be placed in one office at DOE, separate from weapons, and coordinated.

RECOMMENDATIONS

As matters stand now, and while awaiting the results of the National Academy's review, I would suggest setting up a small committee to deal primarily with Rongelap Island, and which later could deal with the rest of the Atoll. Immediate matters would be:

(1) The food issue -- immediate and long-term aspects, including continuation of USDA imports.

(2) Reviewing the Island's contamination problem, technically and psychologically. Would not the use of potassium, as demonstrated on Bikini, provide the necessary assurance concerning safety? Along with this, examining the concerns for infants and small children, and resuming whole-body counting to provide a base-line value for the return.

(3) Dealing with the needed reconditioning of infrastructure.

(4) Estimating the costs of these projects individually, obtaining the needed financial support, and assigning the contractor to the work.

In conclusion, I hope this material meets your immediate needs. If there are additional questions, please do not hesitate to call on me.

Sincerely yours,

Henry I. Kohn

Henry I. Kohn
Referee
Rongelap Reassessment Project

Enclosure

ADDITIONAL NOTES

Data and Results for DOE-1982 DOE-1982 was based on the aerial survey by the EG&G group (1981) and a minimal number of analyses of soil and vegetation on Rongelap Island by the Lawrence Livermore National Laboratory (LLNL). The report misstated the nature of the diet (this was an editorial blunder). The dose was calculated to be 2.5 rem (30 years) for residence on Rongelap, eating a specified diet, but five times greater for residence on Naen Island. Rongelap Island therefore met the U. S. radiation protection guide.

Subsequent Material My Report, published in 1988, included additional data from three sources.

(a) LLNL had reported on vegetation taken in 1986. These results agreed with the earlier ones, so the LLNL estimate of dose based primarily on diet remained the same.

(b) BNL (Brookhaven National Laboratory) had been studying the Rongelap people with a whole-body counter for about 30 years. I found the dose to be about one-half of the LLNL dose. Because the BNL dose is based on actual body scanning rather than on an assumed diet, it is considered to be the better one.

(c) The BNL data for plutonium, based on urinary excretion, appeared to be impossibly high. However, even using this invalid dose, the total BNL dose was within the protection guide limit. After the publication of my Report, BNL discovered that contamination of the urine samples was the cause of the difficulty. This result is being checked on 209 samples from 150 subjects, the work to be completed by July 1, 1990. Data from the first 60 samples indicate that true dose is very small -- no more than 5% of the total dose from all radionuclides (about 1.2 rem in 30 years). It is in practical agreement with the LLNL's estimate, based on diet.

(d) With respect to the model for the dose calculations based on the plutonium content of urine, the literature was reviewed by Leggett and Eckerman in Health Physics 52: 337-346, 1987. Furthermore, it has been pointed out that such models tend to overestimate the plutonium burden in tissues rather than to underestimate them (Kathren, Heid & Swint, Health Physics 53: 487-493, 1987).

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