August 21, 1979

Mr. Theodore Mitchell
Executive Director
Micronesian Legal Services
Corporation, Suite 300
1424 Sixteenth Street, N.W.
Washington, D. C. 20036

Dear Mr. Mitchell:

The Department of Energy is pleased to respond to your letter of August 3, 1979, in which you requested copies of a number of records pursuant to the Freedom of Information Act. The following responses are numbered to coincide with your numbered requests.

Item No. 1. The statement is based upon testimony presented by Messrs. DeBrum, Weissgall, Deal, DeYoung and Mrs. Van Cleve, and others at Hearings before Subcommittees of the Committee on Appropriations, House of Representatives, on April 12, May 22, and June 19, 1978. Copies of pertinent portions of that testimony are enclosed (Tab A). Additional relevant information is available in the Hearings testimony conducted by the Subcommittee on July 25, 1978. We do not have a copy of the final transcript of this testimony.

Reports from Brookhaven National Laboratory indicated that the Cesium-137 levels of Bikini residents increased with time until 1978, and decreased thereafter (post-relocation). These data were based upon whole body counting measurements. A summary of this information is enclosed (Tab B). This increase in body burden coincided with increased availability of locally grown terrestrial foods, particularly coconuts. The Cesium-137 measurements suggest that either the quantity of imported food available to the people or the quantity of available imported food consumed by the people was below that level needed to moderate the increase in Cesium-137 body burdens as locally grown foods became available.

Item No. 2. The aerial photographs of Bikini Atoll (which I believe have previously been sent to you) show that the Bikini and Eneu Islands are separated by approximately five miles of reef. At low tide it is possible to walk from one island to the other. Considering the facts that the island of Bikini is the longed-for home of the Bikini people, that houses already exist on the island, and that tens of thousands of coconut trees are on the island, we feel that it is valid to raise the question of whether or not access to Bikini Island can be controlled if the people reside on Eneu Island. (See also previous comments of Mr. DeBrum.) There are no other records covering the request in Item No. 2.

Item No. 3(a). The Department of Energy has no records bearing upon this subject. Inquiries of this subject presumably should be directed to the Department of Interior.

Item No. 3(b). Please refer to the Brookhaven National Laboratory information provided in (1) above. If body burden levels of Cesium-137 were to be equal to or greater than 3 μCi, it would be expected that radiation exposure levels at or above 500 millirem per year would result. This assumption is based upon Publication 2 of the International Commission on Radiological Protection (Report of Committee II on Permissible Dose for Internal Radiation). In that publication it is stated that the maximum permissible body burden of Cesium-137 (assuming that the total body is the organ of critical reference) for occupational exposure is 30 μCi (see Tab C). Since the occupational exposure limit is 5 rem per year, the body burden of Cesium-137 resulting in an exposure level of 1/10 of 5 rem per year (i.e., 500 millirem per year) is 1/10 of the 30 μCi value, or 3 μCi.

Item No. 4. Lawrence Livermore Laboratory (LLL) currently is in the process of preparing technical articles for publication in the scientific literature addressing these issues. Consequently, the articles as such do not yet exist, and the Department of Energy obviously does not possess them. However, enclosed (Tab D) is a copy of information which the Lawrence Livermore Laboratory sent to the Department of Energy consisting of the food concentrations of radionuclides which LLL used in calculating the dose estimates under discussion.

Item No. 5. The substance of the request addresses the basis of the decision to employ the Federal radiation guidance. The most relevant basis for this is the Federal Radiation Council guidance as presented in the Federal Register over the signatures of Presidents Eisenhower and Kenned

The text on page 6 and footnote 10 on the same page address the AEC recommendations for planning at Enewetak, the bases for which are in the Environmental Impact Statement.

Item No. 6. Lawrence Livermore Laboratory (LLL) is in the process of preparing this document. It is not yet available. The dose estimates were provided by LLL, however, and copies of what the Department received are enclosed (Tab F).

Item No. 7. In response to your FOI request in Item No. 7, the records you requested are at the Lawrence Livermore Laboratory. They are in the process of being assimilated. As soon as they are forwarded here, it will be determined whether they can be released and you will be promptly notified. We anticipate no problems at this time.

Item No. 8. Risk estimates of somatic or genetic consequences of various radiation exposure levels were not made. Risk estimates for some of the radiation exposure values identified (i.e., 170 millirem per year and 5000 millirem per 30 years) are given in the summary statement of the National Academy of Sciences-National Research Council's Report of the Advisory Committee on the Biological Effects of Ionizing Radiation (Tab G).

The Atomic Energy Commission Task Group Report published in the Enewetak Environmental Impact Statement, Volume II, Tab B, pages III-11 and 12 provides a somatic risk assessment for a radiation exposure of 250 millirem per year, the recommended radiation protection criteria for the whole body and for bone marrow.

Item No. 9. No such documents exist.

We trust that this information is responsive to your request.

Sincerely,

Bruce W. Wachholz, Ph.D.
Office of Environment

7 Enclosures

bcc: Mrs. Van Cleve, DOI
Mrs. Clusen, ASEV
Mr. Hollister, ADASEV
Mr. Whitnah, OMS
Dr. Weyzen, OHER
Mr. Deal, OESD
Mr. McCraw, OESD
Mr. Brown, OGC
Mr. Gelband, AD-44

CONCURRENCES
OTI:PA
8/21/79
OESD
McCraw
8/21/79
OESD
Deal
8/21/7
OGC
Brown
8/21/7

TAB

A

Mr. YATES. Were the Bikini people under Federal radiation standards?

Mr. DEAL. They were but the radiation dose from intake of food had begun to rise.

Mr. YATES. Did any go over the top?

Mr. DEAL. None of the people have gone over the top as far as the cesium levels. They are very close to the maximum allowable dose from the maximum of permissible amounts of cesium.

Mr. YATES. Are the people living in the houses along the road?

Mr. DEAL. Yes, and they are getting the radioactivity in their bodies from their diet, from eating the locally grown foods.

In retrospect, this is probably the big mistake made in the beginning of the resettlement program in that we made recommendations which turned out to be impractical in the sense that to have gardens growing but then tell the people not to eat the products.

Mr. YATES. Was he told to grow his garden and eat that food? Was he told that he could do that?

Mr. DEAL. The original recommendations prohibited eating certain of the local foods.

Mr. YATES. This is right. But I think I read here the houses were built on pads of coral and that they were told not to eat the coconut crab. You say you brought in outside foods at the initial stages.

Was this to cut down on the possible intake of radiation residuals? Did you bring in outside food from the start?

Mr. DEAL. Yes, sir.

CURRENT FEEDING PROGRAM ON BIKINI ISLANDS

Mr. YATES. I guess outside food is still being brought in.

Mr. DEYOUNG. It was not until early last year, Mr. Chairman, that the tree crops and some of the other vegetable crops began to become fully productive. So up until 1977 they had been existing primarily on food products that were brought in from the outside. Some of these were surplus agricultural commodity foods plus the local marine food which had been certified to be suitable.

MONITORING OF BIKINI ISLAND

Mr. YATES. When did they get the cesium then?

Mr. DEYOUNG. As Mr. Deal indicated, when this high level of cesium was revealed, a series of analyses were carried out.

Mr. YATES. When was it revealed?

Mr. DEYOUNG. In 1976.

Mr. YATES. Then the Department—were you still the AEC in 1976?

Mr. DEAL. We were ERDA in 1976.

Mr. YATES. So you became a little more alarmed than when you were the Atomic Energy Commission. In '76 you first encountered this kind of a test. Is this an annual test that you had been making of the people?

Mr. DEAL. Yes sir.

Mr. YATES. What kind of tests, monthly, semiannually, every four months, or what?

Mr. DEAL. I can supply you a statement for the record. I will give you some information and we will supply a summary.

[The information follows:]

Chronology of Radiological Surveys—Bikini Atoll

Year and type of survey	*Findings*
August 1964: Early radiobiological survey of Bikini and Enewetak Atolls conducted by the University of Washington for AEC. Measurements and sampling were directed toward external radiation, soils, plans, water, and fish.	Photographed and identified organisms on reefs and islands. No gross anomalies seen in plants and animals due to radioactivity. See UWFL-93.
April 1967: Survey to fill in gaps in data in order that dose estimates can be made for Bikini Atoll residents. Team led by University of Washington. External radiation measurement by the AEC Health and Safety Laboratory, HASL.	Major contributor to total exposure on Bikini and Eneu Islands is Cs-137. Levels vary considerably from island to island in the Atoll. See HASL-190.
February 1969. Survey work done concurrently with cleanup operations by University of Washington scientists for AEC, and by scientists of the Western Environmental Research Laboratory of the Environmental Protection Agency, EPA, under a memorandum of understanding with AEC.	Confirm earlier survey results for external radiation. Cs-137 and Sr-90 predominate in terrestrial organisms. Co-60 and Fe-55 in marine organisms. See NVO-269-6.
June 1970: Team led by University of Washington with participation by Staff of the Public Health Service and AEC. Collection of the first air samples. Also collected soils, plants, animals and made additional external radiation measurements.	Confirm earlier survey results. Levels of Pu in air are two orders of magnitude below FRC guides. See SWRL-111r.
May 1972: Followup survey conducted after coconuts planted on Bikini and [illegible] Islands and housing construction started on Bikini Island. Team led by University of Washington with participation by scientists from the Western Environmental Research Laboratory, EPA, and AEC. Team performed air sampling, collected soils, plants, animals, and made external radiation measurements.	Radionuclide levels slowly decreasing. Earlier estimates confirmed by these data.
April 1974: Followup survey of numerous Atolls, including Bikini, conducted jointly by staff of University of Washington and Brookhaven National Laboratory for the AEC. The survey team collected samples of soils, plants, animals, ground water, and made external radiation measurements.	SSee BNL 50474 and NVO-269-32[1].
[illegible]: S[illegible]y of numerous [illegible] conducted jointly by University of Washington and Brookhaven National Laboratory for the AEC. Samples of soil and food collected along with external radiation measurements.	See NVO-269-32[1] and BNL 50796 in press.

April 1975: Preliminary survey of Bikini and Eneu Islands conducted jointly by University of Washington and Brookhaven National Laboratory for ERDA. Screening survey of external radiation levels and collection of some soil and vegetation samples in preparation for a major survey later this year.	See NVO-269-32[1] and BNL 50796.
June 1975: A major fine grid survey of Bikini and Eneu Island external radiation levels was conducted by Lawrence Livermore Laboratory for ERDA with participation by scientists from EPA, University of Washington, Brookhaven National Laboratory, and ERDA. Also samples of soil, plants, animals, and cistern and ground water were collected.	Exposure rates on Bikini Island highly variable. Eneu Island dose rates lower than Bikini. cistern water on both islands is acceptable for drinking. Some well water acceptable, other wells unacceptable for drinking. See UCRL-51971, 51879 Rev. 1, 51913 Pt. 1, 52170, 51879 Part 2, 51879 Part 3, 51879 Pt. 6, NVO-269-32[1] and BNL 50796
April 1976: A survey of external radiation levels on Nam Island, the 3d largest island at Bikini Atoll, conducted by Brookhaven National Laboratory for ERDA.	To be published.
September 1976. Conduct of a joint survey of 5 Atolls including Bikini by University of Washington and Brookhaven National Laboratory for ERDA. Surveyed external radiation levels and collected environmental samples.	To be published.
April 1977. Site visits by Brookhaven National Laboratory to plan installation of windmill powered air sampling stations. Bikini Atoll one of four sites for long-term air sampling. Work supported by ERDA.	Site identified, agreement obtained.
October 1977: Brookhaven National Laboratory installed wind-powered long-term air sampling station on Bikini Island. Work supported by DOE.	Data not yet available.

In vivo Counting and Urine Bioassay Sampling—Bikini Atoll

Year — *Sampling/Counting*[2]

1970[3]: Pooled urine collected, analyzed for Sr-90, Cs-137, and Pu-239.
1971[3]: Pooled urine collected, analyzed for Sr-90, Cs-137, and Pu-239, 240.
1972[3]: Pooled urine collected. Cs-137 concentration shows factor of 4 increase over 1970. Sr-90 increase is factor of 2.
1973[3]: Cs-137 in urine higher than 1970 by factor of about 10. Sr-90 increase is factor of 4.
April 1974[3]: First in vivo counting of Cs-137 in Bikini residents. Cs-137 urine values about same as 1973. Sr-90 levels down near 1970 values. Pu-239, 240 higher than 1971 by factor of about 5.[4]
April 1975: Pu-239, 240 higher than 1971 by factor of 10.[4]
Fall 1976: Pu-239, 240 higher than 1971 by factor of 2.[4] Cs-137 urine values

[1] Results from several surveys published in one report. Sr-90 and Cs-137 are dominant in the terrestrial environment. Co-60 and Fe-55 in marine environment, and Am-241 and Pu-239, 240 are important in soils. Radioactivity on Bikini Atoll has declined significantly ... time.

[2] Sampling sec. different individuals at different times as people come and go at Bikini Island.

[3] See BNL 50424, Sept. 1975.

[4] These results suspect, samples may have been contaminated, error in measurement is ±100 o/o.

higher than 1970 by factor of about 20. Sr-90 higher by factor of about 5. Memo Conard to Liverman, May 11, 1977.

May 1977. Second in vivo counting of Bikini residents. Collection of large volumes urine samples results suspect. The average Cs-137 burden for 22 individuals in 1977 is 10 times the average for 8 individuals in 1974. Two individuals had body burdens of Cs-137 of 26 nCi/kg which is very near the maximum permissible burden of 43 nCi/kg. Memo Conard to Liverman, May 11, 1977.

October 1977: Large volumes urine samples collected under controlled conditions to avoid cross contamination. Results to be available in May 1978.

Mr. DEAL. We made resurveys of the Bikini environment, including soil and groundwaters in 1969, 1970 and 1972. Annual collection of urine samples for radiation analysis began in 1970, and with those people who were working for the agricultural and housing projects.

Mr. YATES. Are these only Bikinians?

Mr. DEAL. Yes, sir.

Mr. YATES. Did you have non-Bikinians working for them at that time?

Mr. DEAL. I can't answer that, sir.

Mr. DE YOUNG. It is my understanding that there were other Marshallese in the work force who were not from Bikini.

Mr. YATES. You examined them as well. Were they examined through that time?

Mr. DE YOUNG. Yes, as long as they were on the island.

Mr. YATES. Go ahead.

Mr. DEAL. We later included collections from the people who had returned to living in the houses; monitoring the Bikini residents was done by whole body counts in 1974 and 1977.

Mr. YATES. What is a whole body count?

Mr. DEAL. That is a very sophisticated counting system where you essentially sit in a chair and where you have a counter that detects radiation from the cesium that has been taken up in the body. It actually counts the body's burden of cesium.

Mr. YATES. Is that the same strontium?

Mr. DEAL. They travel together in the body. You can see that the strontium is——

Mr. YATES. These are like the heavenly twins.

Mr. DEAL. You can measure the strontium with urine samples, but we have not been able to see much of that in the urine samples available to date. They do the whole body counting sample for cesium.

We had a major resurvey of Bikini and Eneu Islands in 1975.

RESULTS OF THE 1975 RADIATION SURVEY

Mr. YATES. Until '75 you found nothing. What did your tests show?

Mr. DEAL. That is when we began to see the rise in the cesium.

Mr. YATES. Will you place in the record a statement representing the levels you found?

[The information follows:]

MEAN CESIUM-137 LEVELS OBTAINED BY WHOLE BODY COUNTING - 1974*

	MALES			FEMALES		
	No.	μCi**	nCi/kg body wt.***	No.	μCi	nCi/kg body wt.***
Bikini	8	.128	1.84 (0.43-5.11)	13	.073	1.15 (0.22-3.26)
Utirik	9	.262	4.05 (2.64-6.84)	13	.133	2.13 (0.96-3.85)
Rongelap	22	.475	7.76 (4.37-16.3)	24	.304	5.13 (2.71-13.46)
BNL med. team	4	.003	0.0352 (0.0134-.0791)			

*Reference - BNL50424, "A Twenty-Year Review of Medical Findings in a Marshallese Population Accidentally Exposed to Radioactive Fallout," Conard, September 1975.
**Microcuries
***MPC 43 nanocuries per kilogram

MEAN CESIUM-137 BODY BURDENS IN ADULT MARSHALLESE - 1977*

	MALES			FEMALES		
	No.	μCi**	nCi/Kg Body Wt***	No.	μCi	nCi/Kg Body Wt
Rongelap	34	0.296 ±0.11**** (0.113-0.680)*****	5.04 ±1.97	20	0.182 ±0.055 (0.097-0.278)	3.13 ±1.1
Utirik	27	0.119 ±.048 (0.050-0.215)	1.79 ±0.77	21	0.0781 ±0.032 (0.038-0.131)	1.29 ±0.58
Bikini	22	1.301 ±0.73 (0.568-3.232)	19.1 ±10.6	20	0.926 ±0.47 (0.534-2.234)	14.8 ±6.3
Medical Team	7	.00154 ±0.00052 (.00105-.00216)	.0195 ±0.006			

*Reference memo Conard, BNL, to Liverman, May 11, 1977
**Microcuries
***Nanocuries per kilogram of body weight
****Standard deviation
*****Range

MEAN CESIUM-137 BODY BURDENS IN MARSHALLESE CHILDREN - 1977*

	MALES			FEMALES		
	No.	µCi**	nCi/Kg Body Wt***	No.	µCi	nCi/Kg Body Wt
Rongelap	5	0.217 ±0.044**** (0.168-0.246)*****	7.65 ±1.21	5	0.265 ±0.092 (0.154-0.396)	5.97 ±2.1
Utirik	5	0.0663 ±0.018 (0.049-0.091)	2.22 ±0.66	5	0.0843 ±0.024 (0.051-0.108)	2.84 ±1.1
Bikini	3	1.04 ±0.26 (0.824-1.331)	32.3 ±7.6	3	0.861 ±0.29 (0.706-1.196)	22.3 ±15.3

*Reference memo Conard, BNL, to Liverman, May 11, 1977
**Microcuries
***Nanocuries per kilogram of body weight
****Standard deviation
*****Range

Mr. YATES. Then in '75 all of a sudden now that you are ERDA you find the rise.

Mr. DEAL. In '75 we were asked by the Department of Interior for advice on building additional houses in the interior of Bikini Island.

It was at that time we mounted a rather large survey effort which included a lot of people going out and walking around the island with instruments. We have very large surveys done at that time with 30 or 40 people going out and making measurements of the soil, water samples, vegetation samples, and measuring the external radioactivity.

Mr. YATES. Were these tests being taken prior to 1975 as well?

Mr. DEAL. Yes. But not anywhere near the scale we did this time. We concentrated on Bikini Island. It is precisely for this reason we want to have an aerial survey because we can cover much more territory and much faster and we can see the same levels.

When you have a person walking around, it takes more time.

Mr. DUNCAN. I understood you to say that this rise in the level of measurements of strontium began in '75 and that your preliminary analysis indicates that it is coming from the food source and that that food source began to mature last year.

How can we measure the increase in '75 when you say that it is coming from the food if the food wasn't being produced until '77?

Mr. DEAL. That is a very good question.

Mr. McCraw has done a lot of those surveys.

Mr. McCRAW. When the people first returned, there were few if any terrestrial food items grown in Bikini Island soil, and available for their use. There are some things that grow wild. There were a few coconuts and arrowroot. There was a significant planting of coconut trees during the arigcultural rehabilitation effort.

Mr. DUNCAN. Those were the ones that began maturing in '76? Am I not correct? We are in '78, so last year would have been '77. But now he is saying that the planting began to mature and it was '76, so we are narrowing the gap.

Mr. DEYOUNG. It started in '76.

Mr. DUNCAN. It could be coconut or arrowroot that was being consumed prior to '76. You began to notice a rise in the levels of cesium and that those levels have risen more rapidly since the domesticated plants matured and were consumed by the inhabitants.

Mr. McCRAW. We were initially using a predictive capability for a number of items in the diet that are now growing in the atoll. All we could do at first was sample the soil and try to predict the levels in food.

Mr. YATES. Where were they coming from? You said a number of items were not being grown.

Mr. McGRAW. A number of items of the normal diet were not locally available when the people first went back. Those things have subsequently become available and we are seeing an increase in availability, an increase in uptake, and you can't see at what exact point in time things occurred.

Mr. DUNCAN. Is there a level of sophistication to measure this that has been increasing? So we might attribute the greater levels to a greater ability to measure what was there all along?

[illegible] Yes [illegible] measure it easily. You can always measure if [illegible] samples [illegible] soil and vegetation and went through a very costly

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laboratory procedure. But now we can do the same thing with instruments that are stationary.

CURRENT METHODS OF MONITORING

Mr. DUNCAN. What about the measurement of the levels of cesium in the body of the Bikinians? Is that increasing in sophistication so that your measures can detect levels that were previously undetectable?

Mr. DEAL. Let me answer that a little differently. Several years ago no one would have thought you could take a whole body counter into the field. Now it is engineered to be taken out into the field.

Mr. DUNCAN. You did early in 1975. But your first whole body count began in——

Mr. MCCRAW. '74.

Mr. YATES. Is that when you first detected the increase?

Mr. MCCRAW. That is the first measurement of cesium in people. We had predicted what the levels would be.

Mr. DUNCAN. Were your measurements in accordance with the prediction?

Mr. MCCRAW. Yes. All of the surveys that we have done have tended to support the earlier findings. We have gotten a better body of data and more confidence in the radiation doses we are predicting, and we are looking at the actual items of the diet and do not have to rely on estimates of radioactivity in the foods that the people are eating.

Mr. DUNCAN. But your whole body counts in '74 were not alarming. It wasn't until you went back in '75 with your major resurvey that you saw the rise begin?

Mr. MCCRAW. In 1975 we began to predict higher doses on the basis of samples we had collected. In 1977 when the second whole body count was done the levels were a factor of ten higher than in 1974.

FEDERAL STANDARDS AND CURRENT BIKINI LEVELS

Mr. YATES. Above the Federal standards?

Mr. MCCRAW. If I might explain about the standards. There are two numbers. One is for the local population. The other is for an individual where you know the individual's exposure. We have not exceeded that individual number. We have seen levels approaching this lower number for the general population. We feel that we can use the higher number or the standard because we are actually measuring the levels of radioactivity in individuals in the population. We know the distribution. We know the highs and we know the lows.

Mr. YATES. Who is to say that the Federal standards are accurate? How do you know the Federal standards are acceptable?

Mr. DEAL. We don't.

Mr. YATES. Why do you establish standards and say if you come to the standard everything is fine, and if you go above this standard it is not fine. How do you know the Federal standards are not carcinogenic?

Mr. DEAL. I think in the radiation protection field that we are concerned with we have another philosophy which is the lowest practicable solution to a problem and it is believed that the people who work with radiation will not receive——

Mr. DUNCAN. If we gave a whole body count to Mr. Yates right now, would your sophisticated measurements show some level of cesium in him?

Mr. McCRAW. Yes.

Mr. DUNCAN. Do you have any way of knowing that he will not get cancer?

Mr. McCRAW. No.

Mr. DUNCAN. That is all I have. I have to go to another committee. I just wanted to worry you.

Mr. YATES. Wait one half minute for my question.

Getting back to my comment about the Federal standards, my son was treated for a tonsil disease in 1944 by then applicable medical standards. He was given radiation in the treatment of his tonsils. Everyone thought it was great. It was a common medical practice. Thousands of young people were having their tonsils removed or shriveled as a result of this treatment. He, like all the others of that age group, are now threatened with cancer because of having been irradiated 25 years ago. So now these people—I assume the radiation he received may have been comparable to the ingestion of cesium or strontium.

The thought occurs to me, and I talked to the cancer specialists at NCI in connection with some of the herbicides and additions to food, and they say amounts really don't mean very much at any particular time. The question is what will be the effect 25 years from now as a different kind of stimulant or carcinogenic material is brought to bear on the body.

So getting back to the question of Federal standards, five years from now you might decide in the new Department of Energy that the levels you established are much too high and that you should establish lower standards because you have, as Mr. Duncan pointed out, more sophisticated equipment.

Mr. McCRAW. It is not a problem of being able to measure the dose level. It is knowing the effect.

Mr. YATES. You might go now.

Mr. DUNCAN. It is a question of exercising our best judgment. I would suggest that five years from now you might even be able to sustain even lower levels.

Mr. McCRAW. We are looking at 30 year standards, to keep the dose down for a long period of time. We are trying to keep the dose in a year below the annual standards, and all the 30 year doses below the 30 year standard.

SAFETY OF BIKINIANS UNDER PRESENT CONDITIONS

Mr. YATES. That brings us to the question at hand. What are you going to do? You have the level of cesium and strontium in the Bikinians rising over the years. They are still on their island.

Have you told them to get off? For your own good, you ought to move?

Mr. DEAL. Mr. Chairman, I don't know that anyone thinks that this is a life threatening situation at this time.

Mr. YATES. Really?

Mr. DEAL. It is the kind of thing that if you let it continue over a long period of time then it would begin to be of hazard to their health.

Mr. YATES. What happened to Mr. Pincus' article on March 19 where he says—the article is titled, "U.S. Erred on the Safety of Return to Bikini Island."

Nine years ago the U.S. Government told the Bikini Islanders it was safe to return to their atoll, once the site of nuclear weapons tests in the Pacific. Some of the islanders went home. But now the government has found that it was wrong. According to tests last year the groundwater in Bikini is still too radioactive for human consumption. So are the coconuts and fruits and vegetables grown in the still contaminated soil. So the Interior Department has very quietly asked Congress for $15 million to move the islanders to another location.

Why are you asking for more money if it is safe? Is it safe? Safe is a relative term, isn't it?

Mr. DEAL. Yes, it is. If it was practicable for the people to only eat outside food and maybe have to drink outside water, then we think that goes within the Federal standards, and that is the only guideline we have to go with.

Since that is not a practical solution and we do see a rise in the cesium in the whole body counting, we believe that they should not be allowed to eat the food on the island, and it is probably not a practical situation. Any additional resettlement should be on Eneu Island where they can have their schools and other facilities. That is the direction they should move and not try to do that on Bikini Island.

Mr. YATES. Should they stay there is the question. Who is exercising the judgment on whether they should stay there? Haven't the levels been increasing? Our friend has said they are almost up to the top of the Federal standards. If they stay there, won't they go over the top?

Mr. DEAL. The whole question is, if they were to not eat the locally grown foods on Bikini Island, would the radiation dose from cesium go down?

Mr. YATES. What will you do, bring in box lunches?

Mr. DEAL. That is the impractical part of the solution.

CURRENT FEEDING PROGRAM ON BIKINI

Mr. WINKEL. If I might speak to this part of the discussion, because it brings in the present time period. What is being discussed illustrates, as you have pointed out, one of the difficulties of administration. Decisions must be based on available information. Our decisions have to be based on the information which you have been given, which I also have been given, by representatives of the Department of Energy that local conditions would be safe if ample outside food supplies were provided for the people on the island. In addition, we provided equipment for fishing in the lagoon. The outside food is sent in on a regular basis. These food supplies, while not attractive in all respects from the point of view of the normal diet, because some USDA preserved foods are included, provide a food standard which is in terms of nutrition far above the average as far as diet in the Trust Territory is concerned.

Mr. YATES. What does that mean? You deliver K rations to them? What kind of food are you talking about?

Mr. WINKEL. Dried foods, fresh fruits and vegetables from Ponape, as varied a diet as far as protein, starch, carbohydrates is concerned. It is prepared by nutritionists.

Mr. DEAL. I don't know why they don't count the children. It may be a question of sitting still.

Mr. YATES. Why is that?

Mr. DE YOUNG. I am informed by the medical authorities at Brookhaven, that the children under 5 are too small to be subjected to the whole body counts.

Mr. YATES. Why?

Mr. DE YOUNG. I don't know whether it is the size of the child or whether the measurement itself might have some effect on the child, but the whole body count is not given to children under 5 years.

Mr. YATES. Is there an application of some kind of radiation in the test itself?

Mr. DEAL. No, sir.

Mr. YATES. Then why don't they give it to the children?

Mr. DE YOUNG. Dr. Weyzen from D.O.E. is here.

Mr. DEAL. This is Dr. Weyzen from our medical group.

Dr. WEYZEN. There are two problems. One involves lying still for about 20 minutes. I think that is a problem with the children. [illegible] serious problem is the calibration of the instrument. It is [illegible] calibrated for small persons. You get an erroneous reading.

Mr. YATES. For all we know, the children may have been contaminated too?

Mr. DEAL. Yes, sir. If they have been drinking the coconut milk.

CAUSES OF RADIATION EFFECTS ON BIKINI ISLAND

Mr. DUNCAN. What accounts for the rather extreme variations, from 0.270 which is within your limits to 1.180?

Mr. DEAL. I am at a loss to answer that, Mr. Duncan, unless the possibility that some of them didn't eat as many coconuts or drink as much coconut milk. There could be some variations of some kind in their metabolism. I really don't know.

Mr. YATES. Does anybody know?

Mr. McCRAW. Yes, I know. Basically two things account for the variation. One is just how much of the various locally grown foods various individuals are eating. The other is that some of the people have been living on the island longer [illegible] population did not return en masse to live on the island. They came back a few at a time over a period of several years.

Mr. YATES. Starting when?

Mr. McCRAW. About 1972, I believe, the earliest ones came in about 1972, so some people have been there 6 years, some 5 years, some have been there 1 year or less. The body burdens of cesium increase as a function of time, so the individuals in the population that have been there the longest and have been eating the largest quantities, basically of coconut, have the highest burdens and are receiving the highest radiation exposure.

Mr. YATES. I have the impression that you told the committee that in 1977 you suggested to the people on the island they ought not to eat the food there, but that you would provide the food from outside sources. If that is true, why did the count nevertheless go up in 1978?

Mr. DEAL. We understand that they have been eating coconuts. I wasn't there so I am telling you what survey team members repeated to us. They said that the people have been eating some coconuts. They had a drought, and a shortage of fresh water, and they were drinking more of the coconut milk than they might ordinarily.

OUTSIDE FEEDING PROGRAM FOR BIKINI RESIDENTS

Mr. YATES. Did they eat the coconuts and did they drink the milk because you weren't providing them with adequate food and water?

Mr. DEAL. I will have to defer to our friends in Interior on what was provided.

Mr. YATES. Will somebody answer that? Who are his friends in Interior?

Mr. DEAL. I am not sure.

Mr. YATES. Apparently you don't have any friends.

Mr. DEAL. I was afraid of that.

Mr. YATES. Somebody ought to answer that question.

Were you on duty then, Mr. Winkel? When did you take office?

Mr. WINKEL. I took office in June of 1977.

Mr. YATES. Who did you have in charge of this operation?

Mr. WINKEL. I was in charge of the operation, and under me the District Administrator was in charge of the operation. The feeding program was initiated in October and November of 1977, and ample food supplies to provide a balanced diet were delivered, have been delivered. Nutritionists accompanying these supplies and staying with the people for a period of time to help them and assist them in the utilization of the food and so forth. We have no reason to believe the food was not consumed, inasmuch as there is no evidence of unconsumed quantities in any size at all.

Mr. YATES. What kind of food did you deliver to them? Did you also deliver water to them?

Mr. WINKEL. U.S. Department of Agriculture foods, and fresh foods from Ponape, and water was delivered. I do not know myself in what quantities.

Perhaps the District Administrator could respond to that, because he has accompanied one of the shipments in the first instance.

Mr. YATES. Let's hear from him.

What we are trying to find out is why they went back to the coconuts and the milk if they were warned against eating the coconuts and the milk?

Mr. O. DEBRUM. I am the Deputy Administrator of the Marshall Islands.

Coconut is something that the people can see. They will drink the milk. They do that even when we visit the island periodically. They offer us coconuts to drink, so as long as they have coconuts in their surroundings, I do believe that they will drink it.

Mr. YATES. Even in the face of warnings not to drink it?

Mr. O. DEBRUM. Yes, sir.

Mr. YATES. Then they continue to eat the coconut and drink the milk and eat the food that the government gives them.

Mr. O. DEBRUM. The last time I was there they were still eating the coconuts. They have been told not to eat them. To stop them from eating that, sir, we have to remove the people from the islands or cut down the total number of trees.

Mr. YATES. That is the only way you can do it.

DESIRE OF BIKINIANS TO REMAIN ON BIKINI ATOLL

Mr. YATES. Your letter indicates that the Bikinians want to stay on the atoll. Is that impossible?

Mrs. VAN CLEVE. In our judgment, it would be improper for them to remain because of the medical risks involved, and the Department of Energy agrees with that conclusion.

Accordingly, we mean to persist in our plans to relocate them, this in the interests of their physical safety. We recognize, of course, their preference to remain. That is why we have had this problem for some 30 years and it will continue for some decades hence. We are simply trying to meet it in the most reasonable way we know, recognizing the physical threats that exist if they remain on Bikini Island.

CAUSES OF RADIOACTIVITY ON BIKINI ATOLL

Mr. YATES. Let's look at it a minute before we go to the High Commissioner's statement.

The reason they cannot remain there is because of the radioactivity of the coconuts and water. It was the food, the intake, rather than the external causes that was the problem; is that correct?

Mrs. VAN CLEVE. I believe it is a combination of both.

Mr. YATES. That wasn't Mr. Deal's testimony the last time. As I remember his testimony the last time, it was internal causes rather than external causes; is that right, Mr. Deal?

Mr. DEAL. I think maybe both are right. The external radiation has to be considered. The internal is so high that it overshadows the external.

Mr. YATES. How potent is the external; and suppose you did not have the internal radiation? Would it be feasible for them to remain?

Mr. DEAL. The external radiation is about like Denver, Colo.

Mr. YATES. It would be as dangerous as Denver, Colo., is to those who live in Denver?

Mr. DEAL. Yes, sir.

Mr. YATES. They are not evacuating the city of Denver, are they?

Mr. DEAL. I hope not.

Mr. YATES. So, therefore, the amount of external radiation in the city of Denver is not considered sufficient for that city to be evacuated. I assume, therefore, that if that is the same condition on Bikini, the basic cause for your suggestion or your recommendation that Bikinians be evacuated is the ingestion of the food and the water; correct?

Mr. DEAL. Yes, sir.

Mr. YATES. Now if the Bikinians wanted to stay there, stay on their atoll, if they did not consume the water and the food that was there, I would deduce from what you say that it would be as dangerous for them to live on Kili or Jaluit or any one of the other islands as it [illegible] B[illegible] right?

Mr. DEAL. [illegible] sir, the other islands are quite——

Mr. YATES. That gets us to the basic question then: Can you feed them and give them water from other sources that would permit them to stay on Bikini so that they would not be taking in the radiated food and water?

Mr. DEAL. If you ask my opinion, Mr. Chairman, I have personally concluded that it is probably impractical to have people living in

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an area where they are able to farm it and to take the water from the area. I think that is a practical situation.

CONTAMINATION OF FOOD SOURCES

Mr. YATES. Suppose you were to plant other coconut trees. How long does it take coconut trees to come?

Let's ask the next question. We talk as though coconuts were the only food there. Isn't there other food?

Mrs. VAN CLEVE. There is, indeed.

Mr. YATES. What other foods do they eat?

Mrs. VAN CLEVE. Breadfruit, papaya, sweet potatoes.

Mr. YATES. Are all of these contaminated?

Mrs. VAN CLEVE. All of these have turned out to be contaminated when grown in Bikini.

Mr. YATES. That is because of the soil being contaminated?

Mrs. VAN CLEVE. That is correct.

Mr. YATES. And the contamination in the soil is transferred to the food, and there is no way they can grow food without it being contaminated; is this correct?

Mr. DEAL. That is correct.

Mr. YATES. How much of a chore is it to bring food in from the outside? Suppose it were a barren atoll; they didn't have the opportunity to grow things.

Mrs. VAN CLEVE. I think it is entirely feasible to bring food in from the outside. What we believe, however, also to be true, is that it is not feasible to expect the Islanders to live on an island and not eat the things that are growing there and not drink the water that is there. We could feed them entirely from outside sources, but we could not bar them effectively from eating local produce.

CONTAMINATION OF GROUND WATER

Mr. YATES. How do they get their water now? What is the water that is contaminated? Is it from wells?

Mrs. VAN CLEVE. It is a groundwater supply as I understand it, yes.

Mr. DEAL. My understanding is that there are some cisterns too, some runoff water from rain, but I think it is the wells too. They have to use the wells under certain conditions. There isn't enough cistern water.

Mr. YATES. There is not enough cistern water. The cistern water is not contaminated, is it?

Mr. DEAL. Not to any extent to cause them this kind of problem, sir.

Mr. YATES. And the well water is contaminated?

Mr. DEAL. Yes, sir, it is.

Mr. YATES. Is there any way of decontaminating the well water? Can you boil the contaminants out?

Mr. DEAL. No, sir. It would take a very sophisticated system of resins used in chemical processing to remove the radioactivity.

Mr. YATES. How difficult and how expensive is it?

Mr. DEAL. I really don't know. We have never looked at that problem that I know of, except back during the fallout days there was a question about decontaminating milk, and there was some looking at

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LOCAL FOODS BANNED IN 1974

Mr. YATES. We are now up to 1976. Let's go back to the interrogation on page 1171:

"Mr. YATES. Were you still the AEC in 1976?

"Mr. DEAL. We were ERDA in 1976.

"Mr. YATES. So you became a little more alarmed than when you were the Atomic Energy Commission. In 1976 you first encountered this kind of a test. Is this an annual test that you had been making of the people?"

Of course, in retrospect now my question is not correct, because you knew about it in 1974. You knew about the water certainly in 1974. In 1976 the coconuts were first becoming ripe. Mr. deBrum, together with the Bikinians, was eating the coconuts. But you were not drinking the water?

Mr. DEBRUM. Not the well water.

Mr. YATES. Were you eating the pandanus in 1976?

Mr. DEBRUM. Some people ate them.

Mr. YATES. They ate the pandanus. What else was growing there?

Mr. DEBRUM. Papaya was growing on the island.

Mr. YATES. Papaya. Anything else?

Mr. DEBRUM. Pumpkins.

Mr. YATES. Pumpkins?

Mr. DEBRUM. Yes.

Mr. YATES. And people were eating all of these things, all the vegetables?

Mr. DEBRUM. We had indication that some of them admitted they ate them, sir.

Mr. YATES. They ate them?

Mr. DEBRUM. Yes.

Mr. YATES. And were you told you were not to eat them?

Mr. DEBRUM. They were told that it was questionable, sir, and not to eat them.

INITIATION OF TIPI FEEDING PROGRAM

Mr. YATES. And all during the period starting in 1972, every month a ship came to Bikini with food?

Mr. DEBRUM. Yes.

Mr. YATES. And water?

Mr. DEBRUM. No, no water.

Mr. YATES. Just food?

Mr. DEBRUM. Yes.

Mr. YATES. So they were drinking the cistern water?

Mr. DEBRUM. Yes.

Mr. YATES. And you were supplying them with food. Were you supplying them with enough food?

Mr. DEBRUM. At times; we tried to supply them with enough. There were times when we could not get there in time, sir.

Mr. YATES. So in the meantime they had to eat coconuts?

Mr. DEBRUM. Sometimes they were eating coconuts, yes. They indicated that to us.

Mr. YATES. They did?

Mr. DEBRUM. Yes.

Mr. YATES. Why could you not get there in time?

Mr. DeBrum. We wanted to get there in time. At times we had serious transportation problems and were down to one ship for trips to the outer islands. Sometimes, the odds were against us, but we tried to do the best we could.

Mr. Yates. What do you mean, the odds were against you?

Mr. DeBrum. We were down to one ship for all the outer islands at times.

Mr. Yates. And one ship would not service the island or the people?

Mr. DeBrum. It takes three field trip ships to service, to make a complete circuit of the Marshall Island group, once a month.

Mr. Yates. How many ships do you need for the food for the people who were on Bikini? Was one ship adequate for a month's supply of food?

Mr. DeBrum. If we have one ship committed only to Bikini, yes, one ship will do it. The ship that is committed to service Bikini also services other islands in the Marshall Islands.

Mr. Yates. You mean provide food for the other islands?

Mr. DeBrum. It provides services, it brings in copra and takes in trade goods so the people can buy it.

FREQUENCY OF SERVICE TO BIKINI ISLAND

Mr. Yates. Maybe we had better find out about where y– work throughout the islands.

How long would your lapses be? Presumably your schedule was one ship a month with food for Bikini.

Mr. DeBrum. Yes.

Mr. Yates. And how often were there lapses in this?

Mr. DeBrum. Not very much. There were times, as I recall, when we could not provide a ship until it was a month and a half late, sir.

Mr. Yates. A month and a half late; you mean two weeks after the schedule.

Mr. DeBrum. Two weeks after.

TYPE OF FOODS PROVIDED

Mr. Yates. After the schedule date. And what kind of food? You said you provided staples? What do you mean by staples?

Mr. DeBrum. Staples in Marshallese terms is rice, flour, canned meats, milk.

Mr. Yates. No coconuts?

Mr. DeBrum. No coconuts.

Mr. Yates. I mean from the other islands.

Mr. DeBrum. We never shipped any coconuts from the other islands.

Mr. Yates. Why would you not? If coconuts were such a delicacy for the Bikinians, why would you not provide coconuts for them, too?

Mr. DeBrum. It was not a part of our feeding program, sir.

Mr. Yates. If you were a Bikinian you would have liked coconuts, would you not, from other islands?

Mr. DeBrum. I would be climbing a tree and getting it myself.

Mr. Yates. You would not worry about radiation.

Mr. McKay. How do you get coconuts in the program? What kind of a bureaucratic round-about do you have to go through to get them on the program?

Mr. DeBrum. I guess we just include it, make sure we have enough money to go around.

Mr. McKay. Would you have authority to approve it?

Mr. DeBrum. No, sir. It would have to be approved by the High Commissioner.

Mr. McKay. Could he approve it alone or would he have to get approval up here?

Mr. DeBrum. I think he has authority to approve it, the High Commissioner.

Mrs. Van Cleve. Yes.

Mr. Yates. Mr. DeBrum, you said if coconuts were not supplied to you as a Bikinian, you would be climbing the trees to get them?

Mr. DeBrum. Yes, if they were available on the island, yes.

Mr. Yates. And they are available on the island, are they not?

Mr. DeBrum. Yes.

Mr. Yates. So if you do not give them the coconuts they are going to climb the trees to get the coconuts, even if they are contaminated?

Mr. DeBrum. They have been doing that, sir.

NATURE AND THE TYPE OF ANALYSIS BY DOE

Mr. Yates. Let's go back to the interrogation.

"So you became a little more alarmed than when you were the Atomic Energy Commission. In '76 you first encountered this kind of a test. Is this an annual test that you had been making of the people?

"Mr. Deal. Yes, sir.

"Mr. Yates. What kind of tests, monthly, semiannually, every four months, or what?

"Mr. Deal. I can supply you a statement for the record. I will give you some information."

Then there is placed in the record on pages 1172 and 1173 a pretty good statement of tests that were made and a very bad estimate of the results of the tests. We find in 1964 the findings, "photographed and identified organisms on reefs and islands. No gross anomalies seen in plants and animals due to radioactivity."

1976 shows "exposure levels to the Bikinians varies considerably from island to island on the atoll."

February 1967, "confirmed earlier survey results for external radiation."

That does not tell us anything. "Cs-137 and strontium 90 predominate in terrestrial organisms. Co-60 and Fe-55 in marine organisms."

What does that mean, Dr. Deal?

Mr. Deal. It means that in the fish that they were catching they found cobalt-60 and Fe-55.

Mr. Yates. In large amounts?

Mr. Deal. I do not know, sir.

Mr. Yates. This result does not show that then?

Mr. Deal. No. We did not try to give you a complete copy of the reports. We just tried to give you the highlights of the surveys at the time, and probably, as you say, did a pretty poor job on that.

Mr. YATES. Yes.
Mr. McGRAW. And the value is 3.
Mr. YATES. Okay.
Mr. McGRAW. For Bikini 22 people in the sample. The value is 1.3, quite a bit higher than Rongelap, but still a factor of like a third of the standard that we would evaluate with. This is of course 1977 numbers.
As I recall the 1974 data, the value for Bikini was like .1. On the previous page the value for Bikini was .125, so between 1974 and 1977 the values went up by a factor of 10.

DATES OF WARNINGS TO PEOPLE OF BIKINI

Mr. YATES. If all this is true, sir, why four years ago in 1974 were you advising Mr. DeBrum to tell the Bikinians not to drink the well water and why were you then—you were bringing food in four years ago because there is no food on Bikini?
Mr. DEBRUM. That is right, sir.
Mr. YATES. Contaminated or noncontaminated, right?
Mr. DEBRUM. That is correct, sir.
Mr. YATES. Then the food came in two years ago, right? When did the coconut trees start maturing?
Mr. DEBRUM. About two years ago.
Mr. YATES. Were you allowing them to eat the food that was growing on Bikini two years ago, Mr. McGraw?
Mr. McGRAW. Were we allowing them two years ago?
Mr. YATES. Yes.
Mr. McGRAW. When was the recommendation made? Did you say four years ago?
Mr. DEBRUM. Yes, approximately about four years ago.
Mr. YATES. You have coconuts growing on Bikini two years ago. You have pandanus and papayas and breadfruit growing two years ago. Four years ago you told them not to drink the water, there was no food. Two years ago had you told them not to eat the food. Were you told not to eat the food two years ago?
Mr. DEBRUM. That was the time, four years ago, Mr. Chairman, that people were told that they were examining their food and they had suspected——
Mr. YATES. And they were told not to eat it?
Mr. DEBRUM. They were discouraged from eating.
Mr. YATES. Were they told not to eat the food all through this period? They were told not to drink from the wells all during this period?
Mr. DEBRUM. Yes.
Mr. YATES. Were they told not to eat the food all during this period too?
Mr. DEBRUM. Until further analysis convinced them otherwise.
Mr. YATES. The analysis never convinced them?
Mr. DEBRUM. Never convinced them.
Mr. YATES. So they were told all during this period not to eat the food?
Mr. DEBRUM. Yes.

?

ADEQUACY OF FOOD SUPPLIED BY TTPI ADMINISTRATION

Mr. YATES. And in the meantime you were bringing them food?

Mr. DEBRUM. Yes, sir.

Mr. YATES. Every month except where you lapsed?

Mr. DEBRUM. Yes, sir.

Mr. YATES. And there was adequate food for all of them?

Mr. DEBRUM. Yes.

Mr. YATES. You are sure of that?

Mr. DEBRUM. To the best of my knowledge sir.

Mr. YATES. Is that true, Mr. Weisgall?

Mr. WEISGALL. That is not quite the understanding of the Bikinians. As Mr. Leviticus has explained to me, the people living on Bikini would eat the food growing on the island even though they had been advised that it was questionable, when there simply was not enough food. The boats were not coming on as regular basis as was hoped for, and according to Mr. Leviticus, when a family would run out of food it would eat food growing on Bikini, be it coconuts, pandanus, or breadfruit.

REQUEST FOR MORE MONITORING OF BIKINI

Mr. YATES. Let's go back to Mr. Juda's statement.

Mr. NOTE. The second request we convey to you today, Mr. Chairman, is that your subcommittee closely monitor the upcoming radiological and foodstuff tests to be conducted at Bikini Atoll. The people living on Bikini Island desperately wish to remain on Bikini Atoll, and they are hopeful that tests on Eneu Island will show it to be safe. They understand that the recent test results are preliminary, and they hope that resettlement on Eneu will prove to be possible.

Mr. Chairman, we cannot describe the sorrow felt by our people as they learned, with bitter disappointment, that they must once again leave Bikini. Despite the contradictory statements of the U.S. Government over the last ten years, the people of Bikini have begun to understand the situation they face. They have told us that if the upcoming tests show that our people will not be able to live on Bikini or Eneu for the next 40 or 50 years, the people living in Bikini are prepared to relocate to Kili and Jaluit.

UPGRADING CONDITIONS ON KILI ISLAND

A move to Kili, however, and the establishment of Kili as a permanent home for the next two generations of Bikinians cannot come without help from the U.S. Government to develop Kili as a functional, livable community.

For almost 30 years we have lived on Kili, thinking each year that [illegible] move to Bikini the next year. As we face the possibility of 50 more years on Kili, it is clear that we must think and plan in longer terms.

As you know, Kili is an island with no reef and no lagoon, and access to the island is very difficult for most of the year. Faced with these conditions, our people have not processed copra in large quantities because boats visit this island rarely. Months frequently go by without a visit from passing ships, and our only communication with the rest of the world is by radio.

TAB

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BROOKHAVEN NATIONAL LABORATORY
ASSOCIATED UNIVERSITIES, INC.

Upton, New York 11973

Safety & Environmental Protection Division

(516) 345-4207

June 22, 1979

Dr. William L. Robison
L-452
Lawrence Livermore Laboratory
P. O. Box 808
Livermore, California 94550

Dear Bill:

The enclosed tables present dosimetric and body burden information on former Bikini residents. Net external exposure rates (background subtracted) were obtained from "External Exposure Measurements at Bikini Atoll", N. A. Greenhouse et al., BNL Report (in press). Dosimetric models were outlined in several informal reports and are available upon request. Input data were obtained from "Whole Body Counting Results from 1974 to 1979 for Bikini Island Residents", R. S. Miltenberger et al., BNL Report (in press) and from unpublished bioassay results. New information on the long term removal of ^{137}Cs is being derived from replicate counts of former Bikinians done in January and May 1979. This preliminary information is also included, but we would like to corroborate these results with urine bioassay data which will not be available for several more weeks.

If you have any questions or need additional information, please contact me at FTS 666-4207 or Bob Miltenberger at FTS 666-2503.

Sincerely,

N. A. Greenhouse

NAG/lm
Enclosures
cc: E. Lessard
R. Miltenberger
J. Naidu
T. McCraw (OES)
B. Wacholz (EV)

Individual Dosimetry Data for Bikinians - Explanation of Column Headings

Column	Item or Derived Quantity	Measured Quantity	Comments
1	Name	-	Personal Interview
2	ID Number	-	BNL Medical Dept. & S&EP Div. Records
3	Residence Interval	-	Personal Interviews
4	^{90}Sr and ^{90}Y Bone Marrow Dose Equivalent During and Post Residence Interval	Urine Activity Concentration	Three Compartment Model, Constant Continuous Uptake
5	^{137}Cs + ^{137m}Ba Dose Equivalent During and Post Residence Interval	Body Burden Measurements	Two Compartment Model, Monotonically Increasing Uptake
6	Net External Dose Equivalent During Residence Interval	External Exposure Rate Measurements	Assumed Living Patterns
7	Total Body Dose Equivalent	-	Sum of Columns 5 and 6
8	Total Bone Marrow Dose Equivalent During and Post Residence Interval	-	Sum of Columns 4, 5 and 6

INDIVIDUAL DOSIMETRY DATA FOR BIKINIANS

ID Number	Residence Interval Years	^{90}Sr & ^{90}Y Bone Marrow Dose Equiv. During & Post Residence Int. mRem	$^{137}Cs + ^{137m}Ba$ Dose Equiv. During & Post Residence Int. mRem	Net External Dose Equiv. During Residence Interval mRem	Total Body Dose Equiv. During & Post Residence Int. mRem	Total Bone Marrow Dose Equiv. During and Post Residence Interval mRem
6001	7.3	130*	480	950	1400	1600
6127	7.3	39	580	950	1500	1600
6130	.72	49	200	94	300	300
6076	3.3	9.9	900	430	1300	1300
813	4.3	77*	600	560	1200	1200
6019	5.3	190	420	690	1100	1300
6111	.80	7.7	150	100	250	260
6097	4.3	51*	430	520	950	1000
6115	7.3	97	760	880	1600	1700
6109	4.3	51*	240	520	760	810

INDIVIDUAL DOSIMETRY DATA FOR BIKINIANS (cont'd)

ID Number	Residence Interval Years	^{90}Sr & ^{90}Y Bone Marrow Dose Equiv. During & Post Residence Int. mRem	^{137}Cs + ^{137m}Ba Dose Equiv. During & Post Residence Int. mRem	Net External Dose Equiv. During Residence Interval mRem	Total Body Dose Equiv. During & Post Residence Int. mRem	Total Bone Marrow Dose Equiv. During and Post Residence Interval mRem
6091	6.3	74*	550	760	1300	1400
6132	2.3	62	1200	300	1500	1600
6046	2.0	27	400	240	600	700
6061	6.3	65	630	760	1400	1500
6066	3.3	59*	400	430	830	890
6070	10.3	185*	870	1300	2200	2400
6118	6.3	42	420	820	1200	1300
6117	6.3	110*	610	820	1400	1500
6128	7.3	130*	810	950	1800	1900
6122	10.3	86	380	1200	1600	1700

INDIVIDUAL DOSIMETRY DATA FOR BIKINIANS (cont'd)

ID Number	Residence Interval Years	^{90}Sr & ^{90}Y Bone Marrow Dose Equiv. During & Post Residence Int. mRem	^{137}Cs + ^{137m}Ba Dose Equiv. During & Post Residence Int. mRem	Net External Dose Equiv. During Residence Interval mRem	Total Body Dose Equiv. During & Post Residence Int. mRem	Total Bone Marrow Dose Equiv. During and Post Residence Interval mRem
6015	1.7	31*	650	220	870	900
6030	3.3	39*	1200	400	1600	1600
6129	4.3	51*	330	520	850	900
6027	3.3	39*	760	400	1200	1200
6010	7.3	86*	1100	900	2000	2100
6105	3.3	39*	1100	400	1500	1500
6033	8.3	150*	900	1100	2000	2100
6007	.88	15	190	110	300	310
6008	4.3	77*	850	560	1400	1500
6071	1.0	18*	220	130	350	370

INDIVIDUAL DOSIMETRY DATA FOR BIKINIANS (cont'd)

ID Number	Residence Interval Years	^{90}Sr & ^{90}Y Bone Marrow Dose Equiv. During & Post Residence Int. mRem	^{137}Cs + ^{137m}Ba Dose Equiv. During & Post Residence Int. mRem	Net External Dose Equiv. During Residence Interval mRem	Total Body Dose Equiv. During & Post Residence Int. mRem	Total Bone Marrow Dose Equiv. During and Post Residence Interval mRem
863	4.3	120	620	600	1200	1300
6086	8.3	240	990	1100	2100	2300
6069	8.3	150*	580	1100	1700	1900
6073	7.3	130*	490	950	1400	1600
6072	1.0	18*	330	130	460	480
6119	7.3	130*	730	950	1700	1800
864	7.3	130*	960	950	1900	2000
966	7.3	130*	1400	950	2300	2500
6059	1.3	15*	240	160	400	410
6124	.88	10*	180	110	390	400

INDIVIDUAL DOSIMETRY DATA FOR BIKINIANS (cont'd)

ID Number	Residence Interval Years	^{90}Sr & ^{90}Y Bone Marrow Dose Equiv. During & Post Residence Int. mRem	^{137}Cs + ^{137m}Ba Dose Equiv. During & Post Residence Int. mRem	Net External Dose Equiv. During Residence Interval mRem	Total Body Dose Equiv. During & Post Residence Int. mRem	Total Bone Marrow Dose Equiv. During and Post Residence Interval mRem
6058	5.3	63*	550	600	1200	1300
6036	.64	7.6*	260	77	340	340
6110	8.3	98*	450	1000	1400	1500
6051	5.3	63*	520	600	1200	1200
6092	6.3	74*	1600	800	2400	2400
6080	.88	10*	200	110	310	320
6038	2.3	27*	1100	280	1400	1400
6103	3.3	39*	1200	400	1600	1600
6028	5.3	63*	1200	600	1800	1900
6044	5.3	63*	1600	600	2200	2300

INDIVIDUAL DOSIMETRY DATA FOR BIKINIANS (cont'd)

ID Number	Residence Interval Years	^{90}Sr & ^{90}Y Bone Marrow Dose Equiv. During & Post Residence Int. mRem	^{137}Cs + ^{137m}Ba Dose Equiv. During & Post Residence Int. mRem	Net External Dose Equiv. During Residence Interval mRem	Total Body Dose Equiv. During & Post Residence Int. mRem	Total Bone Marrow Dose Equiv. During and Post Residence Interval mRem
6062	4.3	51*	540	520	1100	1100
6034	7.3	86*	880	900	1800	1900
865	7.3	86*	430	900	1300	1400
6050	2.3	27*	410	300	710	740
6009	4.3	77*	1600	600	2200	2300
6049	2.3	41*	1600	300	1900	1900
6042	.55	10*	510	72	580	590
6014	1.6	29*	1300	210	1500	1500
6012	7.3	130*	1500	950	2400	2600
6016	7.3	130*	1500	950	2400	2600

INDIVIDUAL DOSIMETRY DATA FOR BIKINIANS (cont'd)

ID Number	Residence Interval Years	^{90}Sr & ^{90}Y Bone Marrow Dose Equiv. During & Post Residence Int. mRem	^{137}Cs + ^{137m}Ba Dose Equiv. During & Post Residence Int. mRem	Net External Dose Equiv. During Residence Interval mRem	Total Body Dose Equiv. During & Post Residence Int. mRem	Total Bone Marrow Dose Equiv. During and Post Residence Interval mRem
6013	2.3	41*	1300	300	1600	1600
6094	6.3	74*	1300	800	2100	2200
6005	1.8	12	470	230	700	710
6135	1.3	11	330	170	500	510
6125	9.3	45	890	1200	2100	2100
6067	7.3	54	780	950	1700	1800
6002	2.3	7.7	370	300	670	680
6006	1.0	9.5	260	230	490	500
6112	1.3	12	260	160	420	430
6035	6.3	140	600	760	1400	1500

DOE ARCHIVES

INDIVIDUAL DOSIMETRY DATA FOR BIKINIANS (cont'd)

ID Number	Residence Interval Years	^{90}Sr & ^{90}Y Bone Marrow Dose Equiv. During & Post Residence Int. mRem	^{137}Cs + ^{137m}Ba Dose Equiv. During & Post Residence Int. mRem	Net External Dose Equiv. During Residence Interval mRem	Total Body Dose Equiv. During & Post Residence Int. mRem	Total Bone Marrow Dose Equiv. During and Post Residence Interval mRem
6096	3.3	46	680	430	1100	1100
80	1.0	18*	200	130	330	350
6017	8.3	330	1200	1100	2300	2700
6045	1.0	9.0	150	120	270	280
6108	4.3	43	210	520	730	770
6063	4.3	19	620	520	1100	1100
525	1.0	5.6	350	120	470	480
934	6.3	120	1300	760	2100	2200
6068	6.3	60	630	820	1500	1600
6106	3.3	39*	750	400	1100	1200
6025	3.3	39*	900	400	1300	1300

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INDIVIDUAL DOSIMETRY DATA FOR BIKINIANS (cont'd)

ID Number	Residence Interval Years	^{90}Sr & ^{90}Y Bone Marrow Dose Equiv. During & Post Residence Int. mRem	^{137}Cs + ^{137m}Ba Dose Equiv. During & Post Residence Int. mRem	Net External Dose Equiv. During Residence Interval mRem	Total Body Dose Equiv. During & Post Residence Int. mRem	Total Bone Marrow Dose Equiv. During and Post Residence Interval mRem
6113	4.3	19	360	520	880	900
6060	2.3	27*	510	280	790	820
6032	3.3	39*	960	400	1400	1400
6123	4.3	50*	480	520	1000	1100
6098	3.3	39*	320	400	720	760
6065	4.3	130	390	520	910	1000
6004	.55	10*	130	72	200	210
6018	6.3	150	1100	820	1900	2100
6126	2.3	45	1100	300	1400	1400
6003	8.3	250	580	1100	1700	1900
6114	1.0	12*	170	120	290	300

INDIVIDUAL DOSIMETRY DATA FOR BIKINIANS (cont'd)

ID Number	Residence Interval Years	^{90}Sr & ^{90}Y Bone Marrow Dose Equiv. During & Post Residence Int. mRem	^{137}Cs + ^{137m}Ba Dose Equiv. During & Post Residence Int. mRem	Net External Dose Equiv. During Residence Interval mRem	Total Body Dose Equiv. During & Post Residence Int. mRem	Total Bone Marrow Dose Equiv. During and Post Residence Interval mRem
6064	7.3	86*	400	900	1300	1400
6023	4.3	77*	990	560	1500	1600
6131	6.3	110*	950	820	1800	1900
6011	6.3	170	550	820	1400	1600
6081	.97	12*	490	120	610	620
6133	7.3	130*	1900	950	2800	3000
6048	.55	6.5*	590	72	660	670

*These values were derived from average male or average female daily activity ingestion rates for Sr-90.

Body Burden Data for Medically Registered Adult Males Relocated from Bikini Atoll

ed-cal ID	Weight in Kilo-grams	Age (Yr)	Years on Bikini	1974[1] Potassium grams	1974[1] ^{137}Cs µCi	1974[1] ^{137}Cs kBq	1977[2] Potassium grams	1977[2] ^{137}Cs µCi	1977[2] ^{137}Cs kBq	1978 Potassium grams	1978 ^{60}Co nCi	1978 ^{60}Co Bq	1978 ^{137}Cs µCi	1978 ^{137}Cs kBq	January 1979 Potassium grams	January 1979 ^{60}Co nCi	January 1979 ^{60}Co Bq	January 1979 ^{137}Cs µCi	January 1979 ^{137}Cs kBq	May 1979 Potassium grams	May 1979 ^{60}Co nCi	May 1979 ^{60}Co Bq	May 1979 ^{137}Cs µCi	May 1979 ^{137}Cs kBq	^{137}Cs Long-term Removal Rate Constant d^{-1}
80	61	69	0.75	-	-	-	-	-	-	97.6	1.42	53	1.14	42	-	-	-	-	-	133	MDL	MDL	0.12	4.4	
006	63	37	0.75	-	-	-	-	-	-	141	2.39	88	1.47	54	-	-	-	-	-	-	-	-	-	-	
063	67	27	4	-	-	-	146	0.729	27	156	4.93	180	2.34	87	179	2.5	93	1.1	41	-	-	-	-	-	
070	85	28	10	170	0.093	3.4	167	1.51	56	152	8.17	300	3.92	150	137	3.0	111	1.6	59	-	-	-	-	-	
004	95	28	0.25	-	-	-	-	-	-	167	1.88	70	1.33	49	-	-	-	-	-	-	-	-	-	-	
033	79	27	6	148	0.095	3.5	136	1.52	56	172	8.65	320	3.84	140	-	-	-	-	-	-	-	-	-	-	
018	89	34	6	198	0.22	8.2	-	-	-	180	14.3	530	5.88	220	-	-	-	-	-	-	-	-	-	-	
069	61	32	8	-	-	-	-	-	-	132	4.01	150	1.17	43	-	-	-	-	-	166	2.0	76	0.38	14	
068	79	56	6	165	0.051	1.9	144	0.778	29	141	6.17	230	3.07	110	-	-	-	-	-	-	-	-	-	-	
067	74	56	7	-	-	-	-	-	-	151	5.91	220	2.99	110	137	2.4	89	1.0	37	169	1.2	44	0.63	23	4.1x10⁻³
066	94	32	3	-	-	-	-	-	-	168	2.06	75	0.820	30	171	1.2	44	0.48	18	197	MDL	MDL	0.45	17	5.6x10⁻⁴
017	80	45	8	-	-	-	-	-	-	153	13.9	510	5.72	210	-	-	-	-	-	165	1.5	56	0.52	19	
019	60	48	5	-	-	-	119	0.791	29	107	3.95	150	1.03	38	135	2.9	107	0.39	14		-	-	-	-	
001	85	66	7	143	0.078	2.9	-	-	-	126	3.33	120	1.73	[illegible]	132	1.9	70	0.37	28		-	-	-	-	
073	85	24	7	-	-	-	132	0.775	29	127	4.19	160	2.18	80	-	-	-	-	-	134	MDL	MDL	0.12	4.4	
005	70	58	1.5	-	-	-	-	-	-	133	3.40	130	2.08	77	-	-	-	-	-	177	1.1	41	0.16	5.7	
008	55	32	4	-	-	-	153	1.99	74	125	5.00	190	1.94	72	148	3.2	118	1.3	48	-	-	-	-	-	
086	78	46	8	170	0.17	6.2	149	2.14	79	151	7.92	290	3.51	130	179	2.8	104	0.86	32	161	1.9	70	0.40	15	6.7x10⁻³
071	78	32	0.75	-	-	-	-	-	-	136	2.26	84	1.72	64	136	1.2	44	0.93	34	-	-	-	-	-	
076	69	39	3	-	-	-	-	-	-	163	6.64	250	3.44	130	171	2.9	107	2.4	89	-	-	-	-	-	
072	55	20	0.67	-	-	-	-	-	-	128	2.96	110	1.75	65	-	-	-	-	-	-	-	-	-	-	
013	58	23	4	-	-	-	143	0.995	37	138	3.65	140	1.69	62	156	1.8	67	0.61	23		-	-	-	-	
118	55	22	6	126	0.77	2.9	-	-	-	108	1.92	71	0.631	23	144	1.6	59	0.75	28	[illegible]	0.90	33	0.41	15	5.3x10⁻³
126	55	35	2	-	-	-	149	2.21	82	137	7.79	290	3.30	120	-	-	-	-	-	-	-	-	-	-	
003	77	22	8	168	0.076	2.8	161	0.923	34	139	5.60	210	2.44	90	-	-	-	-	-		-	-	-	-	
117	80	22	6	-	-	-	169	1.15	43	148	6.09	230	2.68	99	172	2.9	107	0.90	33	[illegible]	1.5	56	0.44	16	6.4x10⁻³
120	57	31	7	-	-	-	149	1.29	48	119	4.79	180	1.85	69	155	2.7	100	0.92	34		-	-	-	-	
125	64	35	9	159	0.10	3.8	150	1.54	57	144	5.65	210	2.52	93	-	-	-	-	-	[illegible]	2.0	76	0.33	12	
007	82	35	0.58	-	-	-	-	-	-	127	2.58	95	1.49	55	144	0.67	25	0.32	32	-	-	-	-	-	
130	69	29	0.42	-	-	-	-	-	-	143	2.20	81	1.46	54	156	1.5	56	1.5	56	134	MDL	MDL	0.97	36	3.8x10⁻³

...had recently traveled to Bikini Atoll

Body Burden Data for Medically Registered Adult Males Relocated from Bikini Atoll (Cont'd)

ID	Weight in Kilograms	Age (Yr)	Years on Bikini	1976[1] Potassium grams	1976[1] ^{137}Cs µCi	1976[1] ^{137}Cs kBq	1977[2] Potassium grams	1977[2] ^{137}Cs µCi	1977[2] ^{137}Cs kBq	1978 Potassium grams	1978 ^{60}Co nCi	1978 ^{60}Co Bq	1978 ^{137}Cs µCi	1978 ^{137}Cs kBq
19	54	17	7	-	-	-	138	0.641	24	124	4.58	170	2.13	79
64	90	51	7	163	0.29	11	133	3.23	120	116	5.99	220	3.05	110
66	75	56	7	-	-	-	162	2.22	82	174	14.8	550	5.71	210
35	81	35	1	-	-	-	-	-	-	142	3.30	120	2.12	78
96	66	48	3	-	-	-	145	1.93	64	146	4.32	160	1.91	71
07	66	65	2	-	-	-	130	1.04	38	116	2.21	82	1.26	46
61[3,4]	66	34	5	130	0.081	3.0	-	-	-	-	-	-	-	-
56[3,4]	64	58	7	150	0.072	2.7	-	-	-	-	-	-	-	-
14[4]	50	59	5	160	0.043	1.6	-	-	-	-	-	-	-	-
10[4]	85	35	10	156	0.124	4.6	0.74	27	-	-	-	-	-	-

ID	January 1979 Potassium grams	January 1979 ^{60}Co nCi	January 1979 ^{60}Co Bq	January 1979 ^{137}Cs µCi	January 1979 ^{137}Cs kBq	May 1979 Potassium grams	May 1979 ^{60}Co nCi	May 1979 ^{60}Co Bq	May 1979 ^{137}Cs µCi	May 1979 ^{137}Cs kBq	^{137}Cs Long Term Removal Rate Constant d^{-1}
19	-	-	-	-	-	-	-	-	-	-	
64	-	-	-	-	-	-	-	-	-	-	
66	-	-	-	-	-	149	2.5	93	0.48	18	
35	-	-	-	-	-	-	-	-	-	-	
96	146	2.5	93	1.3	48	156	0.9	33	0.70	26	5.4×10^{-3}
07	-	-	-	-	-	-	-	-	-	-	
61[3,4]	142	MDL	MDL	.109	4.0	126	MDL	MDL	0.048	1.8	7.4×10^{-3}
56[3,4]	146	MDL	MDL	0.023	0.85	146	MDL	MDL	0.011	0.41	7.5×10^{-3}
14[4]	130	MDL	MDL	0.067	2.5	144	MDL	MDL	0.025	0.93	4.2×10^{-3}
10[4]	-	-	-	-	-	160	MDL	MDL	0.290	11	

[1] 75

[2] 77

Individuals left Bikini Atoll 8 months prior to the August 1978 Relocation Program.

Individuals received sick call medical care prior to April 1978 but were not officially registered.

Body Burden Data for Medically Registered Adult Females Relocated from Bikini Atoll

ID	Weight in Kilograms	Years on Bikini	Age (Yr)	1974[1] Potassium grams	1974 ^{137}Cs µCi	1974 ^{137}Cs kBq	1977[2] Potassium grams	1977 ^{137}Cs µCi	1977 ^{137}Cs kBq	1978 Potassium grams	1978 ^{60}Co nCi	1978 ^{60}Co Bq	1978 ^{137}Cs µCi	1978 ^{137}Cs kBq	1979 January Potassium grams	Jan. ^{60}Co nCi	Jan. ^{60}Co Bq	Jan. ^{137}Cs µCi	Jan. ^{137}Cs kBq	May 1979 Potassium grams	May ^{60}Co nCi	May ^{60}Co Bq	May ^{137}Cs µCi	May ^{137}Cs kBq
65	83	0.75	28	-	-	-	-	-	-	95	1.79	66	1.15	41	-	-	-	-	-	-	-	-	-	-
12	90	1	35	-	-	-	-	-	-	96	2.18	81	1.76	65	94	1.6	59	0.98	36	118	MDL	MDL	0.46	17
14	56	0.75	33	-	-	-	-	-	-	79	1.40	52	0.818	30	102	MDL	MDL	0.12	4.4	-	-	-	-	-
11	84	0.5	32	-	-	-	-	-	-	100	2.11	78	1.31	49	107	1.2	44	0.53	20.	-	-	-	-	-
22	73	10	70	94	0.033	1.2	-	-	-	86	3.20	120	1.34	49	93	1.9	70.	0.31	11	90	1.1	41	0.11	4.1
23	77	4	50	-	-	-	107	1.53	57	99	3.81	140	1.41	52	126	2.5	93	0.62	23	97	MDL	MDL	0.25	9.3
59	65	1	19	-	-	-	-	-	-	80	1.33	49	0.861	32	-	-	-	-	-	-	-	-	-	-
63	49	4	24	-	-	-	89.6	0.799	30	81	3.16	120	1.52	56	-	-	-	-	-	-	-	-	-	-
12	63	3	32	-	-	-	96.4	1.88	70	100	5.49	200	3.07	110	94	1.7	63	0.77	28	109	1.0	37	0.26	9.6
24	53	0.58	56	-	-	-	-	-	-	71	1.27	47	0.957	35	-	-	-	-	-	-	-	-	-	-
08	86	4	24	94	0.029	1.1	98.0	0.706	26	93	2.48	92	0.729	27	114	1.6	59	0.53	20	-	-	-	-	-
58	66	5	18	106	0.077	2.9	88.8	0.690	26	92	4.63	170	2.08	77	-	-	-	-	-	-	-	-	-	-
13	56	4	25	-	-	-	91.7	0.534	20	91	2.33	86	1.03	38	107	1.1	41	0.30	11	107	MDL	MDL	0.11	4.1
065	52	4	19	-	-	-	101	0.734	27	93	2.39	88	1.06	39	96	1.3	48	0.36	13	-	-	-	-	-
097	53	4	19	86	0.036	1.3	88.9	0.448	17	90	2.15	80	1.27	47	95	1.0	37	0.31	11	86	MDL	MDL	0.16	5.9
109	50	4	15	-	-	-	110	0.621	23	88	1.49	55	0.411	15	106	MDL	MDL	0.060	2.2	116	MDL	MDL	0.018	0.67
046	85	1.75	43	-	-	-	94.3	0.833	31	100	1.81	143	2.10	78	-	-	-	-	-	104	1.2	44	0.36	13
098	60	3	16	-	-	-	91.4	0.706	26	93	4.38	85	.891	31	66	1.2	44	0.47	17	92	MDL	MDL	0.18	6.5
060	55	2	22	-	-	-	-	-	-	81	2.00	77	1.39	51	105	MDL	MDL	0.18	6.7	115	MDL	MDL	0.059	2.2
016	56	0.34	27	-	-	-	-	-	-	73	1.54	57	1.53	57	-	-	-	-	-	-	-	-	-	-
110	77	8	32	111	0.11	4.0	-	-	-	94	3.98	150	1.50	56	-	-	-	-	-	110	MDL	MDL	0.11	4.1
525	78	0.75	37	-	-	-	-	-	-	106	2.96	113	2.36	87	-	-	-	-	-	109	MDL	MDL	0.32	12
064	60	7	30	-	-	-	-	-	-	83	2.55	96	0.907	34	74	1.6	59	0.42	16	88	MDL	MDL	0.22	8.1
061	65	6	32	-	-	-	-	-	-	81	3.62	133	2.22	82	-	-	-	-	-	-	-	-	-	-
051	50	5	19	-	-	-	95.9	0.545	20	88	2.25	83	1.44	53	-	-	-	-	-	73	MDL	MDL	0.045	1.7
934	74	6	43	-	-	-	98.8	2.23	83	110	10.8	403	5.48	200	-	-	-	-	-	76	2.1	74	0.48	18
062	54	4	21	-	-	-	96.8	0.840	31	79	2.53	96	1.44	51	-	-	-	-	-	60	MDL	MDL	0.088	3.3
035	77	6	20	-	-	-	113	0.573	21	100	4.94	180	2.78	100	100	2.3	85	0.65	24	-	-	-	-	-
115	56	7	43	95	0.058	2.2	85.9	1.15	43	80	4.16	150	2.28	84	84	1.8	67	0.48	18	95	2.0	74	0.17	6.3
034	76	7	46	102	0.12	4.3	93.7	0.995	37	92	6.92	260	3.89	140	-	-	-	-	-	106	MDL	MDL	0.15	5.6
065	54	7	45	59	0.018	0.67	89.4	0.558	21	78	1.70	63	1.31	49	-	-	-	-	-	82	1.0	37	0.13	4.8
6050	62	2	22	-	-	-	112	1.14	43	81	3.42	130	1.40	50	-	-	-	-	-	-	-	-	-	-
6167[3,4]	60	7	59	89	0.030	1.1	-	-	-	-	-	-	-	-	92	MDL	MDL	0.015	0.56	97	MDL	MDL	0.079	0.29
6159[3,4]	111	4	27	134	0.073	2.7	-	-	-	-	-	-	-	-	115	MDL	MDL	0.028	1.0	125	MDL	MDL	0.012	0.44
6140[3]	94	3	42	60	0.018	0.67	-	-	-	-	-	-	-	-	90	MDL	MDL	0.037	1.4	96	MDL	MDL	0.015	0.56
6163[3,5]	84	-	30	-	-	-	142	0.570	21	-	-	-	-	-	136	MDL	MDL	0.061	2.3	-	-	-	-	-
6151[3]	82	2	31	-	-	-	102	0.971	36	-	-	-	-	-	87	MDL	MDL	0.121	4.5	77	MDL	MDL	0.059	2.2

1 CO, 75
2 CO 77
3 Individuals received sick call medical care prior to April 1978 but were not officially registered.
4 Individuals left Bikini Atoll 8 months prior to the August 1978 Relocation Program.
5 [illegible] Bikini Atoll 16 months prior to the August 1978 Relocation Program.

1111005

Body Burden Data for Medically Registered Adolescents Relocated from Bikini Atoll

DOE ARCHIVES

Medical ID	Weight kilograms	Years on Bikini	Age (Yr)	1977 Potassium gram	1977 ^{137}Cs µCi	1977 ^{137}Cs kBq
[illegible]						
[illegible]	36	4.5	12	84	0.959	36
[illegible]	33	2	12	-	-	-
[illegible]	38	6	14	96	1.33	49
[illegible]	40	6	11	-	.	-
[illegible]	32	7	11	91	0.024	31
[illegible]	27	7	11	-	.	.
[illegible]	39	1.42	11	-	-	-
[illegible]						
[illegible]	48	4	11	91	0.682	25
[illegible]	40	0.25	11	-	-	-
[illegible]	43	6	13	-	-	-

Medical ID	1978 Potassium Grams	1978 ^{60}Co nCi	1978 ^{60}Co Bq	1978 ^{137}Cs µCi	1978 ^{137}Cs kBq
[illegible]					
[illegible]	-	.	.	-	-
[illegible]	58	3.45	130	1.85	68
[illegible]	69	3.40	130	1.69	63
[illegible]	53	1.34	50	0.810	31
[illegible]	53	2.17	80	0.732	27
[illegible]	53	3.52	130	2.09	78
[illegible]	57	1.18	46	1.28	47
[illegible]					
[illegible]	69	1.32	49	.744	28
[illegible]	70	2.61	96	2.05	76
[illegible]	69	2.20	82	1.17	43

Medical ID	January 1979 Potassium grams	January 1979 ^{60}Co nCi	January 1979 ^{60}Co Bq	January 1979 ^{137}Cs µCi	January 1979 ^{137}Cs kBq
[illegible]					
[illegible]	53	MDL	MDL	0.206	7.6
[illegible]		-	.	-	-
[illegible]	108	2.1	78	0.76	28
[illegible]	59	1.0	37	0.055	2.0
[illegible]	95	2.0	74	0.21	7.8
[illegible]	.	.	.		.
[illegible]	37	MDL	MDL	0.071	2.6
[illegible]					
[illegible]	73	1.2	44	0.27	10
[illegible]	-			-	-
[illegible]	101	1.4	52	0.15	5.6

Medical ID	May 1979 Potassium grams	May 1979 ^{60}Co nCi	May 1979 ^{60}Co Bq	May 1979 ^{137}Cs µCi	May 1979 ^{137}Cs kBq
[illegible]					
[illegible]	94	MDL	MDL	0.075	2.8
[illegible]	-	.	-	-	-
[illegible]	133	1.4	52	0.32	12
[illegible]	74	MDL	MDL	0.017	0.63
[illegible]	60	MDL	MDL	0.053	2.0
[illegible]	55	1.0	37	0.022	0.81
[illegible]	60	MDL	MDL	0.016	0.60
[illegible]					
[illegible]	89	MDL	MDL	0.076	2.8
[illegible]	171	MDL	MDL	0.074	2.7
[illegible]	86	MDL	MDL	0.037	1.4

Medical ID	^{137}Cs Long Term Removal Rate Constant, d^{-1}
6147	8.9×10^{-3}
6131	7.6×10^{-3}
6011	1.1×10^{-2}
6127	1.2×10^{-2}
6015	1.4×10^{-2}
6129	1.1×10^{-2}
6091	1.3×10^{-2}

137Cs Long Term Removal Rate Constant, λ

Body Burden Data for Medically Registered Children Relocated from Bikini Atoll

ical ID	Weight kilograms	Years on Bikini	AGE (Yr)	Potassium Grams	1978 ^{60}Co nCi	1978 ^{60}Co Bq	1978 ^{137}Cs µCi	1978 ^{137}Cs kBq	January 1979 Potassium grams	January 1979 ^{60}Co nCi	January 1979 ^{60}Co Bq	January 1979 ^{137}Cs µCi	January 1979 ^{137}Cs kBq	May 1979 Potassium grams	May 1979 ^{60}Co nCi	May 1979 ^{60}Co Bq	May 1979 ^{137}Cs µCi	May 1979 ^{137}Cs kBq	
les																			
09	20	4	6	36	0.98	36	1.26	47	-	-	-	-	-	59	MDL	MDL	0.007	0.26	
49	23	2	8	47	2.7	99	1.71	63	-	-	-	-	-	-	-	-	-	-	
42	23	0.25	7	43	1.0	38	1.07	39	-	-	-	-	-	-	-	-	-	-	
14	20	1.34	5	41	1.7	64	1.50	56	-	-	-	-	-	69	MDL	MDL	0.012	0.44	
12	24	7	7	41	1.7	63	1.27	47	-	-	-	-	-	63	MDL	MDL	0.022	0.81	
23	28	4	8	52	1.7	63	1.28	47	43	0.91	34	0.16	5.9	-	-	-	-	-	
16	27	7	10	53	2.5	93	1.43	53	-	-	-	-	-	51	1.3	48	0.039	1.4	
18	18	2	5	33	1.3	50	1.00	37	-	-	-	-	-	-	-	-	-	-	
les																			
94	34	6	10	51	2.3	86	2.07	75	-	-	-	-	-		-	-	-	-	
92	29	6	8	52	2.8	100	2.25	83	-	-	-	-	-		-	-	-	-	
80	34	0.58	7	50	MDL	MDL	0.543	20	-	-	-	-	-		-	-		-	
10	29	7	8	56	1.8	67	1.41	52	50	MDL	MDL	0.17	6.3		-	-		-	
38	21	8	6	47	1.3	47	1.00	37	-	-	-	-	-		-	-	-	-	
05	22	3	5	3.	1.2	43	0.967	36	65	-	-	0.053	2.0		1.0	37	0.0074	0.27	2.0×10^{-2}
03	-	3	9	44	1.4	53	1.40	52	-	-	-	-	-		-	-	-	-	
28	25	5	7	52	1.4	51	1.26	47	-	-	-	-	-		1.0	37	0.015	0.56	
30	34	3	10	54	3.0	110	2.38	88	34	MDL	MDL	0.26	9.6	7	MDL	MDL	0.064	2.4	1.3×10^{-2}
27	22	3	6	36	5.6	210	1.16	43	38	MDL	MDL	0.042	1.6		-	-		-	
44	18	5	6	35	6.6	240	1.15	43	-	-	-	-	-		MDL	MDL	0.0062	0.23	
25	31	3	5	44	2.97	36	1.03	38	45	MDL	MDL	0.13	4.8	67	MDL	MDL	0.028	1.0	1.4×10^{-2}
81	26	0.67	9	49	MDL	MDL	1.02	38	-	-	-	-	-	-	-	-	-	-	
86	22	3	6	32	MDL	MDL	0.622	23	37	-	-	0.077	2.9	44	MDL	MDL	0.013	0.48	1.7×10^{-2}

DOE ARCHIVES

Body Burden Data for Medically Registered Children Relocated from Bikini Atoll

ID #	Sex	Age (yr)	Height (cm)	Weight (kg)	Yrs On Bikini	Yrs Off Bikini	January 1979 ^{137}Cs Result nCi	January 1979 ^{137}Cs Result kBq	January 1979 Potassium Result Grams	May 1979 ^{137}Cs Result nCi	May 1979 ^{137}Cs Result kBq	May 1979 Potassium Result Grams	^{137}Cs Long Term Removal Rate Constant, d^{-1}
6031*	M	5	105	20	3	.70	--	--	--	2.8	0.10	35	
6029	M	6	112	20	5	.70	--	--	--	4.7	0.17	25	
6100*	M	5	99	17	4.3	.70	--	--	--	15	0.56	24	3.1×10^{-2}
6021*	M	5	103	19	4.3	.71	46	1.7	NC	6.2	0.23	51	2.6×10^{-2}
6020	M	6	107	20	2	.71	56	2.1	72	7.4	0.27	37	2.7×10^{-2}
6107*	M	5	96	15	4.3	.71	16	0.59	46	2.6	0.096	40	
6074*	M	5	104	20	4.3	.71	9.0	0.33	34	MDL	MDL	25	
6078*	F	5	99	17	--	0.40	3.0	0.11	28	--	--	--	
6088*	F	5	95	15	4.3	.70	--	--	--	3.0	0.11	33	
6090	F	6	108	25	5	.70	--		--	4.9	0.18	31	
6101	F	6	104	19	5.3	.70	51	1.9	12	6.9	0.26	15	2.1×10^{-2}
6056*	F	6	100	17	4.3	.71	46	1.7	NC	7.4	0.27	49	1.4×10^{-2}
6057	F	7	107	26	1	.72	--	--	--	5.8	0.22	66	

*Indicates children were 4 yrs or less April, 1978

NC = Not Calculated

5001444

Body Burden Data for Non-Medically Registered Adult Male Prior Residents of Bikini Atoll

ID #	Sex	Age (yr)	Height (cm)	Weight (kg)	Yrs on Bikini	Yrs off Bikini	May 1979 ^{137}Cs Result nCi	May 1979 ^{137}Cs Result kBq	May 1979 Potassium Result Grams
6190	M	19	166	57	0.25	2	6.0	0.22	161
6205	M	42	170	81	4	4.5	MDL	MDL	159
6211	M	19	163	55	1	3	MDL	MDL	134
6218	M	56	158	72	2	10	MDL	MDL	169
6219	M	30	173	60	2	9	MDL	MDL	143
6220	M	26	166	66	2	9	MDL	MDL	165
6221	M	53	175	82	2	9	4.2	0.16	139
6223	M	66	152	65	2 days May 14, 15, 1979	.016	99	3.7	127
6224	M	45	158	55	2 days May 14, 15, 1979	.016	120	4.4	146
6226	M	18	164	58	2 yr	3	MDL	MDL	137

Body Burden Data for Non-Medically Registered Adult Male Prior Residents of Bikini Atoll

ID #	Sex	Age (yr)	Height (cm)	Weight (kg)	Yrs. On Bikini	Yrs. Off Bikini	January 1979 ^{137}Cs Result nCi	January 1979 ^{137}Cs Result kBq	January 1979 Potassium Result Gram	May 1979 ^{137}Cs Result nCi	May 1979 ^{137}Cs Result kBq	May 1979 Potassium Result Gram	^{137}Cs Long Term Removal Rate Constant d^{-1}
6136	M	48	150	58		4	8.5	0.31	144	--	--	--	
6138	M	20	163	57		3	2.8	0.10	165	--	--	--	
6153	M	23	160	65	1	1.42	5.8	0.21	170	5.4	0.20	146	
6168	M	16	150	44	7	1.0	2.4	0.089	101	MDL	MDL	100	
6174	M	52	174	84		6	17	0.63	158	--	--	--	
6180	M	22	173	67	4	1	34	1.3	141	--	--	--	
6182	M	18	161	53	6	0.42	1220	45	122	620	23	131	6.1×10^{-3}

Body Burden Data of Non-Medically Registered Adult Female Prior Residents of Bikini Atoll

							January			May			
							1979 ^{137}Cs Result		1979 Potassium Result	1979 ^{137}Cs Result		1979 Potassium Result	^{137}Cs Long Term Removal Rate Constant
ID #	Sex	Age (yr)	Height (cm)	Weight (kg)	Yrs. On Bikini	Yrs. Off Bikini	nCi	kBq	Gram	nCi	kBq	Grams	d^{-1}
6137	F	30	161	64	0.33	4	3.8	0.14	113	1.7	0.063	112	
6139	F	22	140	38	--	3	2.1	0.078	89	--	--	--	
6140	F	16	146	46	0.17	0.42	27	1.0	94	8.6	0.32	94	1.1×10^{-2}
6144	F	21	150	44	1	0.42	37	1.4	105	13	0.48	89	1.0×10^{-2}
6152	F	20	157	59	1	1.42	2.4	0.089	123	3.9	0.14	117	
6155	F	24	155	66	6	0.42	390	15	120	150	5.6	96	8.5×10^{-3}
6160	F	65	153	55	6	0.67	360	13	67	140	5.1	87	8.4×10^{-3}
6165	F	36	142	60	--	1.5	6.6	0.24	76	--	--	--	
6175	F	24	155	63	--	--	11	0.41	90	5.2	0.19	92	9.1×10^{-3}
6181	F	44	151	55	4	1	8.5	0.31	105	4.6	0.17	10[illegible]	8.1×10^{-3}
6185	F	21	144	41	3	2.5	2.7	0.10	74	3.4	0.13	79	

Body Burden Data of Non-Medically Registered Adult Female Prior Residents of Bikini Atoll

ID #	Sex	Age (yr)	Height (cm)	Weight (kg)	Yrs on Bikini	Yrs off Bikini	May 1979 ^{137}Cs Result nCi	May 1979 ^{137}Cs Result kBq	May 1979 Potassium Result Gram
6187	F	21	152	54	0.019	1	1.6	0.059	107
6189	F	21	155	--	2.5	1	1.9	0.070	114
6206	F	32	151	73	3	5.5	MDL	MDL	116
6222	F	39	156	66	2.5	3	MDL	MDL	98

Body Burden Data for Non-Medically Registered Adolescents and Children Prior Residents of Bikini Atoll

							January			May		
							1979 ^{137}Cs Result		1979 Potassium Result	1979 ^{137}Cs Result		1979 Potassium Result
ID #	Sex	Age (yr)	Height (cm)	Weight (kg)	Yrs. On Bikini	Yrs. Off Bikini	nCi	kBq	Gram	nCi	kBq	Gram
6156	M	9	130	34	6	1.0	2.0	0.074	53	3.4	0.13	59
6164	M	5	85	15	--	1.5	8.0	0.30	40	--	--	--
6169	M	14	167	46	7	1.0	1.2	0.044	108	MDL	MDL	120
6172	M	10	130	30	7	1.0	2.8	0.10	40	1.9	0.070	74
6178	M	12	157	33	4	1.0	2.0	0.074	46	1.7	0.062	70
6183	M	12	139	35	--	1.67	1.0	0.037	36	MDL	MDL	74
6179	F	8	115	22	4	1	1.2	0.044	MDL	MDL	MDL	59
6177	F	6	103	18	--	6	MDL	MDL	MDL	MDL	MDL	36
6176	F	8	144	24	--	6	MDL	MDL	MDL	MDL	MDL	38
6173	F	13	142	47	3	0.42	4.0	0.15	33	MDL	[illegible]	48
6171	F	6	96	15	2.67	1.0	4.0	0.15	16	1.1	0.041	47
6170	F	13	140	45	7	1.0	2.8	0.10	58	1.8	0.067	77
6162	F	12	147	50	--	1.5	5.0	0.19	36	--		--
6157	F	5	106	20	4	1.0	7.2	0.27	32	MDL	MDL	54
6158	F	6	103	20	4	1.0	3.5	0.13	32	1.2	0.044	46
6150	F	8	120	25	4	0.42	4.0	0.15	42	1.5	0.056	40
6149	F	5	99	19	4.3	0.42	1.6	0.059	37	MDL	MDL	32

Body Burden Data for Non-Medically Registered Adolescents and Children Prior Residents of Bikini Atoll

ID #	Sex	Age (yr)	Height (cm)	Weight (kg)	Yrs on Bikini	Yrs off Bikini	May 1979 ^{137}Cs Result nCi	May 1979 ^{137}Cs Result kBq	May 1979 Potassium Result Gram
6200	M	14	155	43	1	.71	110	4.1	111
6202	M	6	100	19	5.3	.72	1.8	0.067	53
6207	M	12	138	35	4	4.5	MDL	MDL	78
6208	M	10	136	33	4	4.5	MDL	MDL	76
6225	M	11	125	25	5	1.33	MDL	MDL	53
6203	F	5	92	15	4.3	.72	MDL	MDL	54
6204	F	5	104	21	1	.72	1.1	0.040	57
6212	F	14	151	50	1	3	MDL	MDL	73
6213	F	10	121	25	1	3	MDL	MDL	56
6217	F	10	126	25	2	9	MDL	MDL	44

Body Burden Data for Non-Medically Registered Adolescents and Children Never on Bikini Island

ID #	Sex	Age (yr)	Height (cm)	Weight (kg)	January 1979 ^{137}Cs Result nCi	January 1979 ^{137}Cs Result kBq	January 1979 Potassium Result Gram	May 1979 ^{137}Cs Result nCi	May 1979 ^{137}Cs Result kBq	May 1979 Potassium Result Gram
6141	F	12	138	33	2.7	0.10	63	1.5	0.056	112
6142	F	10	126	26	2.3	0.085	52	1.0	0.037	72
6143	F	4	104	19	1.2	0.044	41	MDL	MDL	35
6145	M	5	110	21	1.0	0.037	46	--	--	--
6186	M	5	104	20	--	--	--	MDL	MDL	22
6188	F	14	146	49	--	--	--	2.9	0.11	107
6191	F	6	113	23	--	--	--	1.1	0.041	61

TAB

C

RADIATION PROTECTION

Recommendations of the International Commission on Radiological Protection

ICRP PUBLICATION 2

Report of Committee II

on

Permissible Dose for Internal Radiation

(1959)

PUBLISHED FOR

The International Commission on Radiological Protection

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Table 1. Maximum permissible body burdens and maximum permissible concentrations of radionuclides in air and in water for occupational exposure

Radionuclide and type of decay	Organ of reference* (critical organ **bold face**)	Maximum permissible burden in total body q(μc)	Maximum permissible concentrations: For 40 hr week $(MPC)_w$ (μc/cm^3)	For 40 hr week $(MPC)_a$ (μc/cm^3)	For 168 hr week $(MPC)_w$ (μc/cm^3)	For 168 hr week $(MPC)_a$ (μc/cm^3)
$_1H^3$ (HTO or H_2^3O) (sol.) β^-	**Body tissue**	10^3	0.1	5×10^{-6}	0.03	2×10^{-6}
	Total body	2×10^3	0.2	8×10^{-6}	0.05	3×10^{-6}
(H_2^3) (submersion)	**Skin**			2×10^{-3}		4×10^{-4}
$_4Be^7$ (sol.) ϵ, γ	**GI (LLI)**		0.05	10^{-5}	0.02	4×10^{-6}
	Total body	600	6	6×10^{-6}	2	2×10^{-6}
	Kidney	800	9	8×10^{-6}	3	3×10^{-6}
	Liver	800	9	8×10^{-6}	3	3×10^{-6}
	Bone	2×10^3	20	2×10^{-5}	7	6×10^{-6}
	Spleen	4×10^3	50	4×10^{-5}	20	2×10^{-5}
(insol.)	**Lung**			10^{-6}		4×10^{-7}
	GI (LLI)		0.05	9×10^{-6}	0.02	3×10^{-6}
$_6C^{14}(CO_2)$ (sol.) β^-	**Fat**	300	0.02	4×10^{-6}	8×10^{-3}	10^{-6}
	Total body	400	0.03	5×10^{-6}	0.01	2×10^{-6}
	Bone	400	0.04	6×10^{-6}	0.01	2×10^{-6}
(submersion)	Total body			5×10^{-5}		10^{-5}
$_9F^{18}$ (sol.) β^+	**GI (SI)**		0.02	5×10^{-6}	8×10^{-3}	2×10^{-6}
	Bone and teeth	20	0.2	3×10^{-5}	0.06	9×10^{-6}
	Total body	20	0.3	4×10^{-5}	0.09	10^{-5}
(insol.)	**GI (ULI)**		0.01	3×10^{-6}	5×10^{-3}	9×10^{-7}
	Lung			2×10^{-6}		6×10^{-6}
$_{11}Na^{22}$ (sol.) β^+, γ	**Total body**	10	10^{-3}	2×10^{-7}	4×10^{-4}	6×10^{-8}
	GI (LLI)		0.01	2×10^{-6}	3×10^{-3}	7×10^{-7}
(insol.)	**Lung**			9×10^{-9}		3×10^{-9}
	[illegible]		10^{-4}	2×10^{-7}	3×10^{-4}	5×10^{-9}
$_{11}Na^{24}$ (sol.) β^-, γ	**GI (SI)**		6×10^{-3}	10^{-6}	2×10^{-3}	4×10^{-7}
	Total body	7	0.01	2×10^{-6}	4×10^{-3}	6×10^{-7}
(insol.)	**GI (LLI)**		8×10^{-4}	10^{-7}	3×10^{-4}	5×10^{-8}
	Lung			8×10^{-7}		3×10^{-7}

* The abbreviations GI, S, SI, UL[illegible] LI refer to gastrointestinal tract, stomach, small intestine, upper large intestine, and lower la[illegible] inte[illegible]ctively.

Radionuclide and type of decay	Organ of reference (critical organ bold face)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations: For 40 hr week $(MPC)_w$ $(\mu c/cm^3)$		For 168 hr week $(MPC)_w$ $(\mu c/cm^3)$	
			$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$	$(MPC)_w$ $(\mu c/cm^3)$	$(MPC)_a$ $(\mu c/cm^3)$
$_{55}Cs^{134}$ (sol.) β^-, γ	**Total body**	30	2×10^{-4}	4×10^{-7}	9×10^{-5}	10^{-7}
	Liver	60	5×10^{-4}	7×10^{-7}	2×10^{-4}	2×10^{-7}
	Spleen	80	7×10^{-4}	10^{-6}	2×10^{-4}	4×10^{-7}
	Muscle	90	8×10^{-4}	10^{-6}	3×10^{-4}	4×10^{-7}
	Kidney	100	8×10^{-4}	10^{-6}	3×10^{-4}	4×10^{-7}
	GI (SI)		0.02	5×10^{-6}	8×10^{-3}	2×10^{-6}
	Bone	400	0.03	4×10^{-6}	0.01	2×10^{-6}
	Lung	800	0.06	9×10^{-6}	0.02	3×10^{-6}
(insol.)	**Lung**			2×10^{-7}		6×10^{-8}
	GI (LLI)		2×10^{-3}	3×10^{-7}	6×10^{-4}	10^{-7}
$_{55}Cs^{137}$ (sol.) β^-, γ, e^-	**Total body**	30	4×10^{-4}	6×10^{-8}	2×10^{-4}	2×10^{-8}
	Liver	40	5×10^{-4}	8×10^{-8}	2×10^{-4}	3×10^{-8}
	Spleen	50	6×10^{-4}	9×10^{-8}	2×10^{-4}	3×10^{-8}
	Muscle	50	7×10^{-4}	10^{-7}	2×10^{-4}	4×10^{-8}
	Bone	100	10^{-3}	2×10^{-7}	5×10^{-4}	7×10^{-8}
	Kidney	100	10^{-3}	2×10^{-7}	5×10^{-4}	8×10^{-8}
	Lung	300	5×10^{-3}	6×10^{-7}	2×10^{-3}	2×10^{-7}
	GI (SI)		0.02	5×10^{-6}	8×10^{-3}	2×10^{-6}
(insol.)	**Lung**			10^{-8}		5×10^{-9}
	GI (LLI)		10^{-3}	2×10^{-7}	4×10^{-4}	8×10^{-8}
$_{56}Ba^{131}$ (sol.) ϵ, γ	**GI (LLI)**		5×10^{-3}	10^{-6}	2×10^{-3}	4×10^{-7}
	Total body	50	0.1	2×10^{-6}	0.03	7×10^{-7}
	Bone	80	0.1	3×10^{-6}	0.05	10^{-6}
	Liver	[illegible]	20	4×10^{-6}	7	10^{-6}
	Muscle	2×10^4	40	7×10^{-6}	10	2×10^{-6}
	Lung	2×10^4	40	7×10^{-6}	10	2×10^{-6}
	Spleen	3×10^4	60	10^{-5}	20	4×10^{-6}
	Kidney	4×10^4	70	10^{-5}	20	5×10^{-6}
(insol.)	**Lung**			4×10^{-7}		10^{-7}
	GI (LLI)		5×10^{-3}	9×10^{-7}	2×10^{-3}	3×10^{-7}
$_{56}Ba^{140}$ (sol.) β^-, γ	**GI (LLI)**		8×10^{-4}	2×10^{-7}	3×10^{-4}	6×10^{-8}
	Bone	4	6×10^{-3}	10^{-7}	2×10^{-3}	4×10^{-8}
	Total body	9	0.01	3×10^{-7}	5×10^{-3}	10^{-7}
	Liver	10^3	2	5×10^{-6}	0.9	2×10^{-6}
	Lung	3×10^3	4	9×10^{-6}	2	3×10^{-6}
	[illegible]	3×10^3	5	10^{-5}	2	4×10^{-6}
	[illegible]	4×10^3	6	10^{-5}	2	4×10^{-6}
	Kidney	4×10^3	8	2×10^{-5}	3	5×10^{-6}
(insol.)	**Lung**			4×10^{-8}		10^{-8}
	GI (LLI)		7×10^{-4}	10^{-7}	2×10^{-4}	4×10^{-8}

TAB

D

CONCENTRATION OF ^{137}Cs IN SUBSISTENCE CROPS AND FISH AT ENEU ISLAND

FOOD PRODUCT	NO. OF SAMPLES	AVERAGE CONCENTRATION PCi/G WET WEIGHT	RANGE OF CONCENTRATION PCi/G WET WEIGHT
COCONUT MEAT (GREEN)	6	22.7	3.5-48
COCONUT MEAT (INTERMEDIATE)	9	16.5	4.8-32
COCONUT MEAT (MATURE)	31	30.9	5.3-117
COCONUT MEAT (SPROUTED, SPRINGY)	8	27	16-52
ALL COCONUT MEAT	54	27	3.5-117
COCONUT FLUID	28	13.5	1.2-44
BREADFRUIT	2	6.5	5.2-7.8
SQUASH	12	8.5	1.6-20
PAPAYA	18	14	1.6-31
BANANA	3	0.92	0.54-1.3
SWEET POTATO	2	3.6	2.3-5
WATERMELON	17	2.6	0.26-7.2
GARDEN FRUITS AND VEGETABLES (AVERAGE OF SQUASH, PAPAYA, BANANA, SWEET POTATO, WATERMELON)		5.9	
FISH (MULLET)+	6	0.026+	
DOMESTIC MEAT		15•	

\+ FROM V. NOSHKIN

• ESTIMATED FROM BIKINI PIG DATA

CONCENTRATION OF ^{90}Sr IN SUBSISTENCE CROPS AND FISH AT ENEU ISLAND

FOOD PRODUCT	NO. OF SAMPLES	AVERAGE CONCENTRATION PCi/G WET WEIGHT	RANGE OF CONCENTRATI PCi/G WET WEIGHT
COCONUT MEAT	9	0.021	0.0033 - 0.052
COCONUT FLUID*	-	0.021*	-
BREADFRUIT	2	1.9	0.47 - 3.4
WATERMELON	8	0.031	0.012 - 0.053
SQUASH	6	0.064	0.024 - 0.15
PAPAYA	5	0.29	0.052 - 0.39
SWEET POTATO	1	0.13	-
GARDEN FRUITS AND VEGETABLES (AVERAGE OF WATERMELON, SQUASH, PAPAYA, SWEET POTATO)		0.13	
FISH (MULLET)		0.076+	
CLAMS		0.005+	
DOMESTIC MEAT		0.011**	

* ASSUMED TO BE THE SAME AS COCONUT MEAT

\+ FROM V. NELSON AND B. SCHELL

** FROM 1975 BIKINI DOSE ASSESSMENT

CONCENTRATION OF $^{239+240}Pu$ IN SUBSISTENCE CROPS AND FISH AT ENEU ISLAND

FOOD PRODUCT	NO. OF SAMPLES	AVERAGE CONCENTRATION pCi/g WET WEIGHT	RANGE OF CONCENTRATION pCi/g WET WEIGHT
COCONUT MEAT	9	2.8×10^{-5}	$4.1 \times 10^{-6} - 5.3 \times 10^{-5}$
COCONUT FLUID	-	2.8×10^{-5}*	-
BREADFRUIT	1	1.7×10^{-5}	-
WATERMELON	8	1.3×10^{-5}	$4.4 \times 10^{-6} - 2.0 \times 10^{-}$[illegible]
SQUASH	6	8×10^{-6}	$3.5 \times 10^{-6} - 1.9 \times 10^{-5}$
PAPAYA	3	8.3×10^{-6}	$6.5 \times 10^{-6} - 1.1 \times 10^{-}$[illegible]
GARDEN FRUITS AND VEGETABLE (AVERAGE OF WATERMELON, SQUASH, PAPAYA)		9.8×10^{-6}	
FISH (MULLET)+	6	1.3×10^{-4} +	

* ASSUMED TO BE THE SAME AS COCONUT MEAT

\+ FROM V. NOSHKIN

TAB

E

FEDERAL RADIATION COUNCIL

RADIATION PROTECTION GUIDANCE FOR FEDERAL AGENCIES

Memorandum for the President

Pursuant to Executive Order 10831 and Public Law 86-373, the Federal Radiation Council has made a study of the hazards and use of radiation. We herewith transmit our first report to you concerning our findings and our recommendations for the guidance of Federal agencies in the conduct of their radiation protection activities.

It is the statutory responsibility of the Council to "* * * advise the President with respect to radiation matters, directly or indirectly affecting health, including guidance for all Federal agencies in the formulation of radiation standards and in the establishment and execution of programs of cooperation with States * * *"

Fundamentally, setting basic radiation protection standards involves passing judgment on the extent of the possible health hazard society is willing to accept in order to realize the known benefits of radiation. It involves inevitably a balancing between total health protection, which might require foregoing any activities increasing exposure to radiation, and the vigorous promotion of the use of radiation and atomic energy in order to achieve optimum benefits.

The Federal Radiation Council has reviewed available knowledge on radiation effects and consulted with scientists within and outside the Government. Each member has also examined the guidance recommended in this memorandum in light of his statutory responsibilities. Although the guidance does not cover all phases of radiation protection, such as internal emitters, we find that the guidance which we recommend that you provide for the use of Federal agencies gives appropriate consideration to the requirements of health protection and the beneficial uses of radiation and atomic energy. Our further findings and recommendations follow.

Discussion. The fundamental problem in establishing radiation protection guides is to allow as much of the beneficial uses of ionizing radiation as possible while assuring that man is not exposed to undue hazard. To get a true insight into the scope of the problem and the impact of the decisions involved, a review of the benefits and the hazards is necessary.

It is important in considering both the benefits and hazards of radiation to appreciate that man has existed throughout his history in a bath of natural radiation. This background radiation, which varies over the earth, provides a partial basis for understanding the effects of radiation on man and serves as an indicator of the ranges of radiation exposures within which the human population has developed and increased.

The benefits of ionizing radiation. Radiation properly controlled is a boon to mankind. It has been of inestimable value in the diagnosis and treatment of diseases. It can provide sources of energy greater than any the world has yet had available. In industry, it is used as a tool to measure thickness, quantity or quality, to discover hidden flaws, to trace liquid flow, and for other purposes. So many research uses for ionizing radiation have been found that scientists in many diverse fields now rank radiation with the microscope in value as a working tool.

The hazards of ionizing radiation. Ionizing radiation involves health hazards just as do many other useful tools. Scientific findings concerning the biological effects of radiation of most immediate interest to the establishment of radiation protection standards are the following:

1. Acute doses of radiation may produce immediate or delayed effects, or both.

2. As acute whole body doses increase above approximately 25 rems (units of radiation dose), immediately observable effects increase in severity with dose, beginning from barely detectable changes, to biological signs clearly indicating damage, to death at levels of a few hundred rems.

3. Delayed effects produced either by acute irradiation or by chronic irradiation are similar in kind, but the ability of the body to repair radiation damage is usually more effective in the case of chronic than acute irradiation.

4. The delayed effects from radiation are in general indistinguishable from familiar pathological conditions usually present in the population.

5. Delayed effects include genetic effects (effects transmitted to succeeding generations), increased incidence of tumors, lifespan shortening, and growth and development changes.

6. The child, the infant, and the unborn infant appear to be more sensitive to radiation than the adult.

7. The various organs of the body differ in their sensitivity to radiation.

8. Although ionizing radiation can induce genetic and somatic effects (effects on the individual during his lifetime other than genetic effects), the evidence at the present time is insufficient to justify precise conclusions on the nature of the dose-effect relationship at low doses and dose rates. Moreover, the evidence is insufficient to prove either the hypothesis of a "damage threshold" (a point below which no damage occurs) or the hypothesis of "no threshold" in man at low doses.

9. If one assumes a direct line[...] tion between biological effect [...] amount of dose, it then becomes [...] to relate very low dose to an [...] biological effect even though it is [...] tectable. It is generally agreed [...] effect that may actually occur [...] exceed the amount predicted [...] assumption.

Basic biological assumptions. [...] are insufficient data to provide [...] basis for evaluating radiation ef[...] all types and levels of irradiation [...] is particular uncertainty with re[...] the biological effects at very lo[...] and low-dose rates. It is not [...] therefore to assume that there is [...] of radiation exposure below whi[...] is absolute certainty that no eff[...] occur. This consideration, in [...] to the adoption of the conserva[...] pothesis of a linear relation betw[...] logical effect and the amount [...] determines our basic approach [...] formulation of radiation pr[...] guides.

The lack of adequate scientifi[...] mation makes it urgent that ad[...] research be undertaken and n[...] developed to provide a firmer b[...] evaluating biological risk. App[...] member agencies of the Federal [...] tion Council are sponsoring and [...] aging research in these areas.

Recommendations. In view [...] findings summarized above the f[...] recommendations are made:

It is recommended that:

1. There should not be any m[...] radiation exposure without the [...] tion of benefit resulting from [...] posure. Activities resulting in m[...] radiation exposure should be au[...] for useful applications provided [...] ommendations set forth her[...] followed.

It is recommended that:

2. The term "Radiation Pr[...] Guide" be adopted for Federal u[...] term is defined as the radiati[...] which should not be exceeded [...] careful consideration of the rea[...] doing so; every effort should be [...] encourage the maintenance of r[...] doses as far below this g[...] practicable.

It is recommended that:

3. The following Radiation Pr[...] Guides be adopted for normal p[...] operations:

Type of exposure	Condition	Dose (rem)
Radiation worker:		
(a) Whole body, head and trunk, active blood forming organs, gonads, or lens of eye.	Accumulated dose	5 times the number of y[...] age 18.
	13 weeks	3.
(b) Skin of whole body and thyroid	Year	30.
	13 weeks	10.
(c) Hands and forearms, feet and ankles	Year	75.
	13 weeks	25.
(d) Bone	Body burden	0.1 microgram of radiu[...] biological equivalent.
(e) Other organs	Year	15.
	13 weeks	5.
Population:		
(a) Individual	Year	0.5 (whole body).
(b) Average	30 year	5 (gonads).

The following points are made in relation to the Radiation Protection Guides herein provided:

(1) For the individual in the [...] tion, the basic Guide for annu[...] body dose is 0.5 rem. This Gu[...]

plies when the individual whole body doses are known. As an operational technique, where the individual whole body doses are not known, a suitable sample of the exposed population should be developed whose protection guide for annual whole body dose will be 0.17 rem per capita per year. It is emphasized that this is an operational technique which should be modified to meet special situations.

(2) Considerations of population genetics impose a per capita dose limitation for the gonads of 5 rems in 30 years. The operational mechanism described above for the annual individual whole body dose of 0.5 rem is likely in the immediate future to assure that the gonadal exposure Guide (5 rem in 30 years) is not exceeded.

(3) These Guides do not differ substantially from certain other recommendations such as those made by the National Committee on Radiation Protection and Measurements, the National Academy of Sciences, and the International Commission on Radiological Protection.

(4) The term "maximum permissible dose" is used by the National Committee on Radiation Protection (NCRP) and the International Commission on Radiological Protection (ICRP). However, this term is often misunderstood. The words "maximum" and "permissible" both have unfortunate connotations not intended by either the NCRP or the ICRP.

(5) There can be no single permissible or acceptable level of exposure without regard to the reason for permitting the exposure. It should be general practice to reduce exposure to radiation, and positive effort should be carried out to fulfill the sense of these recommendations. It is basic that exposure to radiation should result from a real determination of its necessity.

(6) There can be different Radiation Protection Guides with different numerical values, depending upon the circumstances. The Guides herein recommended are appropriate for normal peacetime operations.

(7) These Guides are not intended to apply to radiation exposure resulting from natural background or the purposeful exposure of patients by practitioners of the healing arts.

(8) It is recognized that our present scientific knowledge does not provide a firm foundation within a factor of two or three for selection of any particular numerical value in preference to another value. It should be recognized that the Radiation Protection Guides recommended in this paper are well below the level where biological damage has been observed in humans.

It is recommended that:

4. Current protection guides used by the agencies be continued on an interim basis for organ doses to the population.

Recommendations are not made concerning the Radiation Protection Guides for individual organ doses to the population, other than the gonads. Unfortunately, the complexities of establishing guides applicable to radiation exposure of all body organs preclude the Council from making recommendations concerning them at this time. However, current protection guides used by the agencies appear appropriate on an interim basis.

It is recommended that:

5. The term "Radioactivity Concentration Guide" be adopted for Federal use. This term is defined as the concentration of radioactivity in the environment which is determined to result in whole body or organ doses equal to the Radiation Protection Guide.

Within this definition, Radioactivity Concentration Guides can be determined after the Radiation Protection Guides are decided upon. Any given Radioactivity Concentration Guide is applicable only for the circumstances under which the use of its corresponding Radiation Protection Guide is appropriate.

It is recommended that:

6. The Federal agencies, as an interim measure, use radioactivity concentration guides which are consistent with the recommended Radiation Protection Guides. Where no Radiation Protection Guides are provided, Federal agencies continue present practices.

No specific numerical recommendations for Radioactivity Concentration Guides are provided at this time. However, concentration guides now used by the agencies appear appropriate on an interim basis. Where appropriate radioactivity concentration guides are not available, and where Radiation Protection Guides for specific organs are provided herein, the latter Guides can be used by the Federal agencies as a starting point for the derivation of radioactivity concentration guides applicable to their particular problems. The Federal Radiation Council has also initiated action directed towards the development of additional Guides for radiation protection.

It is recommended that:

7. The Federal agencies apply these Radiation Protection Guides with judgment and discretion, to assure that reasonable probability is achieved in the attainment of the desired goal of protecting man from the undesirable effects of radiation. The Guides may be exceeded only after the Federal agency having jurisdiction over the matter has carefully considered the reason for doing so in light of the recommendations in this paper.

The Radiation Protection Guides provide a general framework for the radiation protection requirements. It is expected that each Federal agency, by virtue of its immediate knowledge of its operating problems, will use these Guides as a basis upon which to develop detailed standards tailored to meet its particular requirements. The Council will follow the activities of the Federal agencies in this area and will promote the necessary coordination to achieve an effective Federal program.

If the foregoing recommendations are approved by you for the guidance of Federal agencies in the conduct of their radiation protection activities, it is further recommended that this memorandum be published in the FEDERAL REGISTER.

ARTHUR S. FLEMMING,
Chairman,
Federal Radiation Council.

The recommendations numbe[red] through "7" contained in th[e] memorandum are approved [for the] guidance of Federal agencies, [and this] memorandum shall be publishe[d in the] FEDERAL REGISTER.

DWIGHT D. EISEN[HOWER]

MAY 13, 1960.

[F.R. Doc. 60-4539; Filed, May 1[...] 8:51 a.m.]

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FEDERAL RADIATION COUNCIL

RADIATION PROTECTION GUIDANCE FOR FEDERAL AGENCIES

Memorandum for the President

SEPTEMBER 13, 1961.

Pursuant to Executive Order 10831 and Public Law 86-373, the Federal Radiation Council herewith transmits its second report to you concerning findings and recommendations for guidance for Federal agencies in the conduct of their radiation protection activities.

Background. On May 13, 1960, the first recommendations of the Council were approved by the President and the memorandum containing these recommendations was published in the FEDERAL REGISTER on May 18, 1960. There was also released at the same time, Staff Report No. 1 of the Federal Radiation Council, entitled, "Background Material for the Development of Radiation Protection Standards," dated May 13, 1960.

The first report of the Council provided a general philosophy of radiation protection to be used by Federal agencies in the conduct of their specific programs and responsibilities. It introduced and defined the term "Radiation Protection Guide" (RPG). It provided numerical values for Radiation Protection Guides for the whole body and certain organs of radiation workers and for the whole body of individuals in the general population, as well as an average population gonadal dose. It introduced as an operational technique, where individual whole body doses are not known, the use of a "suitable sample" of the exposed population in which the guide for the average exposure of the sample should be one-third the RPG for the individual members of the group. It emphasized that this operational technique should be modified to meet special situations. In selecting a suitable sample particular care should be taken to assure that a disproportionate fraction of the average dose is not received by the most sensitive population elements. The observations, assumptions, and comments set out in the memorandum published in the FEDERAL REGISTER, May 18, 1960, are equally applicable to this memorandum.

This memorandum contains recommendations for the guidance of Federal agencies in activities designed to limit exposure of members of population groups to radiation from radioactive materials deposited in the body as a result of their occurrence in the environment. These recommendations include: (1) Radiation Protection Guides for certain organs of individuals in the general population, as well as averages over suitable samples of exposed groups; (2) guidance on general principles of control applicable to all radionuclides occurring in the environment; and (3) specific guidance in connection with exposure of population groups to radium-226, iodine-131, strontium-90, and strontium-89. It is the intention of the Council to release the background material leading to these recommendations as Staff Report No. 2 when the recommendations contained herein are approved.

Specific attention was directed to problems associated with radium-226, iodine-131, strontium-90, and strontium-89. Radium-226 is an important naturally occurring radioactive material. The other three were present in fallout from nuclear weapons testing. They could, under certain circumstances, also be major constituents of radioactive materials released to the environment from large scale atomic energy installations used for peaceful purposes. Available data suggest that effective control of these nuclides, in cases of mixed fission product contamination of the environment, would provide reasonable assurance of at least comparable limitation of hazard from other fission products in the body.

Establishment of the Federal Radiation Council followed a period of public concern incident to discussions of fallout. While strontium-90 received the greatest popular attention, exposures to cesium-137, iodine-131, strontium-89 and, in still lesser degrees to other radionuclides, are involved in the evaluation of over-all effects. The characteristics of cesium-137 lead to direct comparison with whole body exposures for which recommendations by the Council have already been made.

Studies by the staff of the Council indicate that observed concentrations of radioactive strontium in food and water do not result in concentrations in the skeleton (and consequently in radiation doses) as large as have been assumed in the past. However, concentrations of iodine-131 in the diets of small children, particularly in milk, equal to those permitted under current standards would lead to radiation doses to the child's thyroid which, in comparison with the general structure of current radiation protection standards, would be too high. This is because current concentration guides for exposure of population groups to radioactive materials in air, food, and water have been derived by application of a single fraction to corresponding occupational guides. In the case of iodine-131 in milk, consumption of milk and retention of iodine by the child may be at least as great as by the adult, while the relatively small size of the thyroid makes the radiation dose to the thyroid much larger than in the case of the adult. In addition, there is evidence that irradiation of the thyroid involves greater risk to children than to adults.

Recommendations as to Radiation Protection Guides. The Federal Radiation Council has previously emphasized that establishment of radiation protection standards involves a balancing of the benefits to be derived from the controlled use of radiation and atomic energy against the risk of radiation exposure. In the development of the Radiation Protection Guides contained herein, the Council has considered both sides of this balance. The Council has reviewed available knowledge, consulted with scientists within and outside the Government, and solicited views of interested individuals and groups from the general public. In particular, the Council has not only drawn heavily upon reports published by the International Commission on Radiological Protection (ICRP), the National Committee on Radiation Protection and Measurements (NCRP), and the National Academy of Sciences (NAS), but has had during the development of the report the benefit of consultation with, and comments and suggestions by, individuals from NCRP and NAS and of their subcommittees. The Radiation Protection Guides recommended below are considered by the Council to represent an appropriate balance between the requirements of health protection and of the beneficial uses of radiation and atomic energy.

It is recommended that:

1. The following Radiation Protection Guides be adopted for normal peacetime operations.

TABLE I—RADIATION PROTECTION GUIDES FOR CERTAIN BODY ORGANS IN RELATION TO EXPOSURE OF POPULATION GROUPS

Organ	RPG for individuals	RPG for average of suitable sample of exposed population group
Thyroid	1.5 rem per year	0.5 rem per year.
Bone marrow	0.5 rem per year	0.17 rem per year.
Bone	1.5 rem per year	0.5 rem per year.
Bone (alternate guide).	0.003 micrograms of Ra-226 in the adult skeleton or the biological equivalent of this amount of Ra-226.	0.001 micrograms of Ra-226 in the adult skeleton or the biological equivalent of this amount of Ra-226.

It will be noted that the preceding table provides Radiation Protection Guides to be applied to the average of a suitable sample of an exposed population group which are one-third of those applying to individuals. This is in accordance with the recommendations in the first report of the Council concerning operational techniques for controlling population exposure. Since in the case of exposure of a population group to radionuclides the radiation doses to individuals are not usually known, the organ dose to be used as a guide for the average of suitable samples of an exposed population group is also given as an RPG.

Recommendations as to general principles. Control of population exposure from radionuclides occurring in the environment is accomplished in general either by restriction on the entry of such materials into the environment or through measures designed to limit the intake by members of the population of radionuclides already in the environment. Both approaches involve the consideration of actual or potential concentrations of radioactive material in air, water, or food. Controls should be based upon an evaluation of population

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exposure with respect to the RPG. For this purpose, the total daily intake of such materials, averaged over periods of the order of a year, constitutes an appropriate criterion.

The control of the intake by members of the general population of radioactive materials from the environment can appropriately involve many different kinds of actions. The character and import of these actions may vary widely, from those which entail little interference with usual activities, such as monitoring and surveillance, to those which involve a major disruption, such as condemnation of food supplies. Some control actions may require prolonged lead times before becoming effective, e.g., major changes in processing facilities or water supplies. The magnitude of control measures should be related to the degree of likelihood that the RPG may be exceeded. The use of a single numerical intake value, which in part has been the practice until now, does not in many instances provide adequate guidance for taking actions appropriate to the risk involved. For planning purposes, it is desirable that insofar as possible control actions to meet contingencies be known in advance.

It is recommended that:

2. The radiological health activities of Federal agencies in connection with environmental contamination with radioactive materials be based, within the limits of the agency's statutory responsibilities, on a graded series of appropriate actions related to ranges of intake of radioactive materials by exposed population groups.

In order to provide guidance to the agencies in adapting the graded approach to their own programs, the recommendations pertaining to the specific radionuclides in this memorandum consider three transient daily rates of intake by suitable samples of exposed population groups. For the other radionuclides, the agencies can use the same general approach, the details of which are considered in Staff Report No. 2. The general types of action appropriate when these transient rates of intake fall into the different ranges are also discussed in Staff Report No. 2. The purpose of these actions is to provide reasonable assurance that average rates of intake by a suitable sampl[illegible] an ex[illegible] population group, ave[illegible] sample and averaged over perio[illegible] of the order of one year, do not exceed the upper value of Range II. The general character of these actions is suggested in the following table.

TABLE II—GRADED SCALES OF ACTION

Ranges of transient rates of daily intake	Graded scale of action
Range I	Periodic confirmatory surveillance as necessary.
Range II	Quantitative surveillance and routine control.
Range III	Evaluation and application of additional control measures as necessary.

Recommendations on Ra-226, I-131, Sr-90, and Sr-89. The Council has given specific consideration to the effects on man of rates of intake of radium-226, iodine-131, strontium-90 and strontium-89 resulting in radiation doses equal to those specified in the appropriate RPG's. The Council has also reviewed past and current activities resulting in the release of these radionuclides to the environment and has given consideration to future developments. For each of the nuclides three ranges of transient daily intake are given which correspond to the guidance contained in Recommendation 2, above. Routine control of useful applications of radiation and atomic energy should be such that expected average exposures of suitable samples of an exposed population group will not exceed the upper value of Range II. For iodine-131 and radium-226, this value corresponds to the RPG for the average of a suitable sample of an exposed population group. In the cases of strontium-90 and strontium-89, the Council's study indicated that there is currently no known operational requirement for an intake value as high as the one corresponding the RPG. Hence, a value estimated to correspond to doses to the critical organ not greater than one-third of the RPG has been used.

The guidance recommended below is given in terms of transient rates of (radioactivity) intake in micromicrocuries per day. The upper limit of Range II is based on an annual RPG (or lower, in case of radioactive strontium) considered as an acceptable risk for a lifetime. However, it is necessary to use averages over periods much shorter than a lifetime for both radiation dose rates and rates of intake for administrative and regulatory purposes. It is recommended that such periods should be of the order of one year. It is to be noted that values listed in the tables are much smaller than any single intake from which an individual might be expected to sustain injury.

It is recommended that:

3. (a) The following guidance on daily intake be adopted for normal peacetime operations to be applied to the average of suitable samples of an exposed population group:

TABLE III—RANGES OF TRANSIENT RATES OF INTAKE (MICROMICROCURIES PER DAY) FOR USE IN GRADED SCALE OF ACTIONS SUMMARIZED IN TABLE II.

Radionuclides	Range I	Range II	Range III
Radium-226	0-2	2-20	20-200
Iodine-131 [1]	0-10	10-100	100-1,000
Strontium-90	0-20	20-200	200-2,000
Strontium-89	0-200	200-2,000	2,000-20,000

[1] In the case of iodine-131, the suitable sample would include only small children. For adults, the RPG for the thyroid would not be exceeded by rates of intake higher by a factor of 10 than those applicable to small children.

(b) Federal agencies determine concentrations of these radionuclides in air, water, or items of food applicable to their particular programs which are consistent with the guidance contained herein on average daily intake for the radionuclides radium-226, iodine-131, strontium-90, and strontium-89. Some of the general considerations involved in the derivation of concentration values from intake values are given in Staff Report No. 2.

It is recommended that:

4. For radionuclides not considered in this report, agencies use concentration values in air, water, or items of food which are consistent with recommended Radiation Protection Guides and the general guidance on intake.

In the future, the Council will direct attention to the development of appropriate radiation protection guidance for those radionuclides for which such consideration appears appropriate or necessary. In particular, the Council will study any radionuclides for which useful applications of radiation or atomic energy require release to the environment of significant amounts of these nuclides. Federal agencies are urged to inform the Council of such situations.

ABRAHAM RIBICOFF,
Chairman,
Federal Radiation Council.

The recommendations numbered "1" through "4" contained in the above memorandum are approved for the guidance of Federal agencies, and the memorandum shall be published in the FEDERAL REGISTER.

JOHN F. KENNEDY.

SEPTEMBER 20, 1961.

TAB

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Table 9. Maximum Annual Dose Rate in mrem/y for a Living Pattern Consisting of 100% Time on Eneu Island

Case When Imported Foods are Readily Available in the Diet

	$^{137}Cs+^{90}Sr^{+}$ Ingestion	External Gamma*	Total
Bone Marrow	121	20	141
Wholebody	100	20	120

Case When Local Subsistence Crops are in Full Use

	$^{137}Cs+^{90}Sr^{+}$ Ingestion	External Gamma*	Total
Bone Marrow	233	20	253
Wholebody	189	20	209

+All food crops are from Eneu Island

*Natural background subtracted

Table 10. Maximum Annual Dose Rate in mrem/y for a Living Pattern Consisting of 80% time on Eneu Island and 20% time on Bikini Island

Case When Imported Foods are Readily Available in the Diet

	$^{137}Cs+^{90}Sr^{+}$ Ingestion	External Gamma*	10%	5%	Total	10%	5%
Bone Marrow	121	67	44	32	188	165	15
Wholebody	100	67	44	32	167	144	13

Case When Local Subsistence Crops are in Full Use

	$^{137}Cs+^{90}Sr^{+}$ Ingestion	External Gamma*			Total		
Bone Marrow	233	67	44	32	300	277	26
Wholebody	189	67	44	32	256	233	22

Table 11. Maximum Annual Dose Rate in mrem/y for a Living Pattern Consisting of 100% time on Bikini Island

Case When Imported Foods are Readily Available in the Diet

	$^{137}Cs+^{90}Sr$ Ingestion	External Gamma*	Total
Bone Marrow	941	256	1,197 ≈ 1.2 rem/y
Wholebody	877	256	1,133 ≈ 1.1 rem/y

Case When Local Subsistence Crops are in Full Use

	$^{137}Cs+^{90}Sr$ Ingestion	External Gamma*	Total
Bone Marrow	2013	256	2,269 ≈ 2.3 rem
Wholebody	1849	256	2,105 ≈ 2.1 rem

*Local Background Substracted

Table 12. 30-Year Integral Dose in Rem for a Living Pattern Consisting of 100% time on Eneu Island and Imported Foods Being Readily Available

Ingestion	Wholebody	Bone Marrow and Bone
^{137}Cs	2.25	2.25
^{90}Sr	--	0.70
$^{239+240}Pu$	--	.00045
^{241}Am	--	.0012
$^{241}Pu/^{241}Am$	--	0.00058
External Gamma	0.433*	0.433*
Total	2.7	3.4

*Based on an initial dose rate for Eneu Island of 20 mrem/y and assuming the entire dose is from ^{137}Cs.

Table 13. 30 YEAR INTEGRAL DOSE IN Rem FOR A LIVING PATTERN CONSISTING OF 100% TIME ON ENEU ISLAND AND FOR FULL USE OF LOCAL SUBSISTENCE CROPS.

INGESTION	WHOLEBODY	BONE MARROW AND BONE
^{137} CS	4.25	4.25
^{90}Sr	-	1.5
$^{239+240}$Pu	-	.0008
^{241}Am	-	.0021
^{241}Pu/^{241}Am	-	0.0019
External Gamma	0.433*	0.433*
TOTAL	4.7	6.2

* Based on an ititial dose rate for Eneu Island of 20 mrem/y and assuming the entire dose is from ^{137}Cs.

Table 14. 30 YEAR INTEGRAL DOSE IN Rem FOR A LIVING PATTERN CONSISTING OF 100 % TIME ON BIKINI ISLAND AND IMPORTED FOODS BEING READILY AVAILABLE.

INGESTION	WHOLEBODY	BONE MARROW AND BONE
^{137}Cs	19.8	19.8
^{90}Sr	-	2.2
$^{239+240}Pu$	-	.00051
^{241}Am	-	.0013
$^{241}Pu/^{241}AM$	-	-
External Gamma	5.54*	5.54*
TOTAL	25.3	27.5

* Based on an initial dose rate of 256 mrem/y and assuming that the entire dose if from ^{137}Cs.

Table 15. 30 YEAR INTEGRAL DOSE IN Rem FOR A LIVING PATTERN CONSISTING OF 100 % TIME ON BIKINI ISLAND AND FULL USE OF LOCALLY GROWN SUBSISTENCE CROPS.

INGESTION	WHOLEBODY	BONE MARROW AND BONE
^{137}Cs	41.6	41.7
^{90}Sr	-	5.6
$^{239+240}Pu$	-	.00094
^{241}Am	-	.0024
$^{241}Pu/^{241}Am$	-	-
External Gamma	5.54*	5.54*
TOTAL	47.1	52.8

* Based on an initial dose rate of 256 mrem per year and assuming that the entire dose is from ^{137}Cs.

TAB G

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
NATIONAL RESEARCH COUNCIL

SUMMARY AND RECOMMENDATIONS

In anticipation of the widespread increased use of nuclear energy, it is time to think anew about radiation protection. We need standards for the major categories of radiation exposure, based insofar as possible on risk estimates and on cost-benefit analyses which compare the activity involving radiation with the alternative options. Such analyses, crude though they must be at this time, are needed to provide a better public understanding of the issues and a sound basis for decision. These analyses should seek to clarify such matters as: (a) the environmental and biological risks of given developments, (b) a comparison of these risks with the benefits to be gained, (c) the feasibility and worth of reducing these environmental and biological risks, (d) the net benefit to society of a given development as compared to the alternative options.

In the foreseeable future, the major contributors to radiation exposure of the population will continue to be natural background with an average whole-body dose of about 100 mrem/year, and medical applications which now contribute comparable exposures to various tissues of the body. Medical exposures are not under control or guidance by regulation or law at present. The use of ionizing radiation in medicine is of tremendous value but it is essential to reduce exposures since this can be accomplished without loss of benefit and at relatively low cost. The aim is not only to reduce the radiation exposure to the individual but also to have procedures carried out with maximum efficiency so that there can be a continuing increase in medical benefits accompanied by a minimum radiation exposure.

Concern about the nuclear power industry arises because of its potential magnitude and widespread distribution. Based on experience to date and present engineering judgment, the contribution to radiation exposure averaged over the U. S. population from the developing nuclear power industry can remain less than about 1 mrem per year (about 1% of natural background) and the exposure of any individual kept to a small fraction of background provided that there is: (a) attainment and long-term maintenance of anticipated engineering performance, (b) adequate management of radioactive wastes, (c) control of sabotage and diversion of fissionable material, (d) avoidance of catastrophic accidents.

The present Radiation Protection Guide for the general population was based on genetic considerations and conforms to the BEAR Committee recommendations that the average individual exposure be less than 10 R (Roentgens) before the mean age of reproduction (30 years). The FRC did not include medical radiation in its limits and set 5 rem as the 30-year limit (0.17 rem per year).

Present estimates of genetic risk are expressed in four ways: (a) *Risk Relative to Natural Background Radiation.* Exposure to man-made radiation below the level of background radiation will produce additional effects that are less in quantity and no different in kind from those which man has experienced and has been able to tolerate throughout his history. (b) *Risk Estimates for Specific Genetic Conditions.* The expected effect of radiation can be compared with current incidence of genetic effects by use of the concept of doubling dose (the dose required to produce a number of mutations equal to those which occur naturally). Based mainly on experimental studies in the mouse and *Drosophila* and with some support from observations of human populations in Hiroshima and Nagasaki, the doubling dose for chronic radiation in man is estimated to fall in the range of 20-200 rem. It is calculated that the effect of 170 mrem per year (or 5 rem per 30-year reproduction generation) would cause in the first generation between 100 and 1800 cases of serious, dominant or X-linked diseases and defects per year (assuming 3.6 million births annually in the U.S.). This is an incidence of 0.05%. At equilibrium (approached after several generations) these numbers would be about five-fold larger. Added to these would be a smaller number caused by chromosomal defects and recessive diseases. (c) *Risk Relative to Current Prevalence of Serious Disabilities.* In addition to those in (b) caused by single-gene defects and chromosome aberrations are congenital abnormalities and constitutional diseases which are partly genetic. It is estimated that the *total* incidence from all these including those in (b) above, would be between 1100 and 27,000 per year at equilibrium (again, based on 3.6 million births). This would be about 0.75% at equilibrium, or 0.1% in the first generation. (d) *The Risk in Terms of Overall Ill-Health.* The most tangible measure of total genetic damage is probably "ill-health" which includes but is not limited to the above categories. It is thought that between 5% and 50% of ill-health is proportional to the mutation rate. Using a value of 20% and a doubling dose of 20 rem, we can calculate that 5 rem per generation would eventually lead to an increase of 5% in the ill-health of the population. Using estimates of the financial costs of ill-health, such effects can be measured in dollars if this is needed for cost-benefit analysis.

Until recently, it has been taken for granted that genetic risks from exposure of populations to ionizing radiation near background levels were of much greater import than were somatic risks. However, this assumption can no longer be made if linear non-threshold relationships are accepted as a basis for estimating cancer risks. Based on knowledge of mechanisms (admittedly incomplete) it must be stated that tumor induction as a result of radiation injury to one or a few cells of the body cannot be excluded. Risk estimates have been made based on this premise and using linear extrapolation from the data from the A-bomb survivors of Hiroshima and Nagasaki, from certain groups of patients irradiated therapeutically, and from groups occupationally exposed. Such calculations based on these data from irradiated humans lead to the prediction that additional exposure of the U. S. population of 5 rem per 30 years could cause from roughly 3,000 to 15,000 cancer deaths annually, depending on the assumptions used in the calculations. The Committee considers the most likely estimate to be approximately 6,000 cancer deaths annually, an increase of about 2% in the spontaneous cancer death rate which is an increase of about 0.3% in the overall death rate from a[ll] causes.

Given the estimates for genetic and somat[ic] risk, the question arises as to how this info[r]mation can be used as a basis for radiatic[on] protection guidance. Logically the guidance [or] standards should be related to risk. Wheth[er] we regard a risk as acceptable or not depen[ds] on how avoidable it is, and, to the extent n[ot] avoidable, how it compares with the risks [of] alternative options and those normally accep[t]ed by society.

There is reason to expect that over the ne[xt] few decades, the dose commitments for all ma[n-]made sources of radiation except medic[al] should not exceed more than a few millire[m] average annual dose to the entire U. S. popu[la]tion. The present guides of 170 mrem/yr gr[ew] out of an effort to balance societal nee[ds] against genetic risks. It appears that the[se] needs can be met with far lower average exp[o]sures and lower genetic and somatic risk th[an] permitted by the current Radiation Protecti[on] Guide. To this extent, the current Guide is u[n]necessarily high.

The exposures from medical and dental us[es] should be subject to the same rationale. To t[he] extent that such exposures can be reduc[ed] without impairing benefits, they are also u[n]necessarily high.

It is not within the scope of this Committee [to] propose numerical limits of radiation exposu[re]. It is apparent that sound decisions requ[ire] technical, economic and sociological conside[ra]tions of a complex nature. However, we c[an] state some general principles, many of whi[ch] are well-recognized and in use, and some [of] which may represent a departure from prese[nt] practice.

a) No exposure to ionizing radiation shou[ld] be permitted without the expectation of [a] commensurate benefit.

b) The public must be protected from radi[a]tion but not to the extent that the degr[ee] of protection provided results in the su[b]stitution of a worse hazard for the radi[a]tion avoided. Additionally there shou[ld] not be attempted the reduction of sm[all] risks even further at the cost of lar[ge] sums of money that spent otherwi[se] would clearly produce greater benefit.

c) There should be an upper limit of man-made non-medical exposure for individuals in the general population such that the risk of serious injury from somatic effects in such individuals is very small relative to risks that are normally accepted. Exceptions to this limit in specific cases should be allowable only if it can be demonstrated that meeting it would cause individuals to be exposed to other risks greater than those from the radiation avoided.

d) There should be an upper limit of man-made non-medical exposure for the general population. The average exposure permitted for the population should be considerably lower than the upper limit permitted for individuals.

e) Medical radiation exposure can and should be reduced considerably by limiting its use to clinically indicated procedures utilizing efficient exposure techniques and optimal operation of radiation equipment. Consideration should be given to the following:

1) Restriction of the use of radiation for public health survey purposes, unless there is a reasonable probability of significant detection of disease.

2) Inspection and licensing of radiation and ancillary equipment.

3) Appropriate training and certification of involved personnel. Gonad shielding (especially shielding the testis) is strongly recommended as a simple and highly efficient way to reduce the Genetically Significant Dose.

f) Guidance for the nuclear power industry should be established on the basis of cost-benefit analysis, particularly taking into account the total biological and environmental risks of the various options available and the cost-effectiveness of reducing these risks. The quantifying of the "as low as practicable" concept and consideration of the net effect on the welfare of society should be encouraged.

g) In addition to normal operating conditions in the nuclear power industry, careful consideration should be given to the probabilities and estimated effects of uncontrolled releases. It has been estimated that a catastrophic accident leading to melting of the core of a large nuclear reactor could result in mortality comparable to that of a severe natural disaster. Hence extraordinary efforts to minimize this risk are clearly called for.

h) Occupational and emergency exposure limits have not been specifically considered but should be based on those sections of the report relating to somatic risk to the individual.

i) In regard to possible effects of radiation on the environment, it is felt that if the guidelines and standards are accepted as adequate for man then it is highly unlikely that populations of other living organisms would be perceptibly harmed. Nevertheless, ecological studies should be improved and strengthened and programs put in force to answer the following questions about release of radioactivity to the environment: (1) how much, where, and what type of radioactivity is released; (2) how are these materials moved through the environment; (3) where are they concentrated in natural systems; (4) how long might it take for them to move through these systems to a position of contact with man; (5) what is their effect on the environment itself; (6) how can this information be used as an early warning system to prevent potential problems from developing?

j) Every effort should be made to assure accurate estimates and predictions of radiation equivalent dosages from all existing and planned sources. This requires use of present knowledge on transport in the environment, on metabolism, and on relative biological efficiencies of radiation as well as further research on many aspects.

LAW OFFICES OF

(M)ICRONESIAN LEGAL SERVICES CORPORATION

ATTORNEYS AND MICRONESIAN COUNSELORS

CABLE ADDRESS: MICROLEX

THEODORE R. MITCHELL
EXECUTIVE DIRECTOR

DANIEL H. MACMEEKIN
DEPUTY DIRECTOR

JESUS C. BORJA
ASSISTANT DIRECTOR

MIDASY AISEK
ALIK J. ALIK
IGNACIO ANASTACIO
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JESUS RAGLMAR
ANTHOLINO K. ROSOKOW
JAMES E. SINDING
ALBERT R. SNYDER
DONALD C. WOODWORTH

CENTRAL OFFICE
POST OFFICE BOX 269
SAIPAN, MARIANA ISLANDS 96950
TELEPHONE 6471 OR 6472

PALAU OFFICE
POST OFFICE BOX 57
KOROR, PALAU,
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TELEPHONE 473

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MAJURO,
MARSHALL ISLANDS 96960
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EASTERN CAROLINE ISLANDS 96941
TELEPHONE 404

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POST OFFICE BOX 826
SAIPAN, MARIANA ISLANDS 96950
TELEPHONE 6243

YAP OFFICE
POST OFFICE BOX 206
COLONIA, YAP,
WESTERN CAROLINE ISLANDS 96943
TELEPHONE 243

KOSRAE OFFICE
POST OFFICE BOX 3
LELU, KOSRAE,
EASTERN CAROLINE ISLANDS 96944

WASHINGTON OFFICE
1424 SIXTEENTH STREET, N.W.
SUITE 300
WASHINGTON, D.C. 20036
TELEPHONE (202) 232-5021

PLEASE REPLY TO Washington Office

FREEDOM OF INFORMATION ACT REQUEST

August 3, 1979

Mr. Milton Jordan
Director
Division of FOI and Privacy
  Acts Activities
Department of Energy
GB-145 Forrestal Building
1000 Independence Avenue, S.W.
Washington, D.C. 20585

Dear Mr. Jordan:

This request is made pursuant to the Freedom of Information Act.

Under date of May 15, 1979, the Assistant Secretary of Environment sent a letter to the Honorable James A. Joseph, Under Secretary of the Interior, having to do with Bikini atoll, Marshall Islands. Attached to the letter is a document entitled "Radiological Implication for Resettlement of Eneu Island." This request relates to that letter and its attachment.

Hereby requested are all documents, records and materials related to the following:

1. On page 1 of the attachment, the following statement appears:

   "Based upon previous experience and past practices, however, it is doubtful whether imported food will be a significant part of the daily diet."

   Please provide any and all records, materials and documentation for this assertion.

2. On the same page the following statement is made:

   "It can also be questioned whether or not access to Bikini Island can be controlled."

   Please provide any and all records, documents, reports and materials which form the basis of this assertion.

3. On page 2 the assertion is made that in August, 1978, the Bikinians "left their Atoll because measurements of radiocesium made in April 1978 showed accumulations in the bodies of 13 out of 101 people such that if this level were maintained for one year, it would result in an annual radiation dose equal to or greater than the 500 mrem/yr federal radiation protection criteria for exposure of individuals." Please provide any and all records, reports, documents or other materials which form the basis of the factual assertions contained in that statement concerning (a) the degree of volition in the departure of the people of Bikini from their atoll, and (b) the measurements of radiocesium in the Bikinians.

4. On page 2 of the attachment appears the following statement:

   "In early 1979, new information was obtained so that dose predictions for residence on Eneu Island could, for the first time, be based upon data from analysis of actual food items of the diet grown on the island rather than on theoretical predictions derived from soil concentrations."

Please provide a copy of all records, reports, or studies or other documents or materials which form the factual basis for this assertion.

5. Regarding the text on page 6 of the attachment which appears at footnote 10, please provide a copy of any study, report or other document which forms the basis of the decision to employ the federal radiation guidance which is taken from the Enewetak Clean-up Environmental Impact Statement of April, 1975. There is no need to provide any materials which are contained in the Environmental Impact Statement. This request is for any additional or other materials.

6. Plese provide a copy of the publication relied upon for the calculated dose estimates which is cited at footnote 14 of the attachment, "An Updated Radiological Dose Assessment of Eneu Island at Bikini Atoll," Robison, W.L. and Phillips, W.A., UCRL-52775, 1979.

7. Beginning at the foot of page 7, the following statement is found:

   "The diets are based on the recent experience and observations of the scientific teams who have been working on Bikini Atoll."

   No support is provided in the text or in the footnote for this statement. Please provide any and all records, reports, studies or other documents or materials which describe the "recent experience and observations" and which provide the names of the members of the "scientific teams" referred to in the quoted statement.

8. With respect to the predicted doses presented on page 8 of the attachment, please provide a copy of any and all studies, reports or other documents

or materials which show the number of fatal cancer cases and the number of genetic malformations to be expected from a dose of 170 millirem per year, and the expected increase in the frequency of such cancer cases and genetic malformations, to be expected for the predicted dose rates presented on page 8 of the attachment. In other words, what is the expected frequency of fatal cancer cases at an average dose rate for the population of 170 millirem per year, compared with, for the whole body, a dose rate of 210 millirem per year, 240 millirem per year, and 260 millirem per year? For another example, what is the expected increase in leukemia cases at 170 millirem per year compared with 190 millirem per year, 260 millirem per year, 280 millirem per year, and 300 millirem per year?

What is the expected frequency of genetic anomalies at an average whole body dose rate of 5000 millirem per 30 years compared with 2700 millirem, 3200 millirem, 4700 millirem, 5200 millirem and 5700 millirem?

9. Please provide any records, documents and materials which would explain why the attachment and the letter of May 15 did not contain any discussion of the biological risks associated with the predicted doses. If no such documents exist, please so state, and explain why such a discussion was not included in the advice provided to the Department of Interior.

Thank you in advance for your prompt attention to this request.

Sincerely,

Theodore R. Mitchell

xc: Ruth C. Clusen
Bruce Wachholz

SUMMARY, MEASURED BODY BURDENS ^{137}Cs

BIKINI IS. RESIDENTS

μCi

	1974	1977	1978	1979*	'78-'79 REDUCTION FACTOR
MALE	.1	1.3	1.9	1.0	2.3
FEMALE	.04	.9	1.4	.4	3.8
CHILDREN	—	—	1.2	.1	12

*45 RESIDENTS MEASURED IN JANUARY '79 AT MAJURO ATOLL WERE AMONG 101 MEASURED IN APRIL '78 AT BIKINI IS.

3 μc Cs is maximum permissible Body Burden

AVERAGE TOTAL BODY DOSES - EXTERNAL PLUS INTERNAL

BIKINI RESIDENTS - mREM

	DOSE DURING RESIDENCE	DOSE COMMITMENT
ADULT MALES	1,100	110
ADULT FEMALES	840	85
CHILDREN (5-14 YEARS)	1,200	140