

thyroid dose
Acute Phase

Obtained from BNL
9/9/80

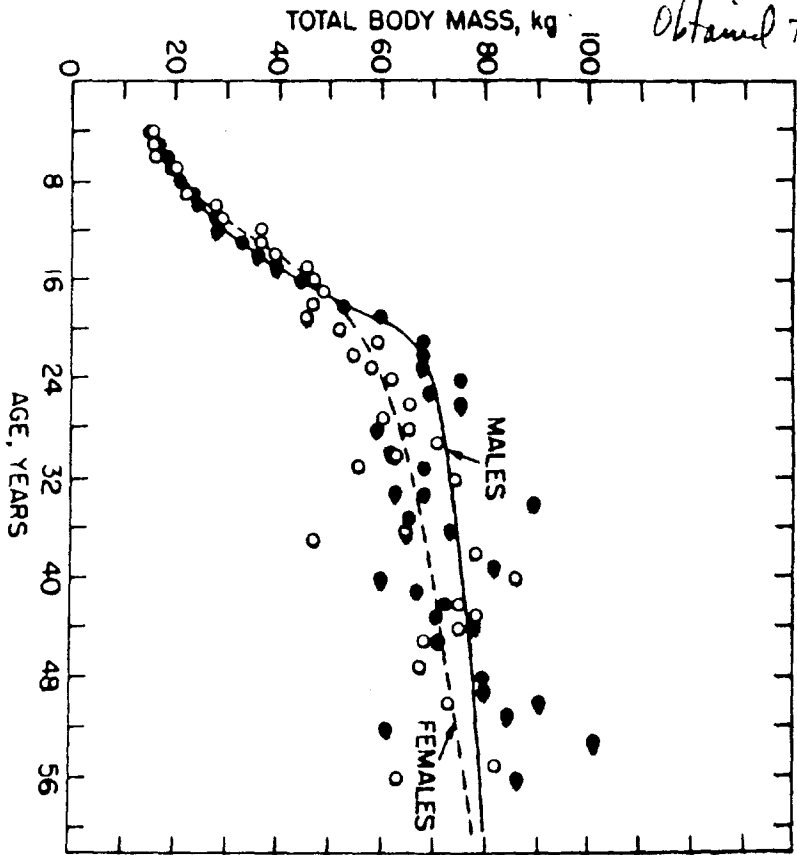


Fig. 1 Body Mass as a Function of Age for Residents of Rongelap Atoll from 1979 Med Study

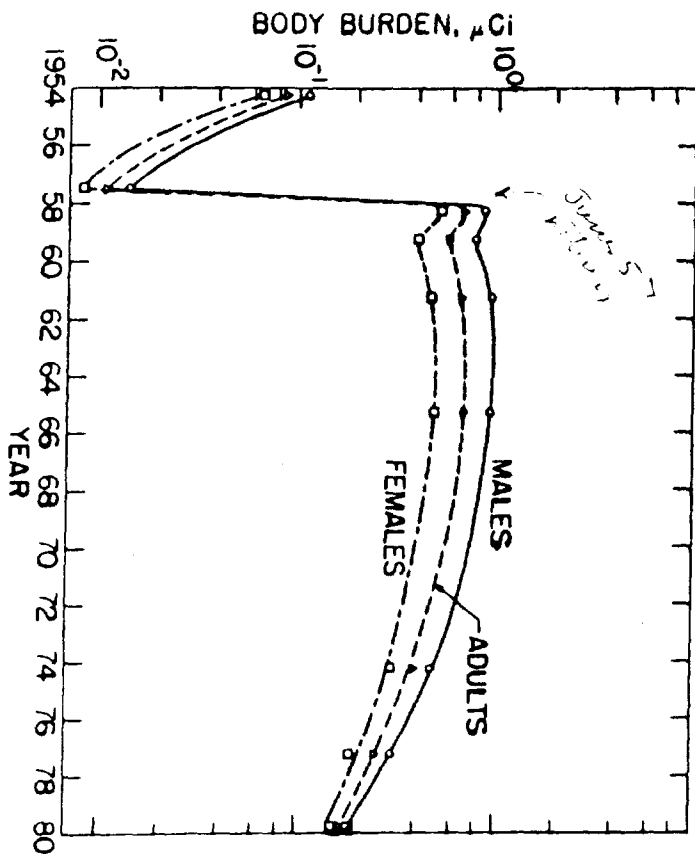


Fig. 2 Mean Adult ¹³⁷Cs Body Burden History at Rongelap Atoll

Figure 3
Mean Body Burden
at Rongelap Atoll

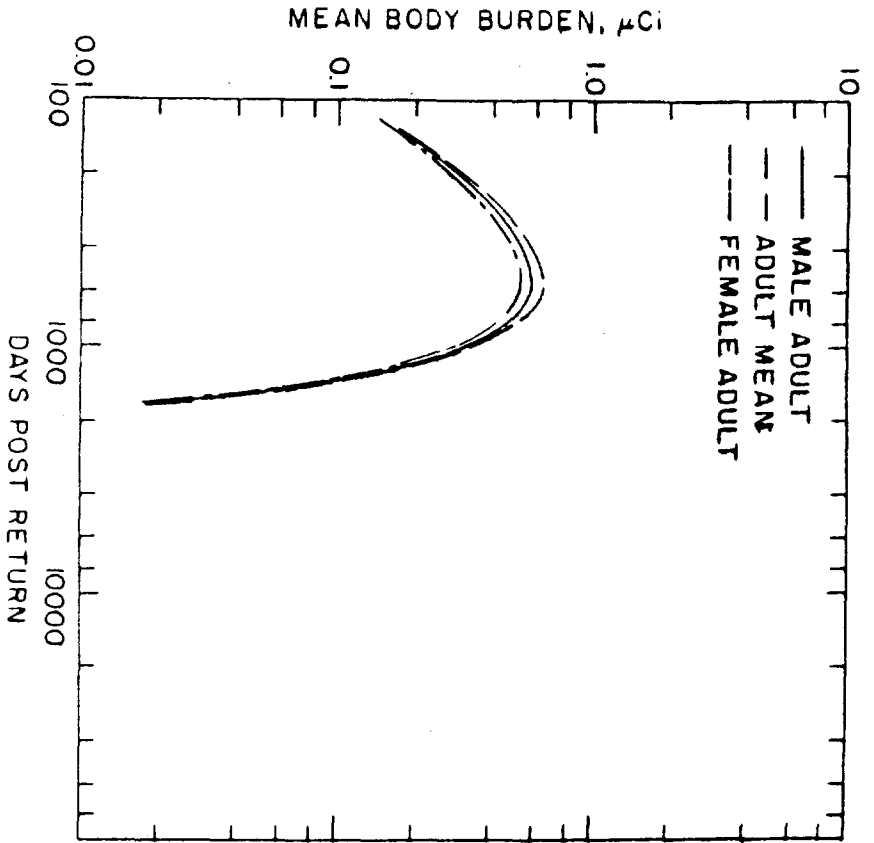


Fig. 3 Mean Adult ^{65}Zn Body Burden History at Rongelap Atoll

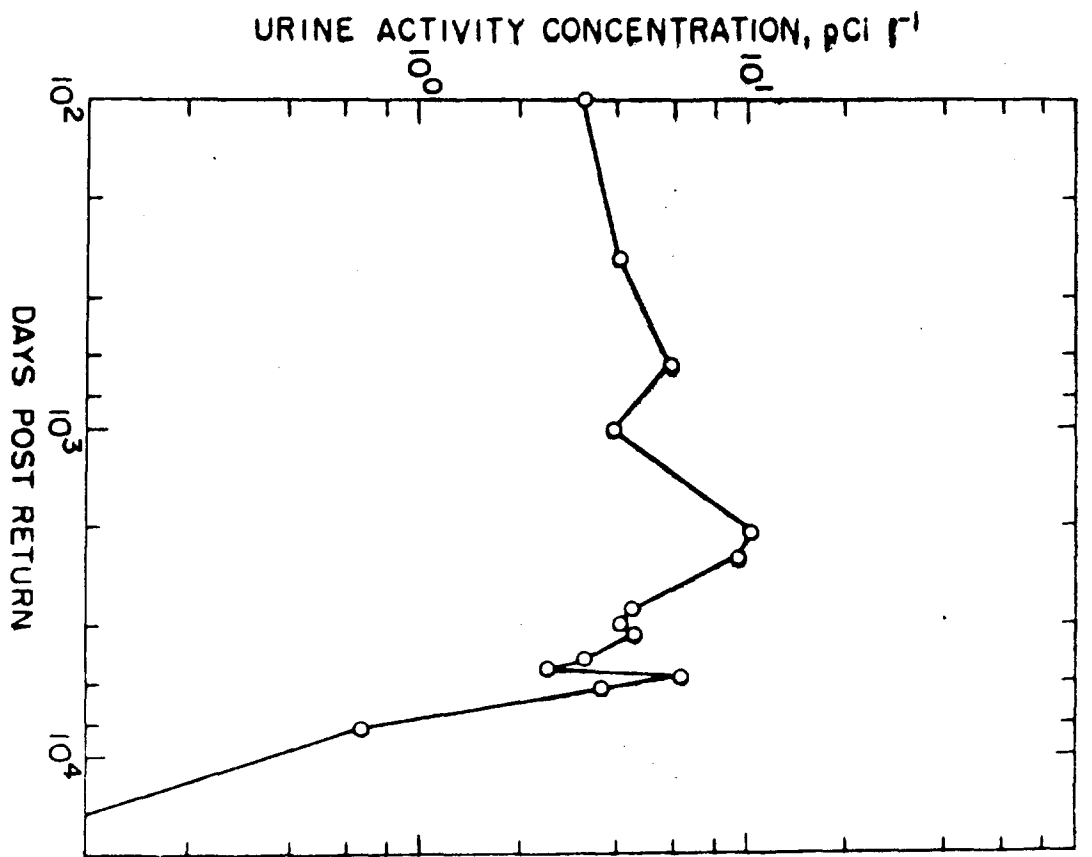


Fig. 4 Mean Adult ^{90}Sr Urine Activity Concentration History at Rongelap Atoll

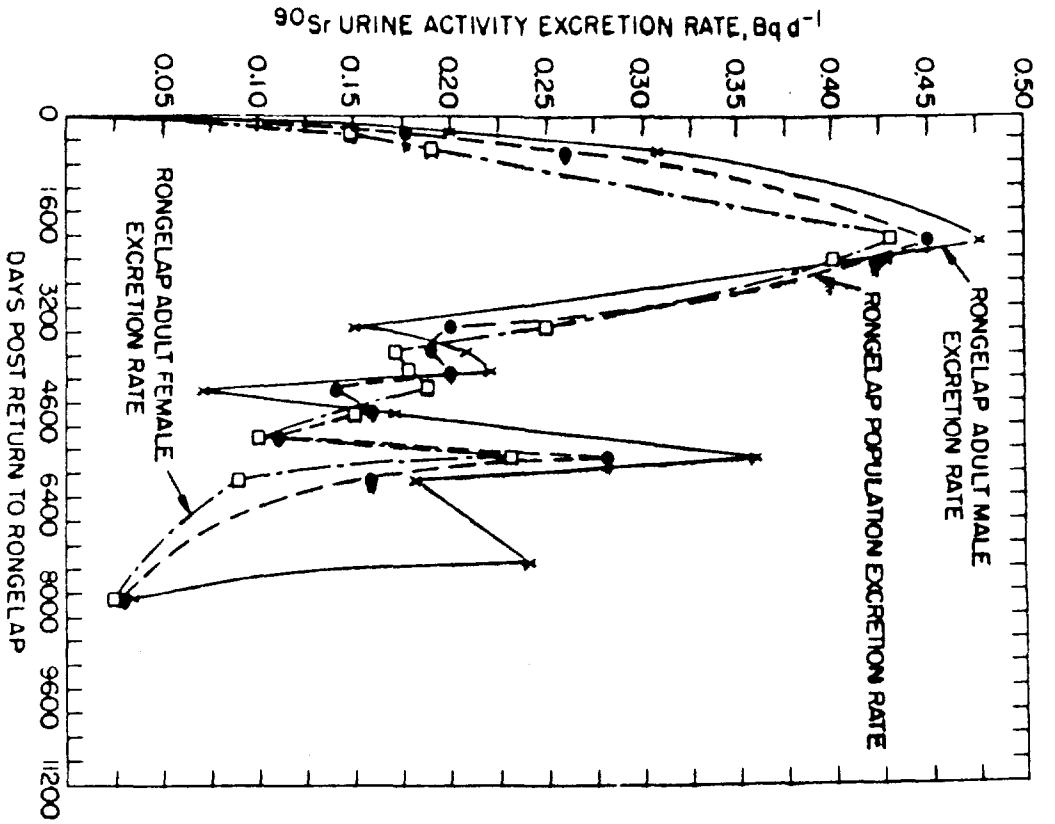


Fig. 5 Mean Adult ^{90}Sr Urine Activity Excretion Rate at Rongelap Atooll

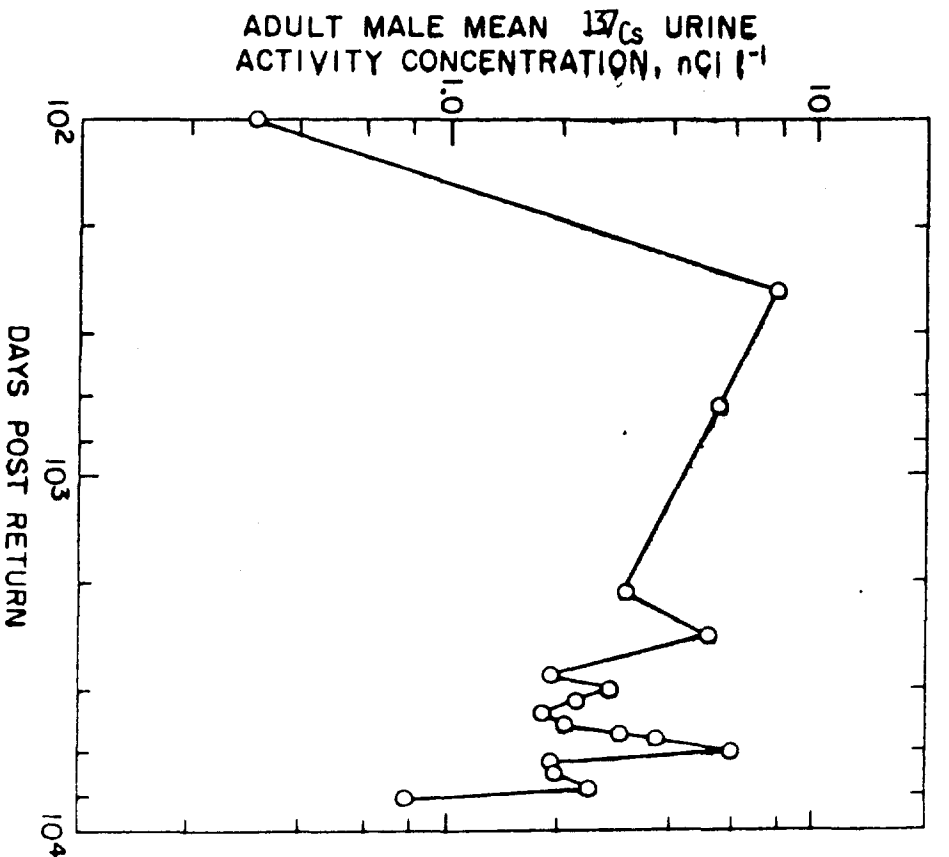


Fig. 6 Mean Adult Male ^{137}Cs Urine Activity Concentration History at Rongelap Atooll

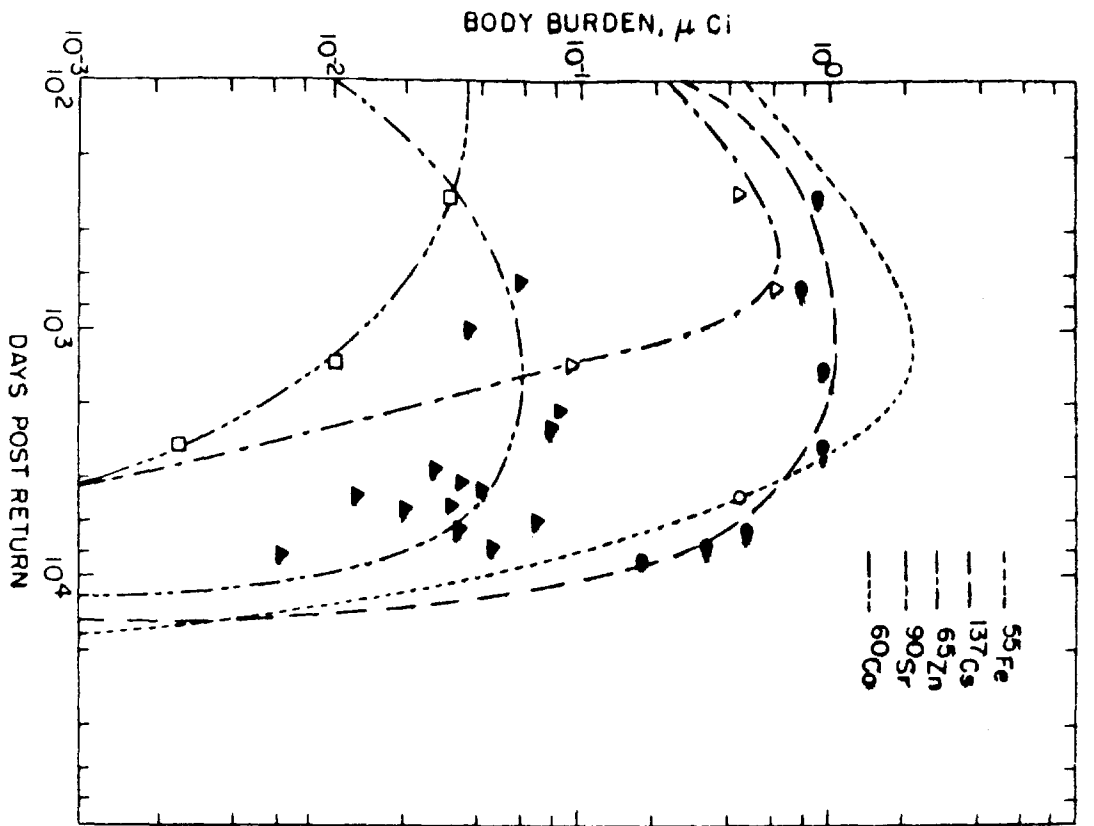


Fig. 7 Composite Nuclide Body Burden History for Adults at Rongelap Atoll

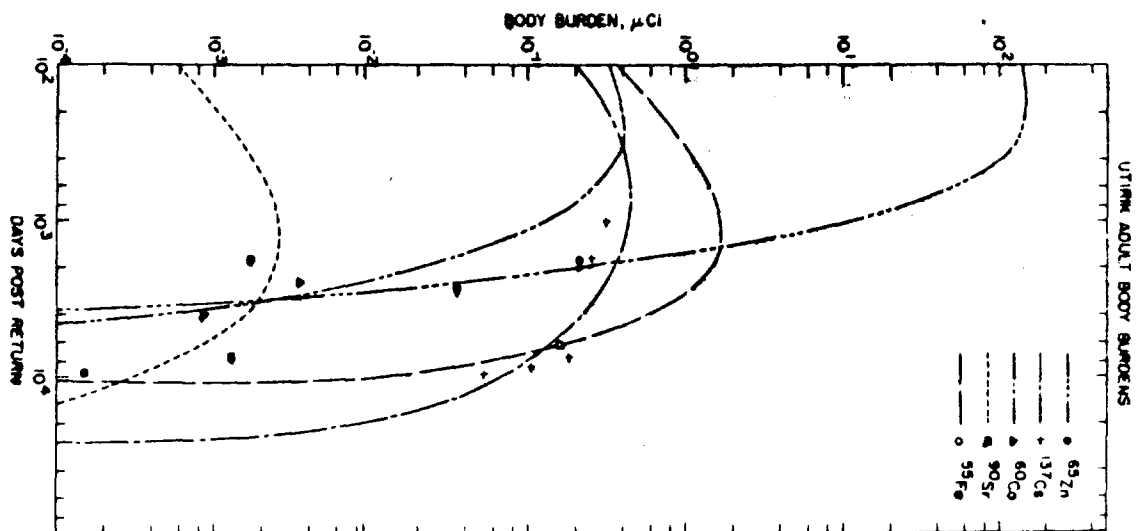


Fig. 8 Composite Nuclide Body Burden History for Adults at Utrik Atoll

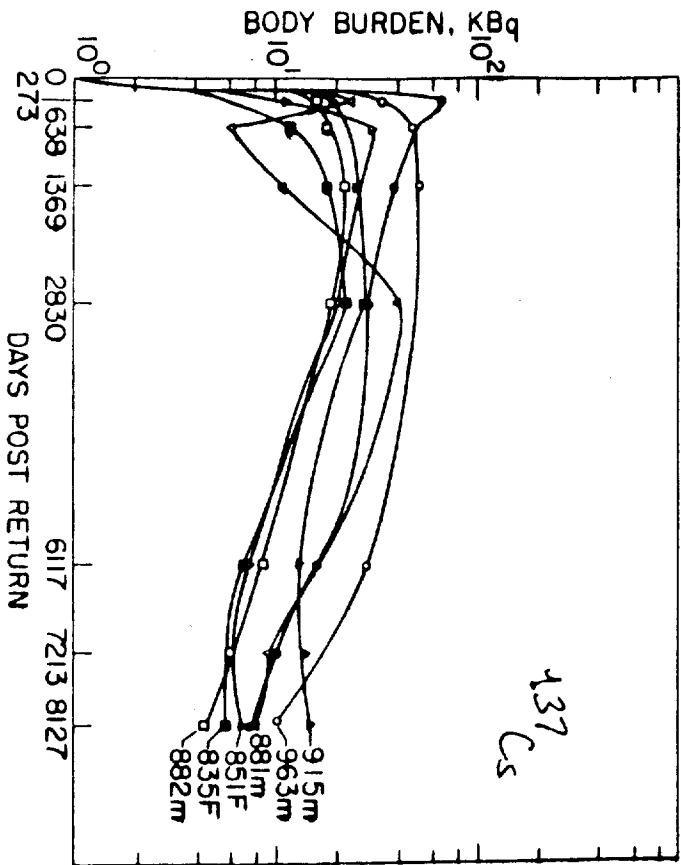


Fig. 9 Individual Male and Female Body Burden Histories Randomly Chosen from the Rongelap Atoll Population

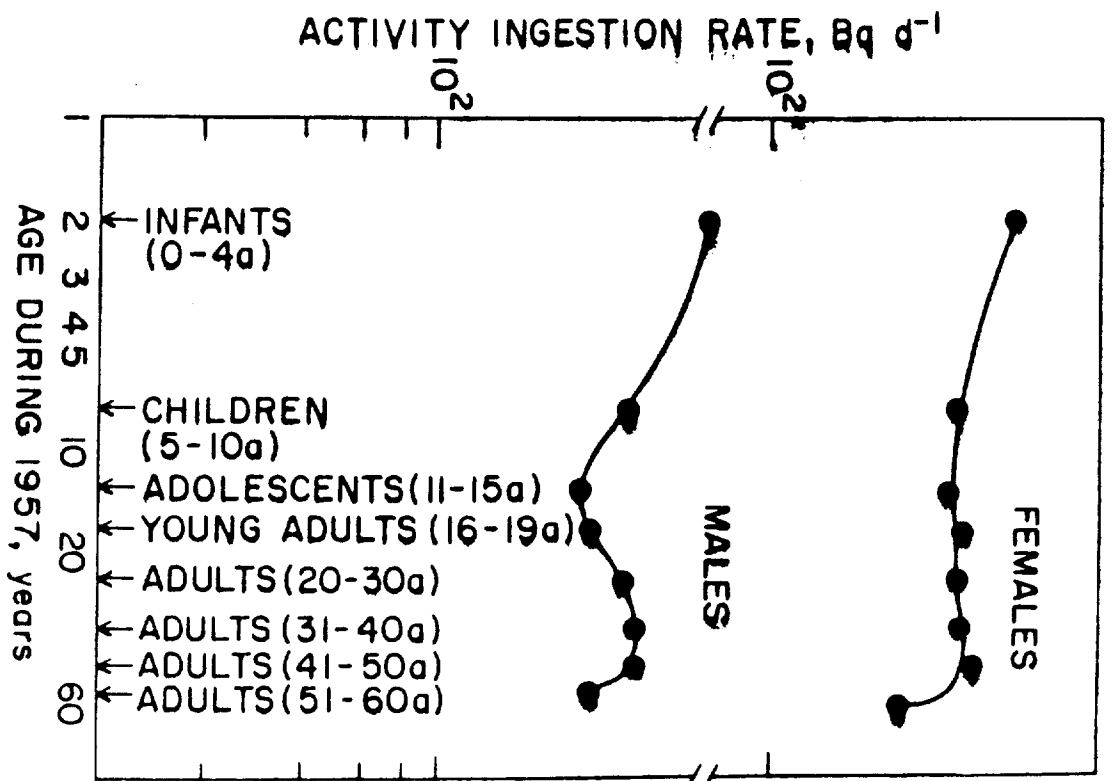


Fig. 10 Age and Sex Group Mean Values for 137Cs Activity Ingestion Rate Referenced to Mid-1957 for Rongelap Atoll

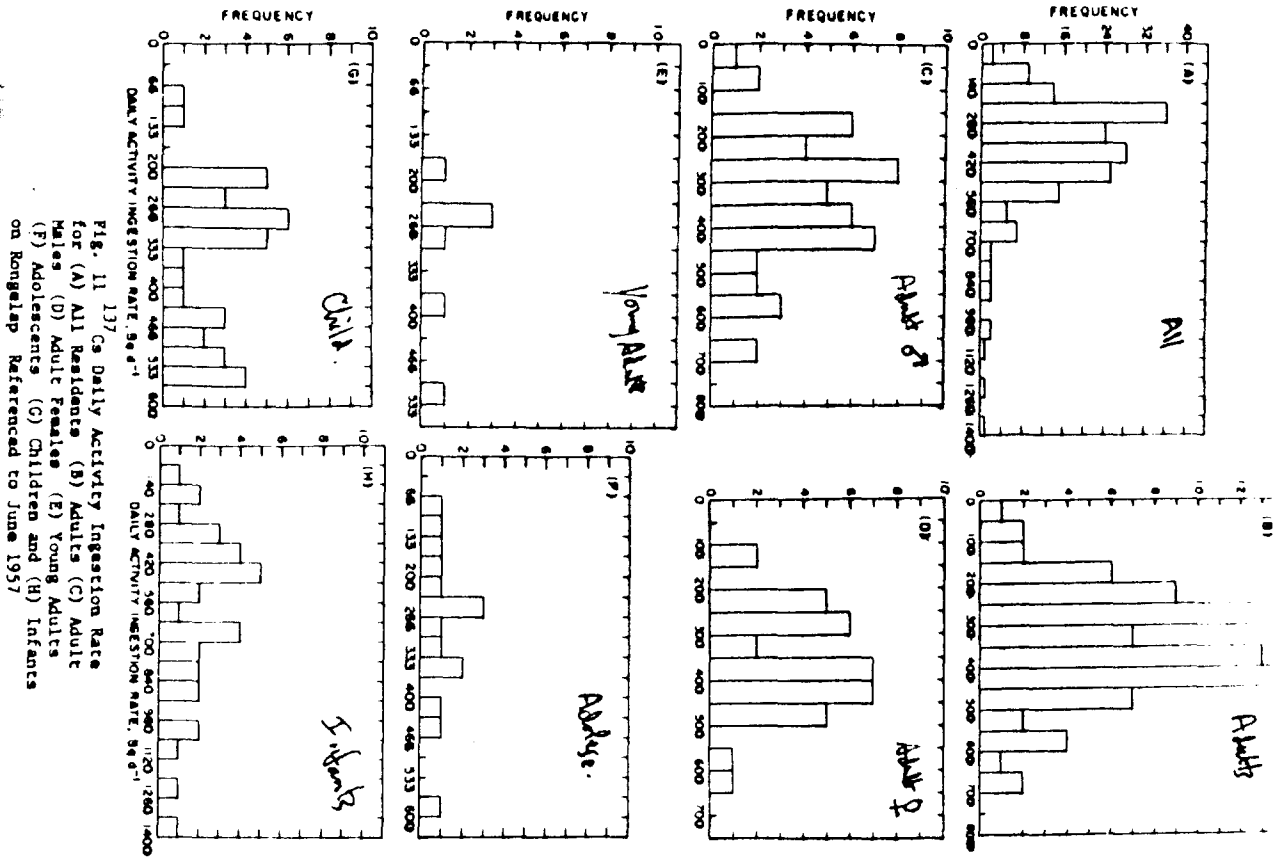


Fig. 11 137 Cs Daily Activity Ingestion Rate for (A) All Residents (B) Adults (C) Adult Males (D) Adult Females (E) Young Adults (F) Adolescents (G) Children and (H) Infants on Rongelap Referenced to June 1957

ACTIVITY INGESTION RATE, Bq d⁻¹

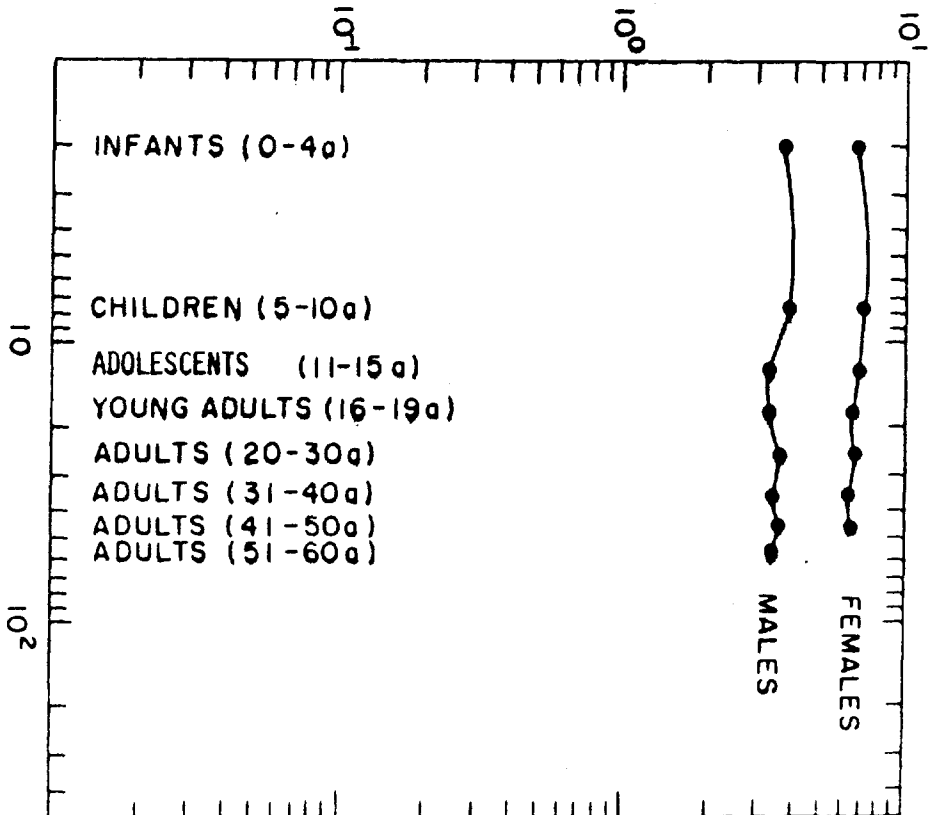


Fig. 12 Age and Sex Group Mean Values for ⁹⁰Sr Activity Ingestion Rate Referenced to Mid-1957 for Rongelap Atoll

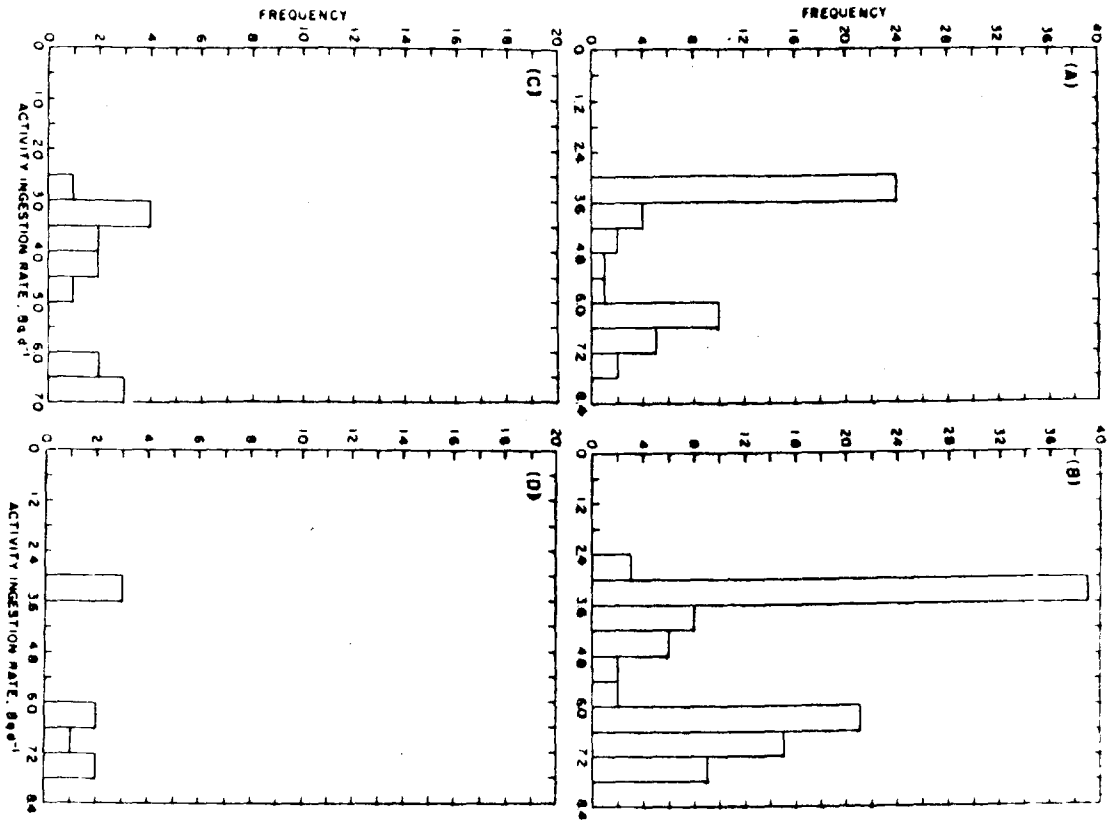


Fig. 13a ^{90}Sr Daily Activity Ingestion Rate for (A) Adults (B) All Residents (C) Infants and (D) Adolescents on Rongelap

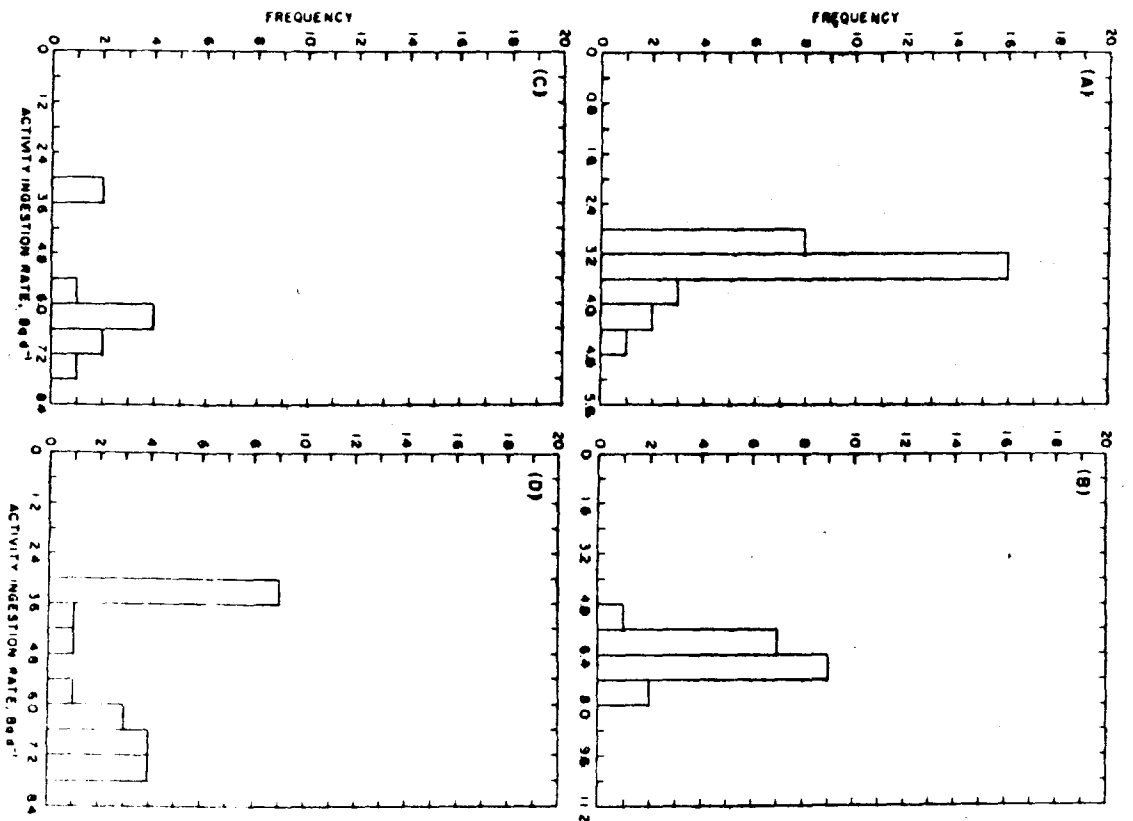


Fig. 13b ^{90}Sr Daily Activity Ingestion Rate for (A) Adult Males (B) Adult Females (C) Young Adults and (D) Children on Rongelap

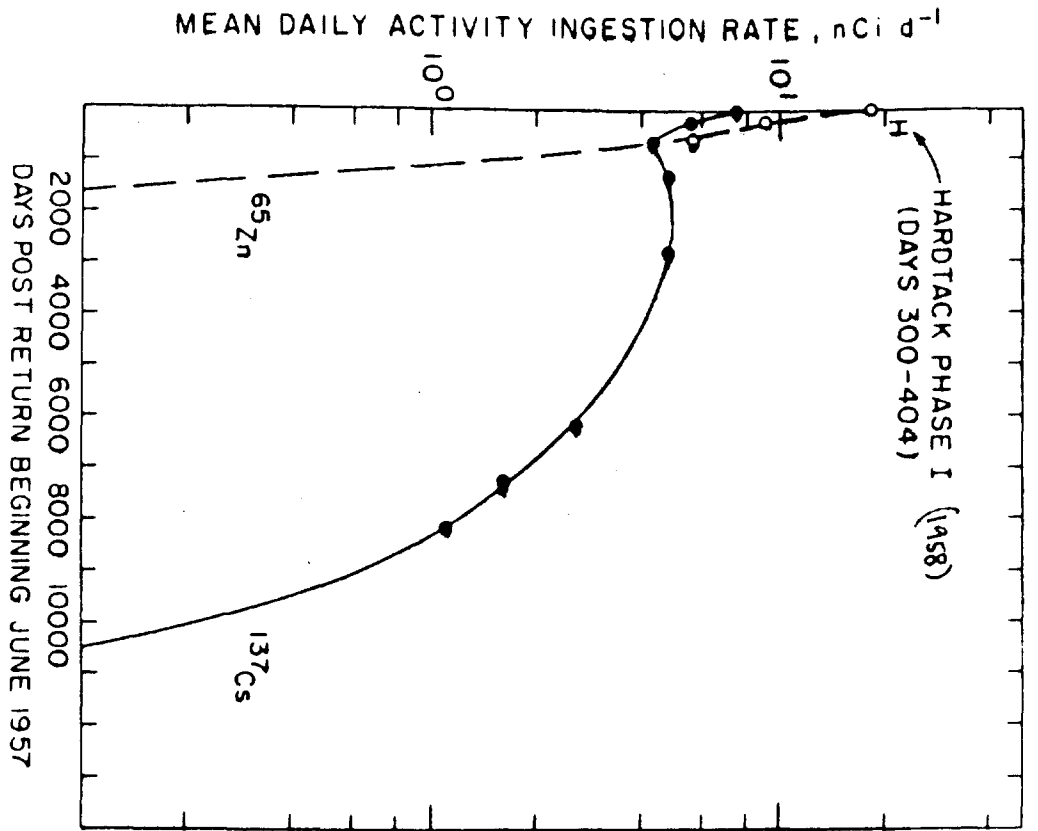


Fig. 14 Adult Mean Daily Activity Ingestion Rate for ^{137}Cs and ^{65}Zn at Rongelap Referenced to MID-1957

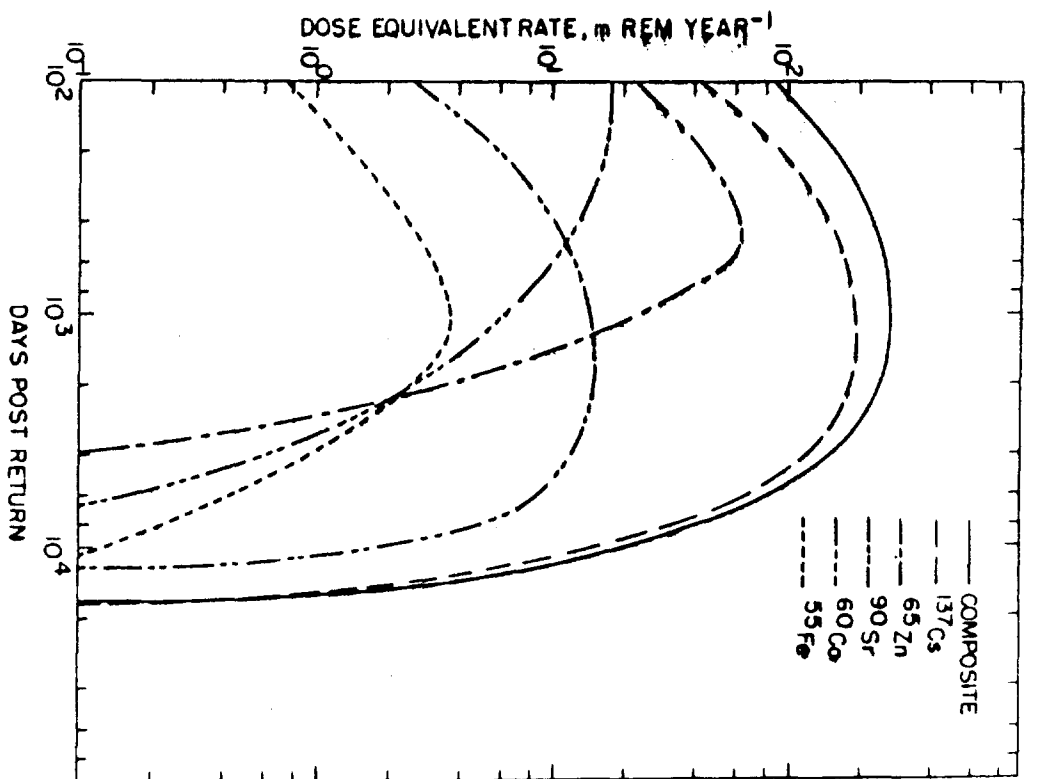


FIG. 15 Adult Mean Total Body Dose Equivalent Rate at Rongelap Atoll Post MID-1957

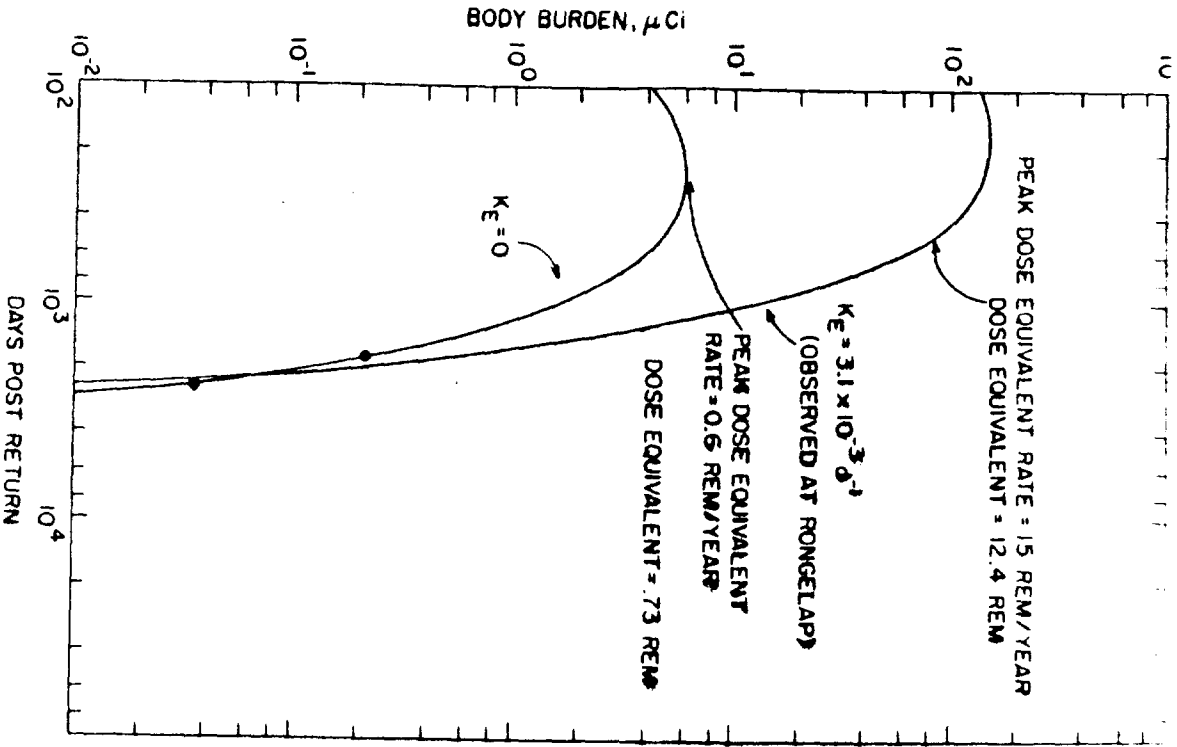


Fig. 16 Mean Adult ⁶⁵Zn Body Burden, Peak Dose Equivalent Rate and Dose Equivalent for Utririk Atoll

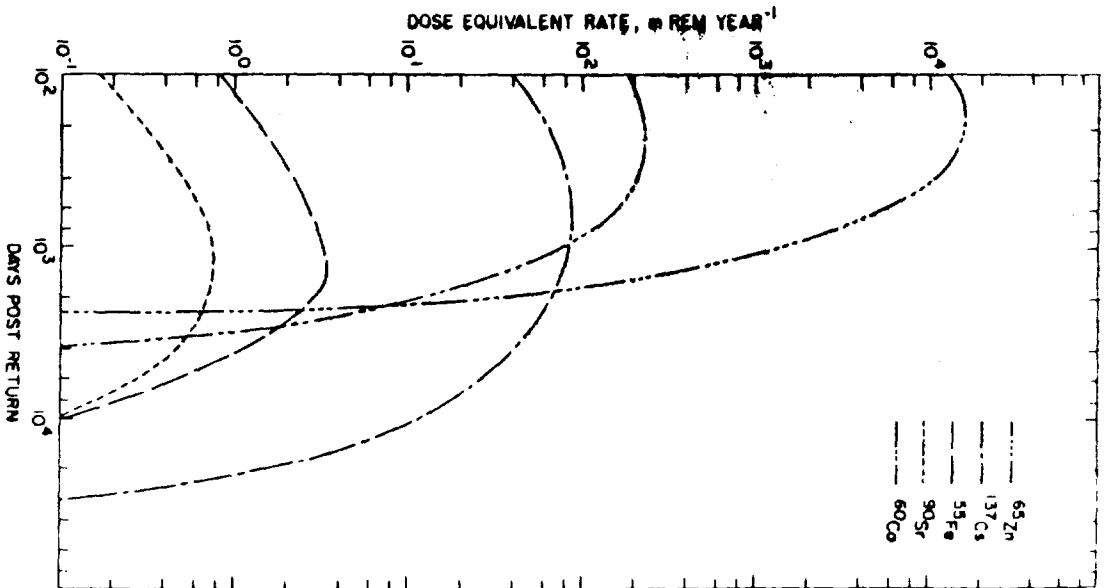


Fig. 17 Adult Mean Total Body Dose Equivalent Rate at Utririk Atoll Post Mid-1954

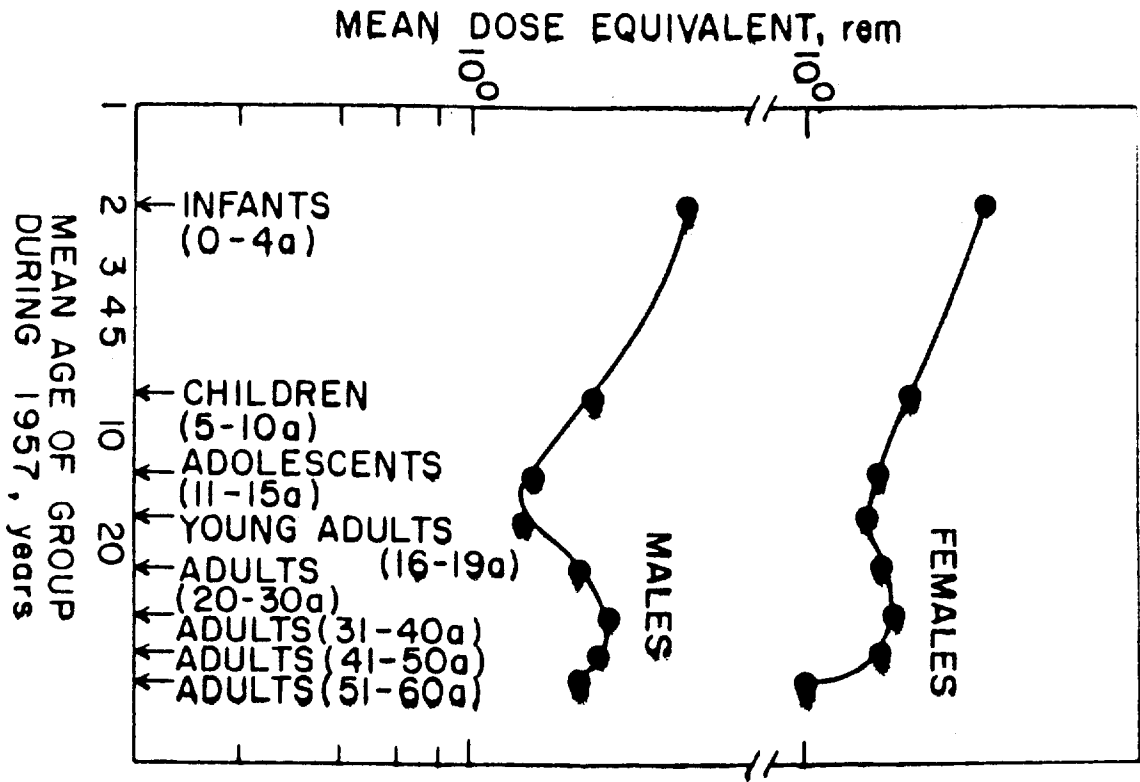


Fig. 18 137Cs Mean Dose Equivalent for Various Mid-1957 Age Groups for the Interval 1957 to 1980 at Rongelap Atoll

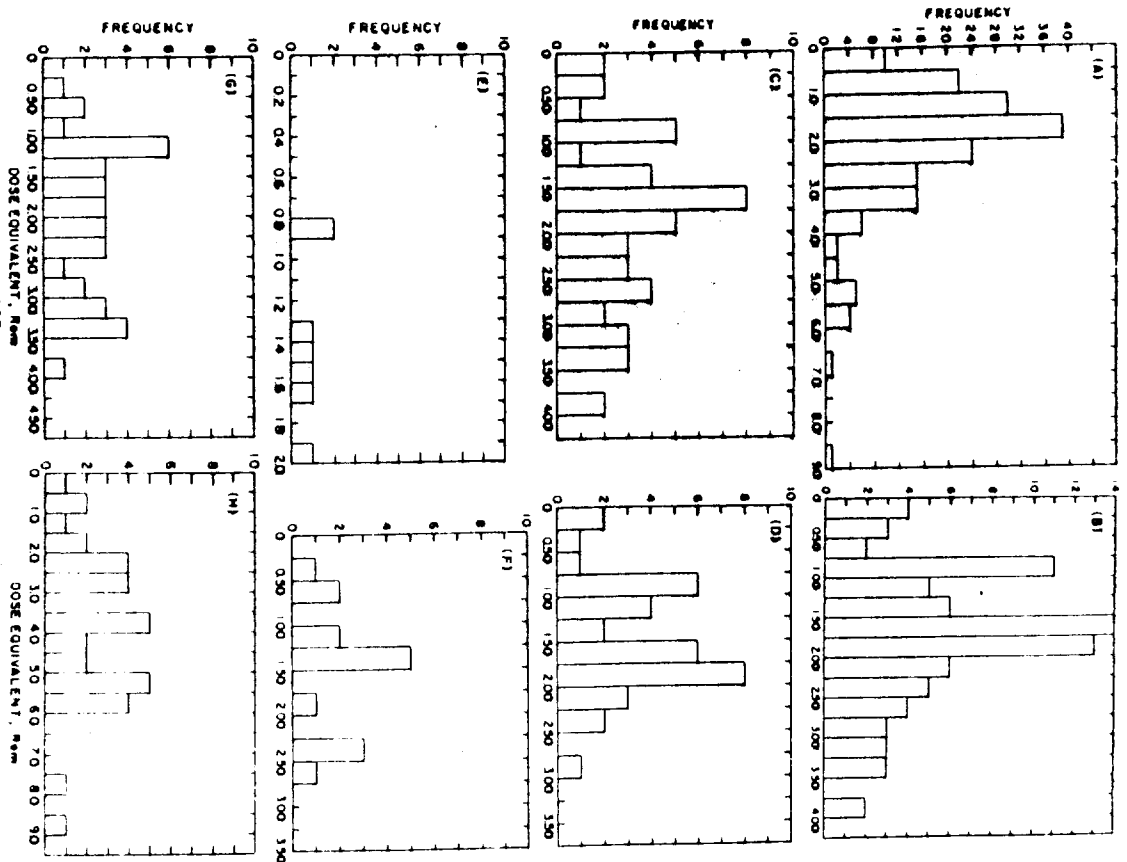


Fig. 19 137Cs Dose Equivalent to (A) All Residents (B) Adult Males (C) Adult Females (D) Young Adults (E) Adolescents (F) Children and (H) Infants on Rongelap.

MEAN DOSE EQUIVALENT, mrem

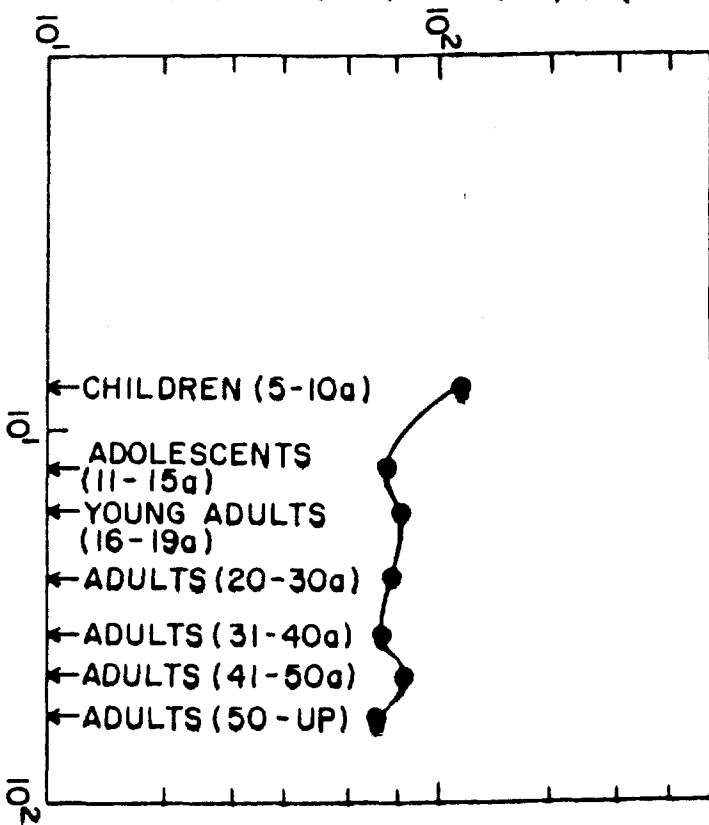


Fig. 20 ⁶⁵Zn Mean Dose Equivalent for Various Mid-1957 Age Groups for the Interval 1957 to 1980 at Rongelap Atoll

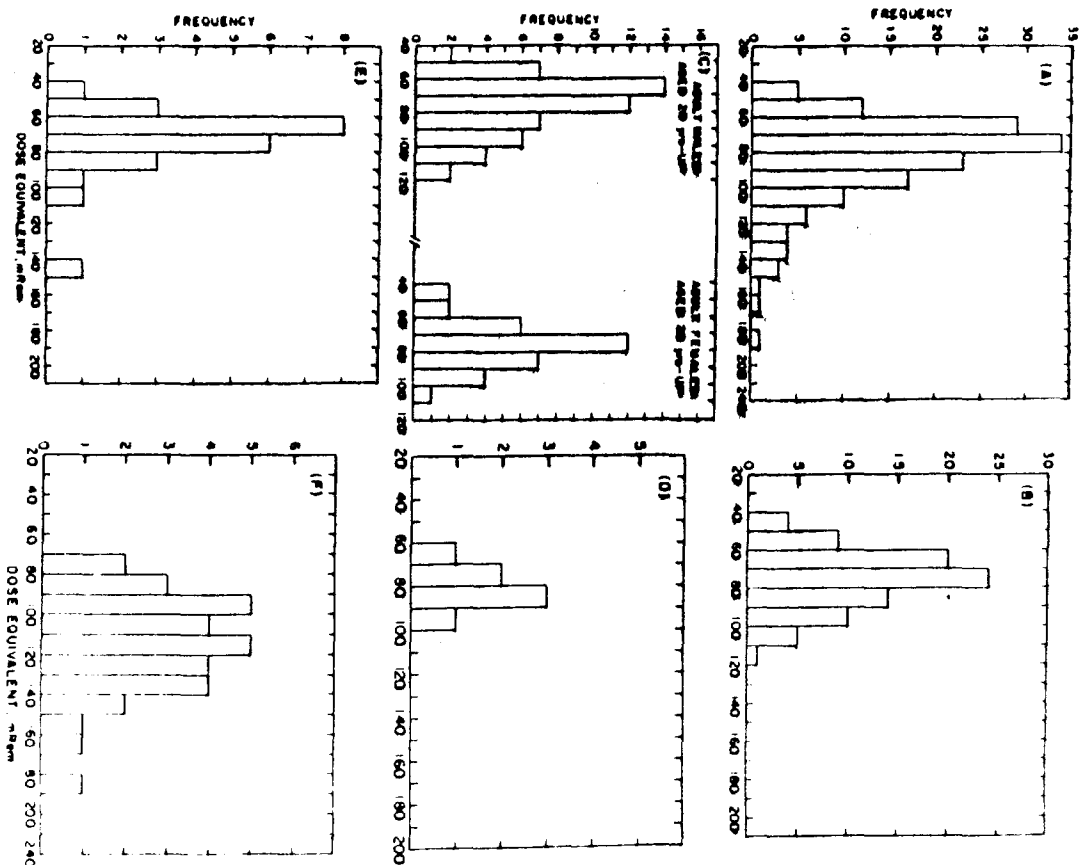


Fig. 21 ⁶⁵Zn Dose Equivalent to (A) All Residents (B) Adult Males and Females (C) Adolescents (D) Children and (E) Infants at Rongelap Atoll.

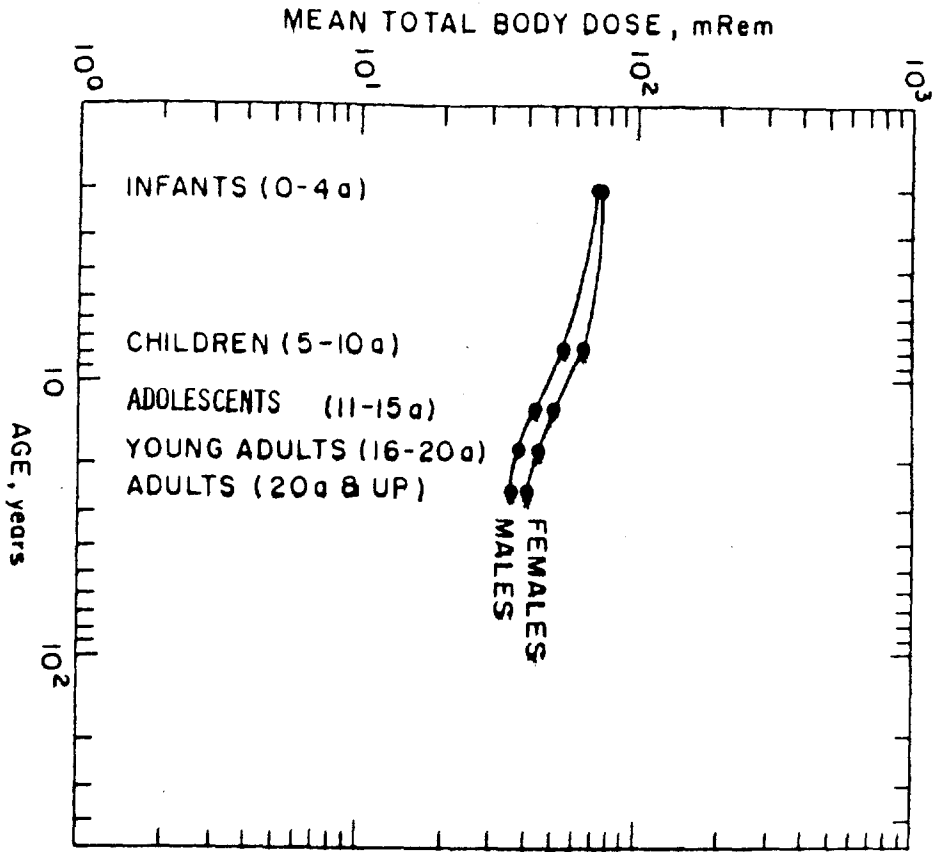


Fig. 22 Age and Sex Group Mean Values for ⁹⁰Sr Dose Equivalent for the Interval 1957 to 1980 at Rongelap Atoll

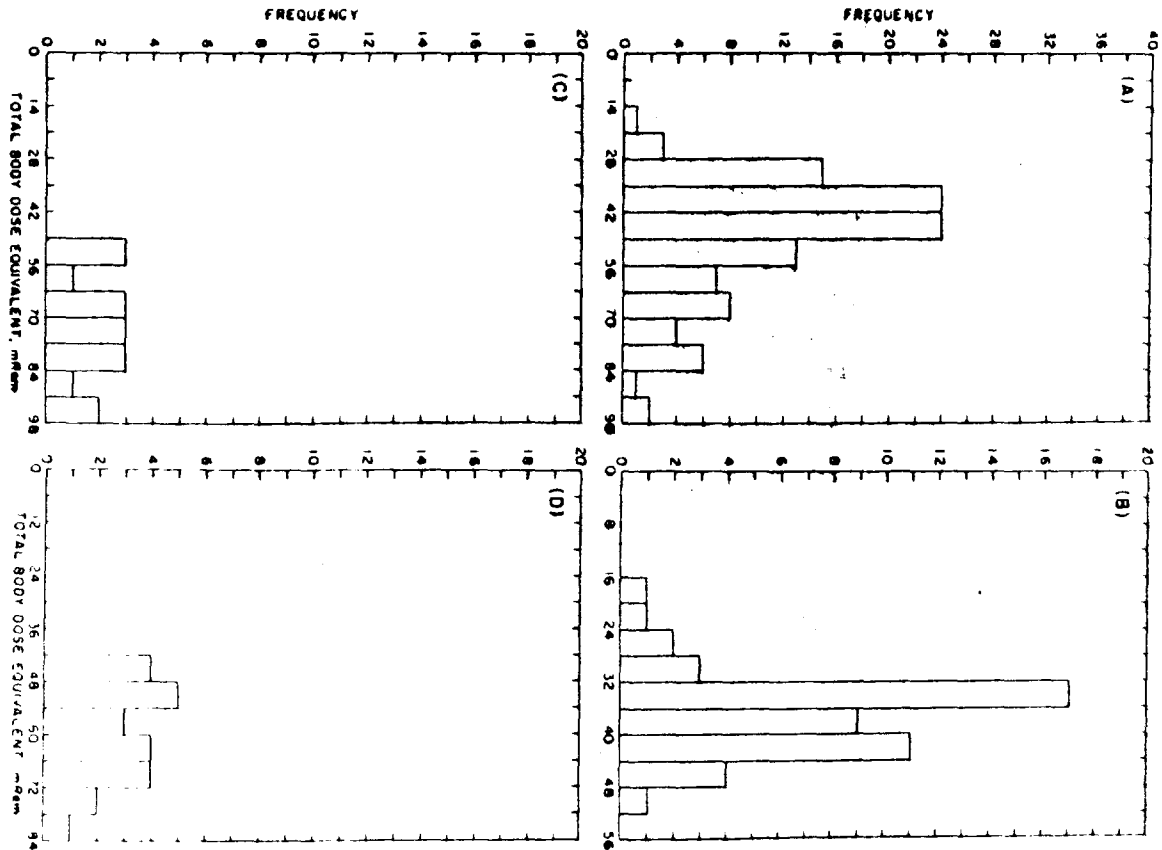


Fig. 23a ⁹⁰Sr Dose Equivalent for (A) All Residents (B) Adults (C) Infants and (D) Children on Rongelap

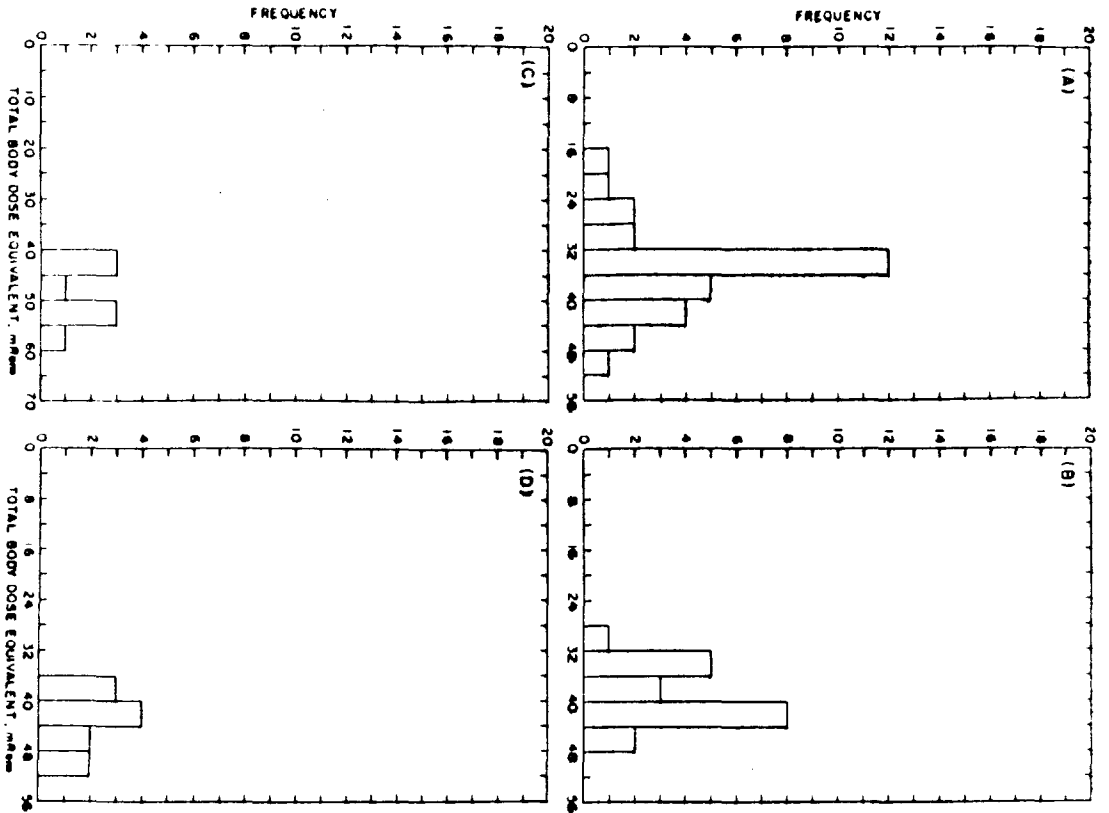


Fig. 23b ⁹⁰Sr Dose Equivalent for
 (A) Adult Males (B) Adult Females
 (C) Adolescents and (D) Young Adults
 on Rongelap

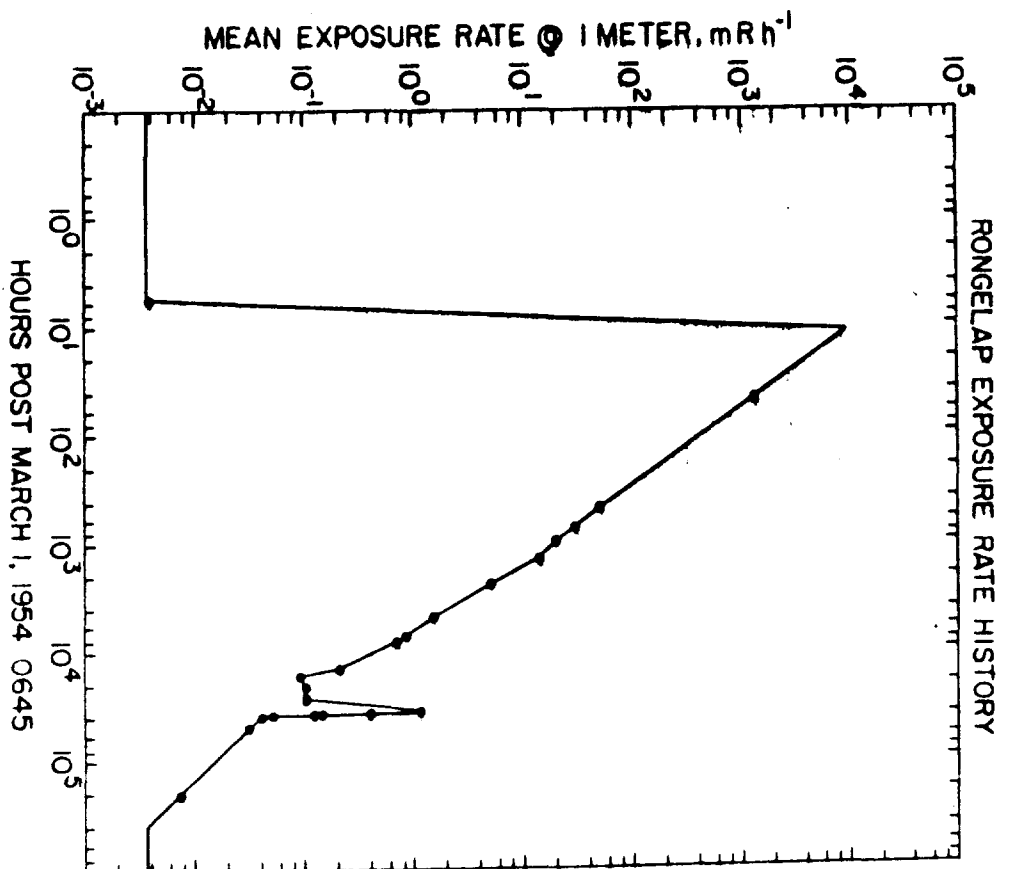


Fig. 24 Rongelap External
 Exposure Rate History
 Post Bravo

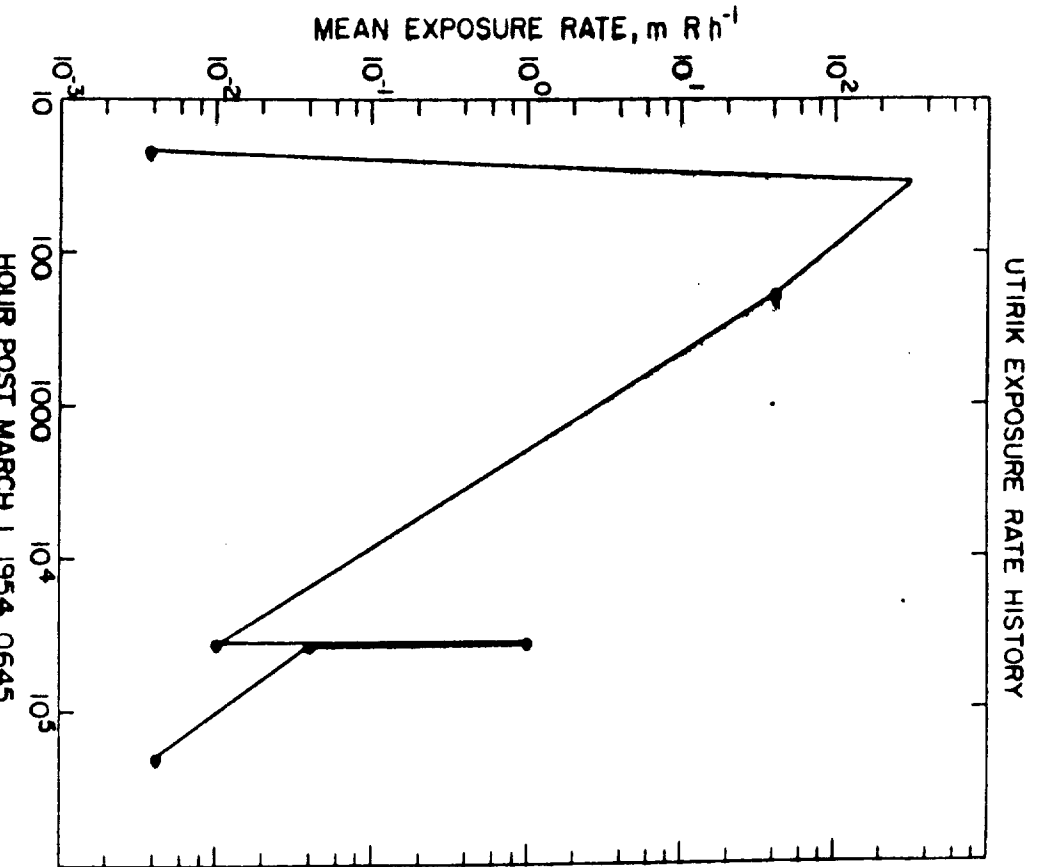
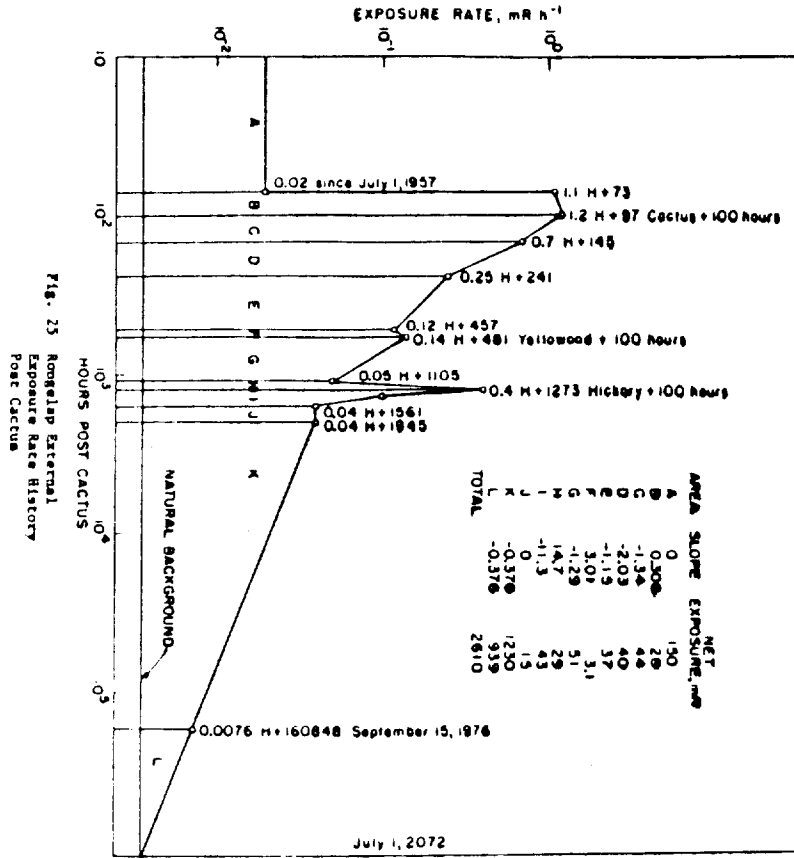


Fig. 26 Utririk External Exposure Rate History Post Bravo

Table 1

Rongelap Body Burdens

	Adult Males		Adult Females		Adults		Days Post Return Days
	Body Burden μCi	Number of Persons	Body Burden μCi	Number of Persons	Body Burden μCi	Number of Persons	
^{60}Co	2.9×10^{-5}	NA	1.7×10^{-5}	NA	2.3×10^{-5}	NA	1
	1.0×10^{-2}	37	7.8×10^{-3}	37	9.0×10^{-3}	74	1370
	2.5×10^{-3}	45	2.0×10^{-3}	45	2.2×10^{-3}	90	2831
^{65}Zn	4.3×10^{-2}	NA	3.8×10^{-2}	NA	4.1×10^{-2}	NA	1
	4.3×10^{-1}	30	3.8×10^{-1}	12	4.1×10^{-1}	42	304
	6.2×10^{-1}	32	5.0×10^{-1}	27	5.6×10^{-1}	59	639
	9.5×10^{-2}	38	8.5×10^{-2}	23	9.0×10^{-2}	61	1370
^{55}Fe	4.3×10^{-1}	28	4.0×10^{-1}	32	4.1×10^{-1}	60	4626
^{90}Sr	1.9×10^{-4}	NA	1.4×10^{-4}	NA	1.7×10^{-4}	NA	1
	3.7×10^{-3}	11	2.8×10^{-3}	4	3.4×10^{-3}	15	304
	5.7×10^{-3}	24	3.5×10^{-3}	16	4.8×10^{-3}	40	639
	3.7×10^{-3}	9	1.6×10^{-3}	4	3.0×10^{-3}	13	1370
	8.8×10^{-3}	12	7.9×10^{-3}	13	8.4×10^{-3}	25	2100
	7.9×10^{-3}	11	7.4×10^{-3}	7	7.7×10^{-3}	18	2466
	2.8×10^{-3}	12	4.6×10^{-3}	12	3.7×10^{-3}	24	3561
	3.9×10^{-3}	11	3.1×10^{-3}	11	3.5×10^{-3}	22	3927
	4.1×10^{-3}	11	3.3×10^{-3}	13	3.6×10^{-3}	24	4292
	1.3×10^{-3}	8	3.3×10^{-3}	11	2.5×10^{-3}	19	4657
	3.1×10^{-3}	8	2.8×10^{-3}	7	3.0×10^{-3}	15	5022
	2.0×10^{-3}	5	1.4×10^{-3}	7	1.6×10^{-3}	12	5388
	6.6×10^{-3}	4	4.2×10^{-3}	7	4.3×10^{-3}	13	5753
	3.3×10^{-3}	10	1.7×10^{-3}	4	2.8×10^{-3}	14	6118
	4.4×10^{-3}	23	NA	0	NA	NA	7579
6.3×10^{-4}	24	4.6×10^{-4}	19	5.5×10^{-4}	43	8097	
^{137}Cs	1.4×10^{-2}	NA	8.4×10^{-3}	NA	1.1×10^{-2}	NA	1
	8.7×10^{-1}	NA	5.2×10^{-1}	NA	6.8×10^{-1}	NA	304
	7.9×10^{-1}	47	4.1×10^{-1}	49	5.7×10^{-1}	96	639
	9.5×10^{-1}	37	4.7×10^{-1}	37	6.7×10^{-1}	74	1370
	9.4×10^{-1}	44	4.9×10^{-1}	45	6.8×10^{-1}	89	2831
	4.8×10^{-1}	22	3.0×10^{-1}	24	3.9×10^{-1}	46	6118
	3.0×10^{-1}	30	1.9×10^{-1}	21	2.5×10^{-1}	51	7213
	1.8×10^{-1}	19	1.5×10^{-1}	18	1.7×10^{-1}	37	8097

NA = Not available

Table 2

Utirik Body Burdens

	Adult Males		Adult Females		Adults		Days Post Return Days
	Body Burden μCi	Number of Persons	Body Burden μCi	Number of Persons	Body Burden μCi	Number of Persons	
^{60}Co							
D	4.0×10^{-3}		3.1×10^{-3}		3.5×10^{-3}		2464
D	9.7×10^{-4}		7.6×10^{-4}		8.7×10^{-4}		3924
^{65}Zn							
D	$3.5 \times 10^{-1*}$	2	-		-		
D	2.7×10^{-1}	14	1.6×10^{-1}	15	2.1×10^{-1}	29	1734
D	3.7×10^{-2}		3.3×10^{-2}		3.5×10^{-2}		2464
^{55}Fe							
D	1.7×10^{-1}		1.6×10^{-1}		1.6×10^{-1}		6114
^{90}Sr							
D	1.4×10^{-3}	5	2.4×10^{-3}	2	1.7×10^{-3}	7	1734
D	1.2×10^{-3}	5	1.3×10^{-3}	6	1.3×10^{-3}	11	7213
D	NA	12	NA	12	NA	24	8669
D	1.5×10^{-4}	14	1.5×10^{-4}	17	1.5×10^{-4}	31	9223
^{137}Cs							
D	4.1×10^{-1}	NA	2.7×10^{-1}	NA	3.3×10^{-1}	NA	1004
D	2.9×10^{-1}	15	2.0×10^{-1}	15	2.5×10^{-1}	30	1734
D	2.6×10^{-1}	9	1.3×10^{-1}	13	1.8×10^{-1}	22	7213
D	1.2×10^{-1}	27	7.8×10^{-2}	21	1.0×10^{-1}	48	8309
D	6.2×10^{-2}	19	4.3×10^{-2}	17	5.3×10^{-2}	36	9223

D = Ratio derived body burden

NA = Not available

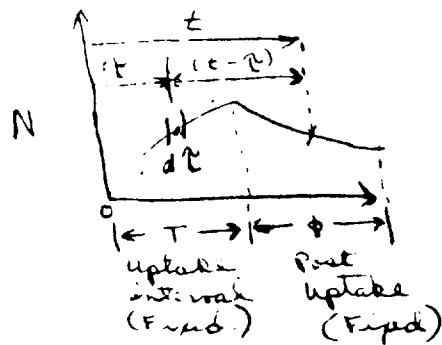
* = Measured at Argonne National Laboratory

Table 4

Total Body Dosimetric and Physiologic Data

Nuclide	Compartment Deposition Fraction	Compartment Removal Rate Constant	GI Tract to Blood Transfer	Fraction Excreted in Urine	Decay Constant	Significant Progeny	Branching Ratio
$\begin{smallmatrix} A \\ Z \end{smallmatrix} X$	x_i	k_{d-1}	f_1	f_u	λ_{d-1}	$\begin{smallmatrix} A \\ Z \end{smallmatrix} X$	
$\begin{smallmatrix} 137 \\ 55 \end{smallmatrix} \text{Cs}$	0.13 0.87	0.50 0.0051	1.0	0.90	6.3×10^{-5}	$\begin{smallmatrix} 137m \\ 56 \end{smallmatrix} \text{Ba}$	0.946
$\begin{smallmatrix} 65 \\ 30 \end{smallmatrix} \text{Zn}$	0.25 0.75	0.058 0.0022	0.35	0.25	2.8×10^{-3}	$\begin{smallmatrix} 65m \\ 29 \end{smallmatrix} \text{Cu}$	0.49
$\begin{smallmatrix} 90 \\ 38 \end{smallmatrix} \text{Sr}$	0.89 0.059 0.051	0.21 7.1×10^{-4} 1.0×10^{-4}	0.20	0.85	6.5×10^{-5}	$\begin{smallmatrix} 90 \\ 39 \end{smallmatrix} \text{Y}$ $\begin{smallmatrix} 90m \\ 40 \end{smallmatrix} \text{Zr}$	1.0 0.0002
$\begin{smallmatrix} 60 \\ 27 \end{smallmatrix} \text{Co}$	0.5 0.3 0.1 0.1	1.4 0.12 0.012 8.7×10^{-4}	0.05	0.70	3.6×10^{-4}	$\begin{smallmatrix} 60m \\ 28 \end{smallmatrix} \text{Ni}$	1.0
$\begin{smallmatrix} 55 \\ 26 \end{smallmatrix} \text{Fe}$	1.0	3.5×10^{-4}	0.1	0.0	7.0×10^{-3}		

DEVELOPMENT OF DOSIMETRIC EQUATIONS



$$f_i P(t) = f_i P^0 e^{-(k_e + \lambda)t} \quad \text{GI tract to blood function}$$

$$r(t - T) = \sum_i \chi_i e^{-(\lambda + k_i)(t - T)} \quad \text{whole body retention function}$$

Instantaneous number of atoms inputted into blood during dt ,

$$f_i P^0 e^{-(k_e + \lambda)t} dt$$

instantaneous number of atoms at time $t - T$ that remain following input during dt ,

$$f_i P^0 e^{-(k_e + \lambda)t} dt r(t - T)$$

Instantaneous number of atoms @ $t - T$ that remain following input during T ,

$$N = \int_{T=0}^{T=T} f_i P^0 e^{-(k_e + \lambda)t} dt r(t - T)$$

$$N = f_i P^0 \int_{T=0}^{T=T} \sum_i \chi_i e^{-(k_e + \lambda)t} e^{-(\lambda + k_i)t} e^{(\lambda + k_i)T} dt$$

$$N = f_i P^0 \sum_i \chi_i e^{-(k_e + \lambda)t} \left(\frac{e^{(k_i - k_e)T} - 1}{-1} \right)$$

for $t = T$

$$\lambda N = \lambda P^0 f_i \sum_i \frac{\chi_i (e^{-(\lambda+\kappa_e)T} - e^{-(\lambda+\kappa_i)T})}{\kappa_i - \kappa_e}$$

for $t = T + \phi$

$$\bullet \lambda N = \lambda P^0 f_i \sum_i \frac{\chi_i (e^{-(\lambda+\kappa_e)T} - e^{-(\lambda+\kappa_i)T}) e^{-\kappa_i \phi}}{\kappa_i - \kappa_e}$$

for $t = T + \phi$ and initial contamination

$$\lambda N = \frac{\lambda P^0 f_i \sum_i \chi_i (e^{-(\lambda+\kappa_e)T} - e^{-(\lambda+\kappa_i)T}) e^{-(\lambda+\kappa_i)\phi}}{\kappa_i - \kappa_e} + q_0 \sum_i \chi_i e^{-\kappa_i \phi}$$

Chronic Phase
D.E. and Committed Dose Equivalent Summary, Rem

Utirik June '59 to Jan '80
Rongelap June '57 to " " "

Nuclide	<u>Total Body</u>		<u>Thyroid</u>	
	Utirik Adults	Rongelap Adults	Utirik Adults	Rongelap Adults
⁹⁰ Sr	.0118	.0267	.000749	.00169
⁵⁵ Fe	.0329	.0230	.0594	.0415
¹³⁷ Cs	1.13	1.71	1.55	2.35
⁶⁰ Co	.507	.0143	.359	.0101
⁶⁵ Zn	12.5	.0757	11.1	.0672
Internal	14.2	1.85	13.1	2.47
External	3.19	2.02	3.19	2.02
Total	17.4	3.87	16.3	4.49
	<u>Red Marrow</u>		<u>Testes-Ovaries</u>	
⁹⁰ Sr	.0537	.123	.000749-.000749	.00169-.00169
⁵⁵ Fe	.0603	.0422	.0583-.0620	.0736-.0433
¹³⁷ Cs	1.70	2.57	1.54-1.74	2.33-2.63
⁶⁰ Co	.629	.0177	.443-1.78	0.12-.0502
⁶⁵ Zn	17.2	.103	11.3-16.3	.0685-.0988
Internal	19.6	2.86	13.3-19.9	2.49-2.82
External	3.19	2.02	3.19	2.02
Total	22.8	4.88	16.5-23.1	4.51-4.84
	<u>Lower Large Intestine Wall</u>		<u>Liver</u>	
⁹⁰ Sr	.225	.567	.000671	.00152
⁵⁵ Fe	.0666	.0465	.115	.0804
¹³⁷ Cs	.591	.895	1.81	2.74
⁶⁰ Co	4.66	.132	.792	.0223
⁶⁵ Zn	15.0	.0910	16.5	.136
Internal	20.5	1.73	19.2	2.98
External	3.19	2.02	3.19	2.02
Total	23.7	3.75	22.4	5.00

I-129 Average Atom Density of Soil Samples

MODEL

Rongelap-Rongelap

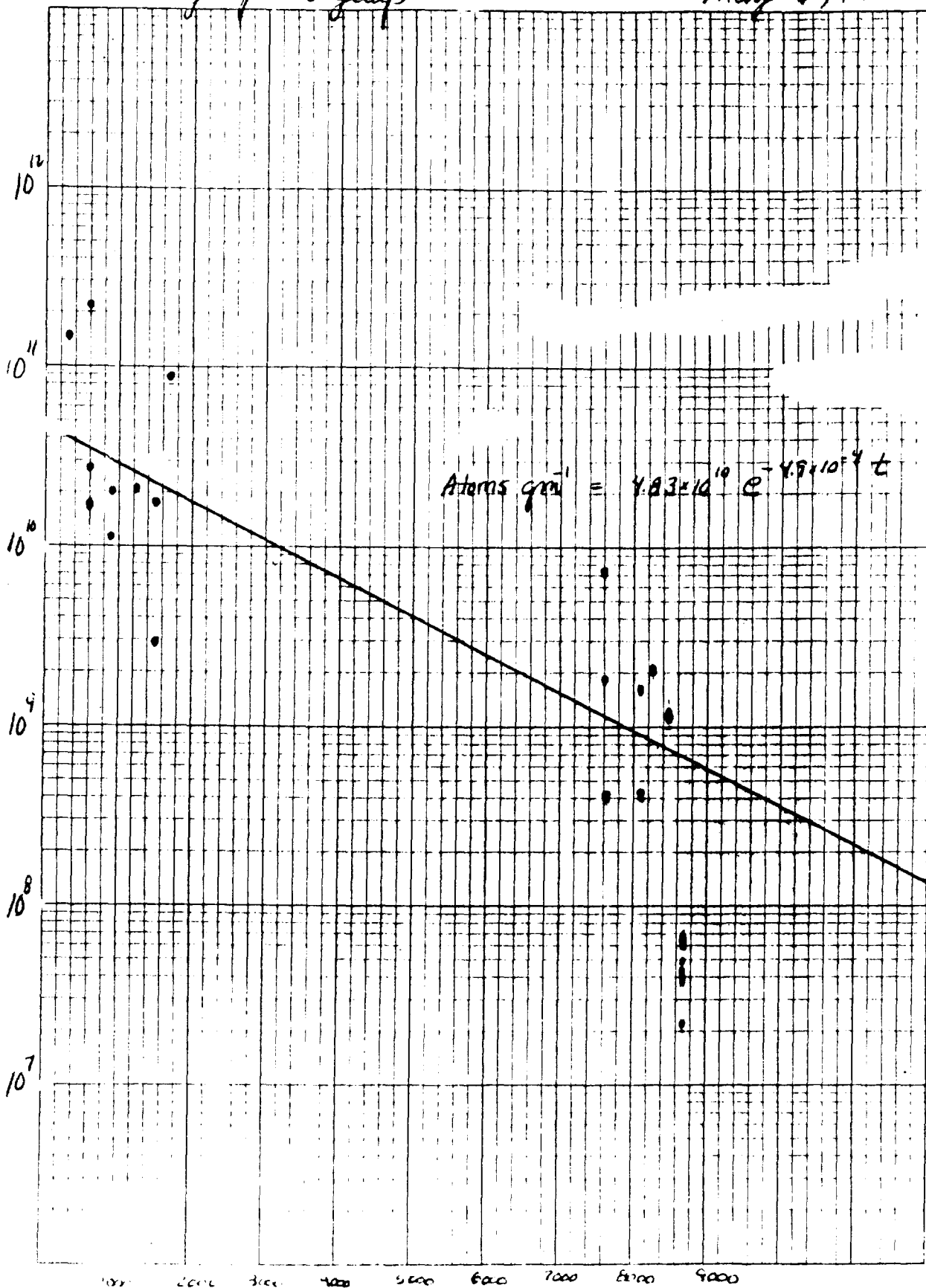
DATE

May 6, 1980

46 6460

K·E SEMI-LOGARITHMIC 7 CYCLES X 60 DIVISIONS
KEUFEL & ESSER CO. MADE IN U.S.A.

¹²⁹I / gm of soil, C



Soil Samples

Soil samples consisted of entire first inch of soil. Since, \bar{x} , the ~~mean free path~~ ^{relaxation depth} is 3 cm, the soil sample does not represent a kernel. It expresses the average activity in the sample.

The total number of atoms in an areal plot 2.54 cm deep is

$$\int_0^{2.54} N dx = \int_0^{2.54} N_0 e^{-\mu x} dx,$$

where $N_0 \equiv$ atoms cm^{-3} at depth $x=0$,

$N \equiv$ atoms cm^{-3} at depth x ,

$\mu \equiv$ instantaneous fraction of atom concentration remaining at depth x .

The average atom concentration is

$$\frac{\int_0^{2.54} N_0 e^{-\mu x} dx}{2.54 \text{ cm}}.$$

The average atom density, C , is

$$C = \frac{N_0 [1 - e^{-2.54 \mu}]}{\mu \rho_{\text{soil}} (2.54 \text{ cm})}.$$

The total number of atoms cm^{-2} in an areal plot of infinite depth

$$C_A = \int_0^{\infty} N_0 e^{-\mu x} dx = \frac{N_0}{\mu}.$$

Soil Samples

Thus,

$$C_A = 6.23 C, \text{ atoms cm}^{-2},$$

where C has units of atoms I-129 per gm.

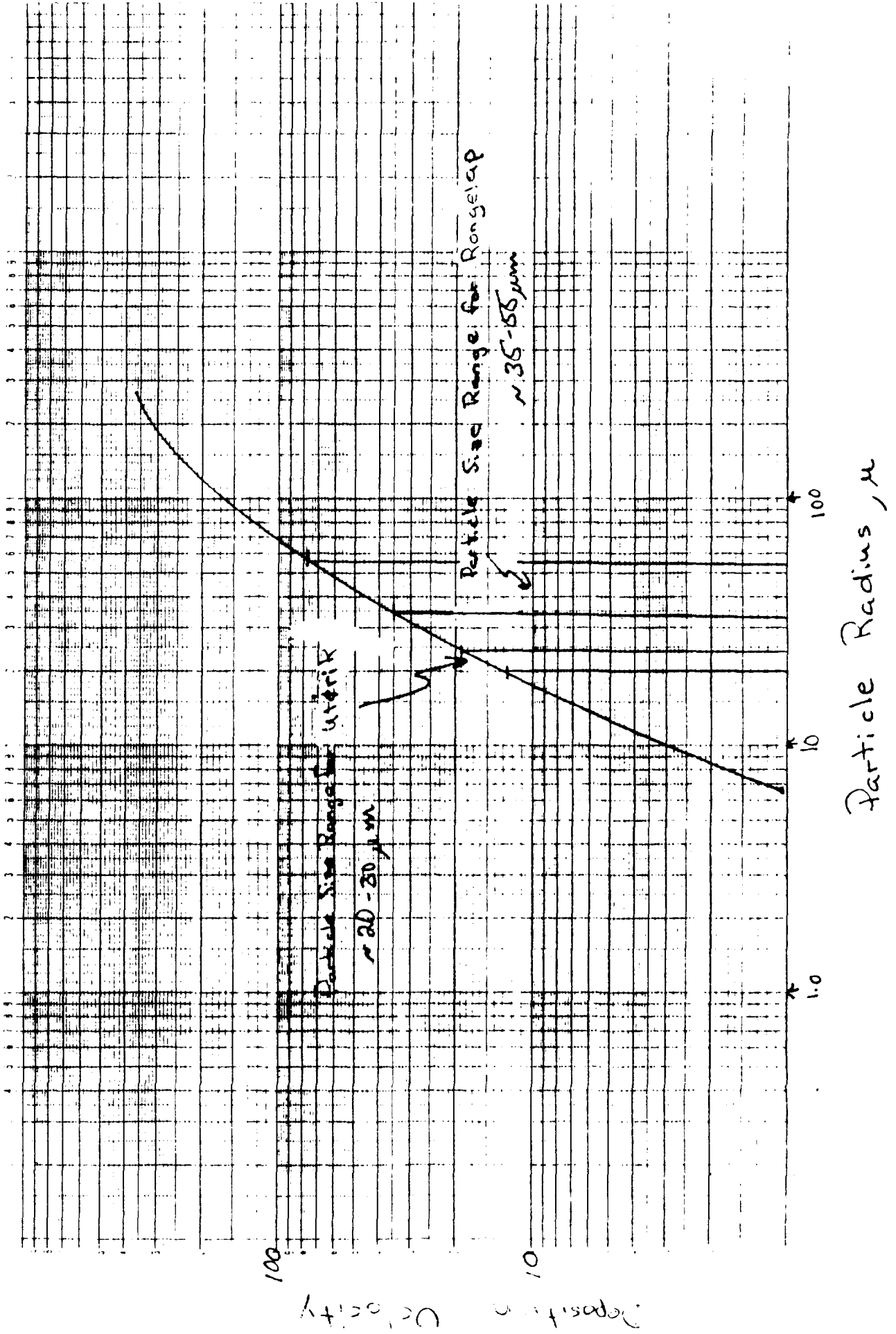
At one year post Bravo I-129 ingrowth had finished. Soil samples were taken post the ingrowth interval, thus the corrected I-129 deposited after fallout deposition is

$$C_A = 6.23 \times 4.83 \times 10^{10} \times .659 = \underline{\underline{* 1.98 \times 10^{11} \text{ atoms cm}^{-2}}}$$

Additionally, the maximum and minimum values for I-129 atoms in Rongelap soil are taken from the graph. This results in a maximum and minimum value of approximately 8 times the mean value.

* Sandhu's suggests bounding upper + lower bounds on μ + resultant C_A values

Deposition Velocity vs Particle Size †



of Time Isotope Atoms $10,000$ Fissions
 Thermal Fuel Fission of U-235 Atoms
 1st Reaction

5

t Hours	I-125 Atoms	I-131 Atoms	I-132 Atoms	I-133 Atoms	I-134 Atoms	I-135 Atoms
0	7.62×10^{-11}	4.34×10^1	4.80×10^5	1.10×10^8	5.20×10^1	2.53×10^1
2	1.68×10^1	3.04×10^2	8.99×10^1	5.01×10^2	2.02×10^2	4.44×10^2
4	4.63×10^1	3.50×10^2	1.13×10^1	5.22×10^2	6.63×10^1	3.60×10^2
6	7.31×10^1	3.52×10^2	1.24×10^1	5.01×10^2	1.66×10^1	2.92×10^2
8	9.13×10^1	3.52×10^2	1.30×10^1	4.71×10^2	3.86×10^1	2.37×10^2
10	1.10×10^2	3.51×10^2	1.31×10^1	4.42×10^2	8.52×10^1	1.92×10^2
12	1.22×10^2	3.50×10^2	1.31×10^1	4.13×10^2	1.83×10^1	1.56×10^2
14	1.31×10^2	3.50×10^2	1.30×10^1	3.81×10^2	3.87×10^1	1.26×10^2
16	1.37×10^2	3.49×10^2	1.28×10^1	3.62×10^2	8.69×10^1	1.02×10^2
18	1.42×10^2	3.48×10^2	1.27×10^1	3.39×10^2	1.68×10^2	8.30×10^1
20	1.45×10^2	3.47×10^2	1.25×10^1	3.17×10^2	3.47×10^2	6.73×10^1
22	1.48×10^2	3.45×10^2	1.22×10^1	2.97×10^2	7.16×10^2	5.46×10^1
24	1.49×10^2	3.44×10^2	1.20×10^1	2.78×10^2	1.47×10^3	4.42×10^1
26	1.51×10^2	3.43×10^2	1.18×10^1	2.60×10^2	3.03×10^3	3.59×10^1
28	1.52×10^2	3.42×10^2	1.16×10^1	2.43×10^2	6.23×10^3	2.91×10^1
30	1.53×10^2	3.40×10^2	1.14×10^1	2.28×10^2	1.28×10^4	2.36×10^1
32	1.53×10^2	3.39×10^2	1.12×10^1	2.13×10^2	2.62×10^4	1.91×10^1
34	1.54×10^2	3.38×10^2	1.10×10^1	1.99×10^2	5.38×10^4	1.55×10^1
36	1.54×10^2	3.36×10^2	1.08×10^1	1.87×10^2	1.10×10^5	1.26×10^1
38	1.54×10^2	3.34×10^2	1.06×10^1	1.75×10^2	2.27×10^5	1.02×10^1
40	1.54×10^2	3.33×10^2	1.04×10^1	1.63×10^2	4.67×10^5	8.26×10^0
Per. X	1.85×10^2	3.52×10^2	1.31×10^1			

borg - what about other thyroid-seeking nuclides?

see Shellabarger, Van Middlesworth @ ORNL
 Jan Wolf @ NIH

I-129 Deposition

(6)

L	~20 min intervals	Particle Radius, μm	F	I
	Interval H + Hour		Fraction of Total Atoms Deposited During Interval*	Ingrowth Factor, $\frac{\text{I-129 atoms at mid}}{\text{I-129 atoms at H=1}}$
1	5.5-5.825	55.6 - 53.3	.0927	.563
2	5.825-6.150	53.3 - 51.3	.0891	.600
3	6.150-6.475	51.3 - 49.4	.0888	.619
4	6.475-6.800	49.3 - 48.2	.0581	.656
5	6.800-7.125	48.2 - 47.0	.0556	.684
6	7.125-7.45	47.0 - 46.0	.0532	.712
7	7.45-7.775	46.0 - 45.0	.0512	.740
8	7.775-8.10	45.0 - 44.1	.0491	.768
9	8.10-8.425	44.1 - 43.2	.0468	.791
10	8.425-8.750	43.2 - 42.4	.0454	.813
11	8.750-9.075	42.4 - 41.6	.0434	.835
12	9.075-9.40	41.6 - 40.9	.0418	.856
13	9.40-9.725	40.9 - 40.2	.0404	.877
14	9.725-10.050	40.2 - 39.5	.0386	.898
15	10.050-10.375	39.5 - 38.9	.0376	.918
16	10.375-10.70	38.9 - 38.2	.0361	.932
17	10.70-11.025	38.2-37.7	.0346	.946
18	11.025-11.350	37.7 - 37.1	.0336	.960
19	11.350-11.675	37.1 - 36.6	.0325	.973
20	11.675-12.0	36.6 - 36.1	.0313	.986

* These fractions are relative to total I-129 atoms at H=12 and are not corrected for ingrowth, however they correct for non-uniform

Areal Concentration of Iodine Isotopes

The areal deposition during interval i is given by the product of C_A , the total number of I-129 atoms per cm^2 after fallout deposition, the fraction of I-129 atoms deposited during interval i , and the ingrowth factor. Thus

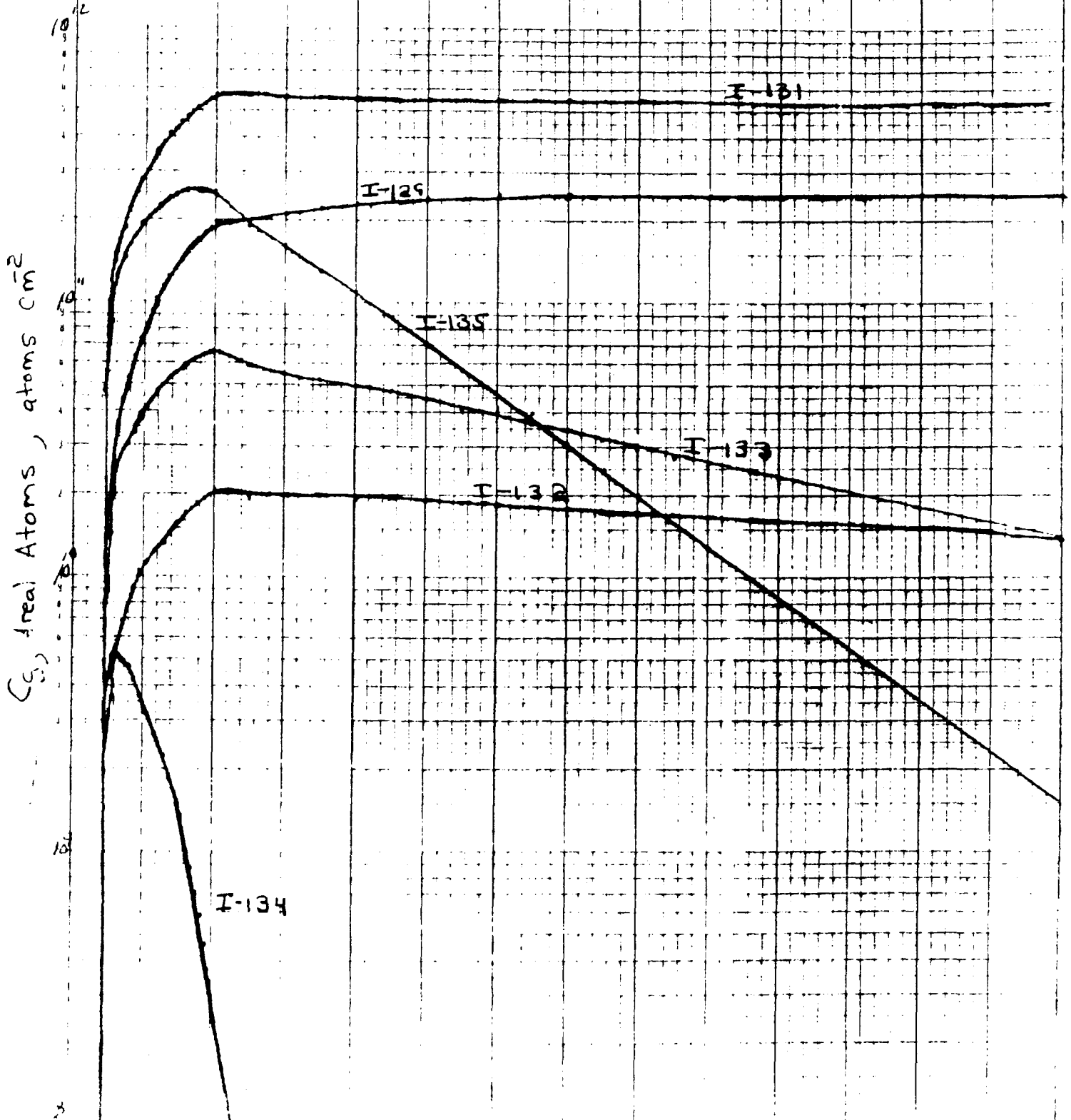
$$A_i = C_A \times F \times I$$

The above equation was used to determine the number of I-129 atoms per cm^2 versus time post detonation (Graph). The areal concentrations of the remaining iodine isotopes were determined from the instantaneous ratio of the number of iodine isotope atoms to I-129 atoms per 10,000 thermonuclear fissions of U-238 at times post creation (Table).

To obtain a point on graph , the following relationship was used,

C_g , the number of I-129 atom cm^{-2} on the ground at the end of interval two =
atoms cm^{-2} fallen during interval one $\times \frac{\text{atoms of I-129 at end } t_2}{\text{atoms of I-129 at mid } t_1}$

AREAL IODINE ISOTOPE ATOMS ON RONGELAP POST BRAVO



Activity Ingested By Rongelapese

WT-938 → Depth of H₂O = .67 ft = 80.4 cm
 → Drank 1 pt day⁻¹ = 19.7 cm³ hr⁻¹

Nuclide	Area During Deposition, atom cm ² hr	Activity * Ingested, μCi	Thyroid Rem
I-131	2.92×10^{12}	76.	138.
I-132	8.14×10^{10}	179.	11.6
I-133	2.80×10^{12}	672.	393.
I-134	1.48×10^{10}	85.	2.54
I-135	1.24×10^{12}	940.	151.
Total			605.

Nuclide	Area Post Deposition, atom cm ² hr	Activity * Ingested, μCi	Thyroid Rem
I-131	2.15×10^{13}	558.	1910
I-132	7.50×10^{11}	1649.	107
I-133	1.52×10^{13}	3649.	1642
I-134	2.83×10^8	1.62	.49
I-135	2.58×10^{12}	1961.	314
Total			3074.

* Activity Ingested = $\frac{\int_0^{\tau} \text{Areal Atoms } d\tau}{\text{Depth of Water}} \times \text{Water Intake Rate} \times \text{Decay Constant}$

where τ = deposition or post deposition interval.

Air Concentrations of Iodine Isotopes

Time Integral of Volumetric Concentration is equal to the ratio amount of deposition per unit area and the deposition velocity, thus during interval i

$$\int_0^{t_i} C_i dt = \frac{A_i}{V_i} .$$

Thus,

$$C_i = \frac{A_i}{V_i t_i} .$$

where

$t_i \equiv$ length of interval, ~~325~~ hours,

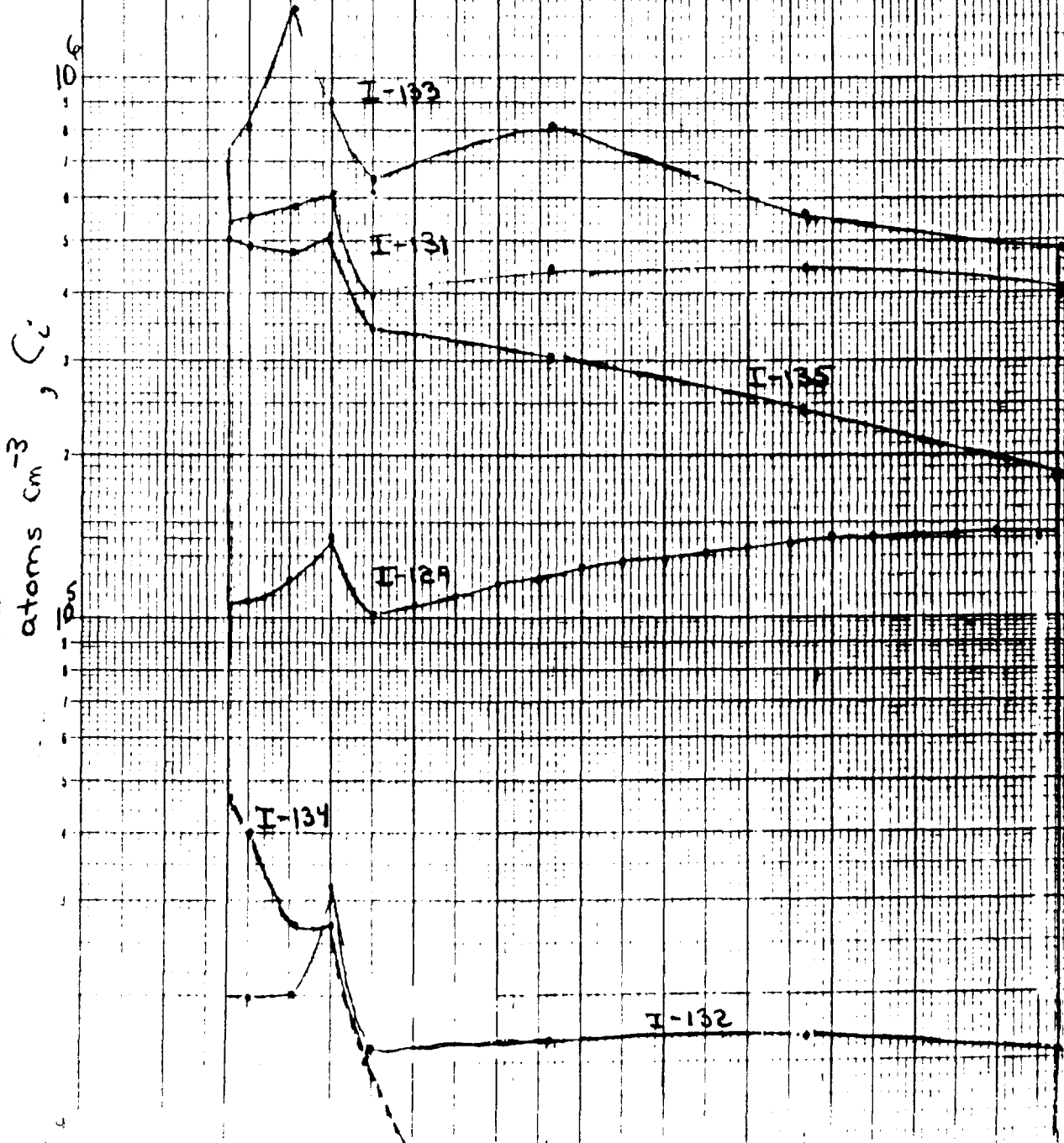
$V_i \equiv$ average deposition velocity during interval,

$A_i \equiv$ areal deposition during t_i

The above analysis was used for I-129 and a graph of I-129 atoms per cm^3 versus time post detonation was drawn (Graph 4). The air concentrations of the remaining Iodine isotopes were determined from the instantaneous ratio of the number of iodine isotope atoms to I-129 atoms per 10,000 thermonuclear fissions of

Fallout Air Concentrations of Iodine Isotopes on Rongelap

Graph 4



AD 8840-00

SEM. LOG. INSTR. 3 CYCLES 1 TAL. DIVISION

CONCENTRATION 5000 COUNTS PER MINUTE

6

Activity Inhaled During Fallout on Rongelap

Thyroid
Rem μCi^{-1}
(30-100 μ)

Breathing Rate = $8.729 \times 10^5 \text{ cm}^3 \text{ h}^{-1}$

.844	I-131
.0085	I-132
.163	I-133
.0145	I-134
.045	I-135

Atoms Inhaled =

Area of Atom Concentration
Curve on Graph 4
x Breathing Rate.

Nuclide	Inhaled μCi	Thyroid Rem
I-131	69	58
I-132	2118	18
I-133	833	136
I-134	218	9.2
I-135	1293	68
Total		273 Rem

Resuspension of Iodine Atoms

Resuspended Concentration
in Air = areal atoms on ground \times
resuspension factor

$$C_r = C_g \times K,$$

where C_r = resuspended air conc., atoms cm^{-3}

C_g = areal atoms, graph 3, atom cm^{-2} ,

$K = 10^{-7} \text{ cm}^{-1}$, UNSCEAR A/AC.02/B.369.

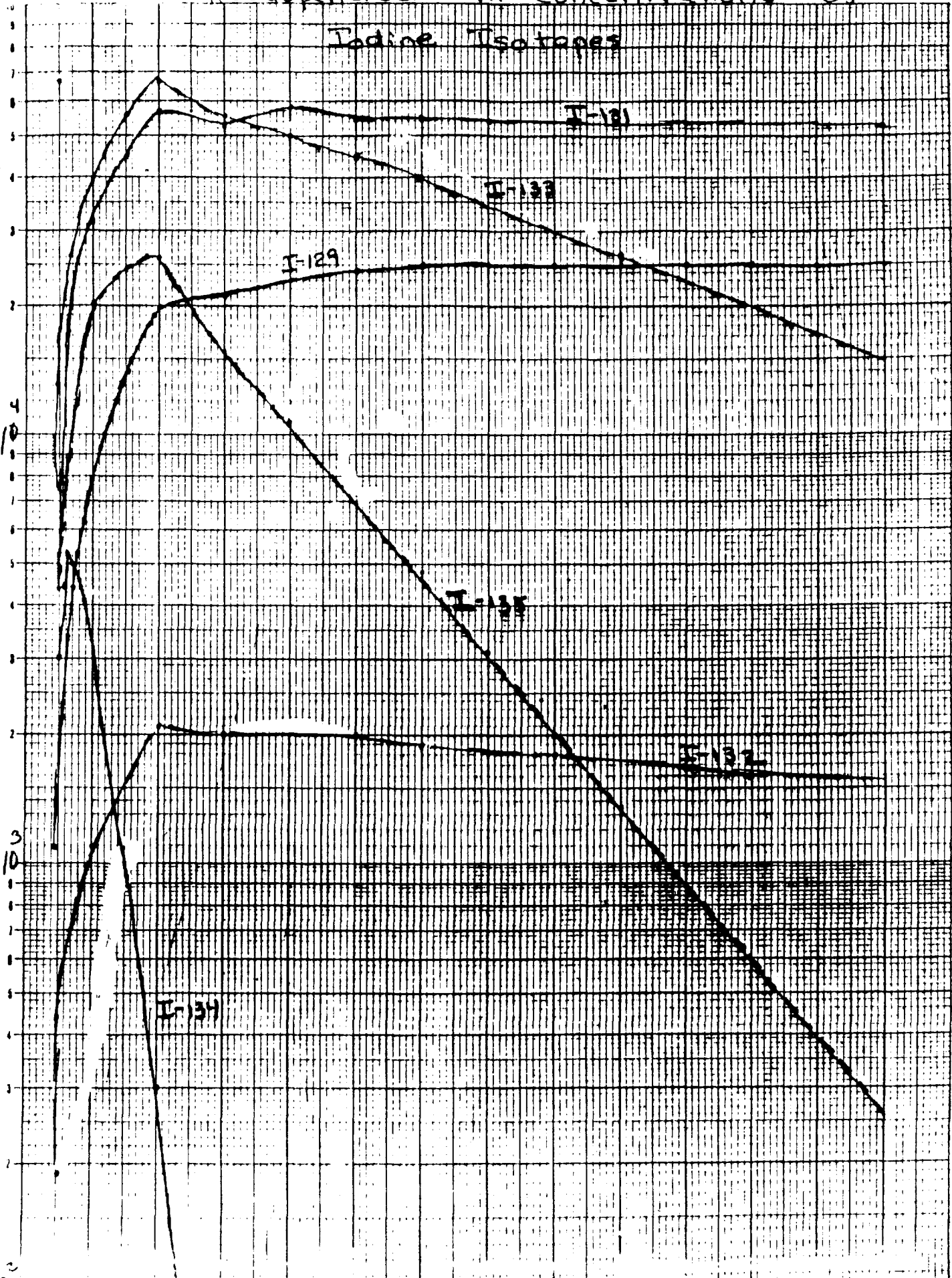
The above expression was used to develop the resuspended air concentration of I-129 atoms post detonation. Resuspension occurred during and post fallout cloud passage. The resuspended air concentrations of the remaining iodine isotopes were determined from the instantaneous ratio of the number of iodine isotope atoms to I-129 atoms per 10,000 thermonuclear fissions of U-238 at times post creation (Table 1). The resuspended air concentrations are shown on graph 5.

Resuspended Air Concentrations of
Iodine Isotopes

SEMI-CALORIMIC 3 CYCLES 140 DIVISIONS 40-4000-40

GRAPHIC CONTROLS CORPORATION BOSTON, MASS. U.S.A.

Atom Concentration in Air, atoms cm^{-3}



Activity Inhaled Due To Resuspension on Bongelap

$$\text{Atoms Inhaled} = \text{Area of Atom Concentration Curve on Graph 5} \times \text{Breathing Rate}$$

During Deposition (H+5.5 to H+12)

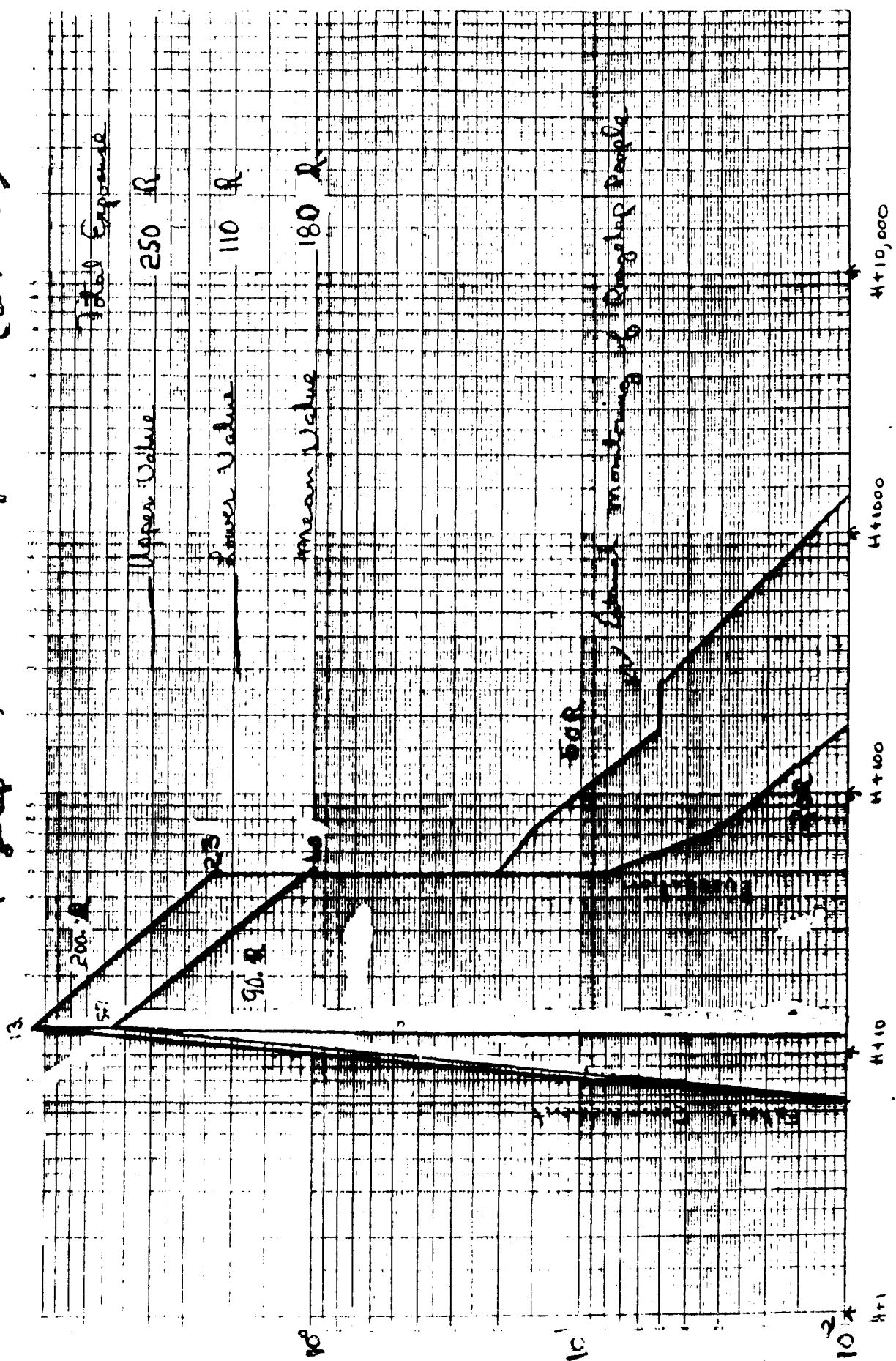
Nuclide	Atoms Inhaled	$\mu\text{Ci}/\text{Atom}$	Activity Inhaled, μCi	Rem/ μCi	Thyroid Rem
I-131	1.82×10^{11}	2.7×10^{-11}	4.9	.844	4.1
I-132	6.71×10^9	2.3×10^{-9}	15.4	.0085	.13
I-133	2.33×10^{11}	2.5×10^{-10}	58.3	.163	9.5
I-134	1.24×10^{10}	6.0×10^{-9}	74.4	.015	1.1
I-135	1.04×10^{11}	7.9×10^{-11}	82.2	.045	3.7

Post Deposition (H+12 to H+51)

I-131	1.72×10^{12}		46.4		39.
I-132	5.97×10^{10}		126		1.1
I-133	7.84×10^{11}		196		32.
I-134	4.32×10^5		-		-
I-135	2.2×10^{11}		174		7.8

Total 98.4

Rongelap External Exposure (WT 938) * Graph 6



Hours Post Castle Bravo

External Exposure of Marshall Islanders and Military Personnel

ACUTE PHASE

17

Rongelap

Adult Male Thyroid Dose Summary

	<u>Rem</u>
Direct inhalation of passing cloud	273
Ingestion of water during deposition	605
Ingestion of water post deposition	3070
Resuspended and inhaled during deposition	18
Resuspended and inhaled post deposition	80
External exposure during residence	51.9
External exposure after evacuation	25.6
TOTAL	4160