10-95-100

United States Nuclear Regulatory Commission
Office of Public Affairs, Region I
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I-95-62 October 24, 1995

Contact: Diane Screnci
Victor Dricks

NRC TO HOLD MEETING IN BOSTON TO DISCUSS INVESTIGATION
INTO THE INGESTION OF RADIOACTIVE MATERIAL BY MIT RESEARCHER

The Nuclear Regulatory Commission's Incident Investigation Team (IIT) investigating an ingestion of radioactive material by a researcher at the Massachusetts Institute of Technology (MIT) will hold an open exit meeting with MIT tomorrow (10/25). The meeting will be held at 10 a.m. in MIT's Little Theater, Kresge Auditorium, at 48 Massachusetts Avenue (across the street from the main entrance to MIT). The meeting is open to the public for observation only. The IIT team leader will be available to answer questions from the media or the public following the exit meeting.

The IIT has been at MIT since October 17, gathering data, conducting interviews, inspecting equipment and facilities, meeting with the licensee, concurring in licensee action plans and analyzing facts. The team was sent to investigate the circumstances surrounding the August 14 ingestion of phosphorus-32 by a male researcher. MIT notified the NRC of the ingestion on October 16.

#

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10-95-101

9/13 12:00- 9/14 12:00	31	2193	625 572	588 535	568	0.561	
9/14 12:00- 9/15 12:00	32	3102	348 346	311 309	314	0.439	
9/15 12:00- 9/16 12:00	33	2400	384 364	347 327	377	0.407	
9/16 12:00- 9/17 12:00	34	3370	259 253	222 216	233	0.354	
9/17 12:00- 9/18 12:00	35	2190	363 340	326 303	319	0.315	
9/18 12:00- 9/19 12:00	36	2784	303 286	266 249	274	0.344	
9/19 12:00- 9/20 12:00	37	2550	300 299	263 262	266	0.306	
9/20 12:00- 9/21 12:00	38	2918	296 288	259 251	259	0.341	
9/21 12:00- 9/22 12:00	39	2123	359 357	322 320	326	0.311	
9/22 12:00- 9/23 12:00	40	2794	235 221	198 184	213	0.268	
9/23 12:00- 9/24 12:00	41	3282	195 207	158 170	174	0.257	
9/24 12:00- 9/25 12:00	42	3070	220 230	183 193	190	0.263	
9/25 12:00- 9/26 12:00	43	2706	206 209	169 172	172	0.210	
9/26 12:00- 9/27 12:00	44	2323	248 240	211 203	209	0.219	
9/27 12:00- 9/28 12:00	45	3288	172 184	135 147	142	0.211	
9/28 12:00- 9/29 12:00	46	2562	206 189	169 152	187	0.216	
9/29 12:00- 9/30 12:00	47	2806	176 172	139 135	153	0.193	
9/30 12:00- 10/1 12:00	48	2278	193 191	156 154	165	0.169	
10/1 12:00- 10/2 12:00	49	2897	146 148	109 111	111	0.145	
10/2 12:00- 10/3 12:00	50	2524	174 168	137 131	136	0.154	
10/3 12:00- 10/4 12:00	51	1858	213 200	176 163	172	0.144	
10/4 12:00- 10/5 12:00	52	2385	161 153	124 116	122	0.131	

10/5 12:00- 10/6 12:00	53	3128	142 137	105 100	104	0.146	
10/6 12:00- 10/7 12:00	54	2323	124 116	87 79	97	0.101	
10/7 12:00- 10/8 12:00	55	2349	110 118	73 81	86	0.091	
10/8 12:00- 10/9 12:00	56	2378	120 145	83 108	102	0.109	
10/9 12:00- 10/10 12:00	57	2514	131 113	94 76	86	0.098	
10/10 12:00- 10/11 12:00	58	2507	115 120	78 83	82	0.092	

*1 All the measurement were made by mixing 1ml of urine sample with about 10 ml of scintilation counting cocktail (OptiFlour from Packward) using a Beckman 3801 scintilation counter.

*2 The background was obtained by measure 10 ml of scintilation counting cocktail without urine sample and is constantly around 37 cpm.

*3 The counting efficiency is assumed 99% when converting to dpm.

*4 The total activity and adjusted dpm shown above has been adjusted to the end of the 24-hr peroid.

10-95-103

INVESTIGATION LEVELS OF RADIOISOTOPES IN THE BODY AND IN URINE. CONSEQUENCES OF THE RECENT RECOMMENDATIONS ON THE ANNUAL LIMITS OF INTAKE

Y. Shamai, M. Tirkel and T. Schlesinger

The recommendations of Committee 2 of the International Commission on Radiological Protection (ICRP) concerning annual limits of intake (ALI) for workers (1) have recently been published. These limits differ in many cases from the maximum permissible annual intake (MPAI) recommended previously by the same committee (2,3). The new recommendations directly influence the derived health physics parameters, such as the acceptable total body burden and concentrations of radioisotopes in the urine.

Radioactivity in the body can be monitored routinely either by whole body counting or indirectly by urine analysis. Thus the monitoring laboratories have to know the relation between the activity in the urine or the body and the committed dose for calculating the latter from their measurements.

The activity of a radioelement in the body at any time t after intake of a unit of activity is given by its retention R(t):

$$R(t) = F_1 \exp(-\lambda t) \sum_i A_i \sum_j B_{ij} \exp(-\lambda_{ij} t)$$

where F_1 is the coefficient expressing the fraction of the intake transferred to the transfer compartment; A_i are coefficients expressing the fractions transferred from the transfer compartment to the i-th organ; B_{ij} are the coefficients of the linear combination of exponentials with decay constants λ_{ij} representing the retention in the i-th organ (1,4) and λ is the physical decay constant.

The amount of activity U(t) excreted in the urine at any time t after the intake of a unit of activity, is given by the first derivative of the biological retention function, multiplied by F_u the fraction of the excretion that is excreted through the urine (3,5):

$$U(t) = F_1 F_u \exp(-\lambda t) \sum_i A_i \sum_j \lambda_{ij} B_{ij} \exp(-\lambda_{ij} t)$$

When the decay constants λ are expressed in $days^{-1}$ then U(t) is the daily excretion. The average daily urine volume is 1.4 liters (5); thus division by 1.4 yields the concentration of the radioelement per liter.

The investigation level at any time t after intake was defined as the concentration of activity in the urine arising from an intake of 1/20 of an ALI (3). An analogous definition is used here for the total body investigation level. A computer code was written which

receives as input t
ALI (1,4) and calcu
list the investigat
commonly used radio
Different tables sho

TABLE 1. Total bod
ingestion.

Isotope	Organ
^{22}Na	T.B.*
^{42}K	T.B.
^{51}Cr	T.B.
	T.B.
^{57}Co	T.B.
	T.B.
^{60}Co	T.B.
	T.B.
^{59}Fe	T.B.
^{65}Zn	T.B.
^{67}Ga	T.B.
^{75}Se	T.B.
	T.B.
^{99}Mo	T.B.
	T.B.
^{99m}Tc	T.B.
^{125}I	Thyroid
^{131}I	Thyroid
^{137}Cs	T.B.
^{144}Ce	L.L.I.*
^{226}Ra	B.S.*
^{232}Th	B.S.
^{238}U	B.S.
	T.B.
** ^{239}Pu	B.S.
** ^{241}Am	B.S.

* T.B. = total bod
** intestine

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receives as input the various coefficients $F_1, F_u, A_i, B_{ij}, \lambda_{ij}, \lambda$ and the ALI (1,4) and calculates the investigation levels. Tables 1 and 2 list the investigation levels in the body and the urine of a few commonly used radioisotopes, as a function of time after ingestion. Different tables should be used for the case of inhalation.

TABLE 1. Total body investigation levels as a function of time after ingestion.

Isotope	Organ	Chemical form	Investigation level (μCi)			
			days after ingestion			
			3	7	30	60
^{22}Na	T.B.*		14	12	4.0	0.97
^{42}K	T.B.		0.51	$2.2 \cdot 10^{-3}$	-	-
^{51}Cr	T.B.	Trivalent	9.1	6.5	2.0	0.73
	T.B.	Hexavalent	91	65	20	7.3
^{57}Co	T.B.	Inorganic	8.4	6.5	3.3	2.5
	T.B.	Organic	26	20	10	7.9
^{60}Co	T.B.	Inorganic	0.52	0.41	0.22	0.18
	T.B.	Organic	1.2	0.92	0.50	0.40
^{59}Fe	T.B.		3.9	3.6	2.5	1.6
^{65}Zn	T.B.		8.5	8.1	6.5	5.3
^{67}Ga	T.B.		0.17	0.056	$0.19 \cdot 10^{-3}$	-
^{75}Se	T.B.	Elemental	5.4	4.2	2.1	1.1
	T.B.	Inorganic	30	23	11	6.2
^{99}Mo	T.B.	Sulfide	1.1	0.39	$0.96 \cdot 10^{-3}$	-
	T.B.	Other	27	9.4	0.023	$9.0 \cdot 10^{-6}$
^{99m}Tc	T.B.		0.66	$3.5 \cdot 10^{-6}$	-	-
^{125}I	Thyroid		0.39	0.36	0.25	0.16
^{131}I	Thyroid		0.31	0.21	0.026	$1.7 \cdot 10^{-3}$
^{137}Cs	T.B.		5.0	4.7	4.0	3.3
^{144}Ce	L.L.I.*		$3.2 \cdot 10^{-3}$	$3.2 \cdot 10^{-3}$	$3.0 \cdot 10^{-3}$	$2.8 \cdot 10^{-3}$
^{226}Ra	B.S.*		$4.8 \cdot 10^{-3}$	$2.9 \cdot 10^{-3}$	$1.5 \cdot 10^{-3}$	$1.2 \cdot 10^{-3}$
^{232}Th	B.S.		$7.3 \cdot 10^{-6}$	$7.3 \cdot 10^{-6}$	$7.2 \cdot 10^{-6}$	$7.2 \cdot 10^{-6}$
^{238}U	B.S.	Hexavalent	$13 \cdot 10^{-3}$	$9.6 \cdot 10^{-3}$	$3.4 \cdot 10^{-3}$	$1.6 \cdot 10^{-3}$
	T.B.	Tetravalent	$7.2 \cdot 10^{-3}$	$5.4 \cdot 10^{-3}$	$1.9 \cdot 10^{-3}$	$0.9 \cdot 10^{-3}$
^{239}Pu	B.S.		$24 \cdot 10^{-6}$	$24 \cdot 10^{-6}$	$24 \cdot 10^{-6}$	$24 \cdot 10^{-6}$
^{241}Am	B.S.		$30 \cdot 10^{-6}$	$30 \cdot 10^{-6}$	$30 \cdot 10^{-6}$	$30 \cdot 10^{-6}$

* T.B. = total body; B.S. = bone surface; L.L.I. = lower large intestine

The following assumptions are inherent in the calculations:

a) The activity build-up time in the organs is assumed to be negligible compared to the decay time. Since the exponential approximation is in any case too crude to use for calculations for the first day no attempt was made to insert the build-up effect in the calculations. Therefore, this calculation should not be used for the first day.

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b) The urinary excretion fraction F_u is taken as one constant for all organs and at any time. It will be possible to insert better approximations into the computer code when more biological information is available.

The computer code and Tables 1 and 2 give the levels in the urine and the body arising from an intake that corresponds to a particular committed dose. In the future we shall use the same tables and routines to reverse the procedure and calculate the committed dose from a measured activity.

TABLE 2. Investigation level in urine as a function of time after ingestion.

Isotope	Organ	Chemical form	Investigation level (μCi) days after ingestion 3	7	30	60
^{3}H	T.B.	Water	81	62	12	1.6
^{22}Na	T.B.		0.46	0.39	0.13	0.032
^{32}P	T.B.		0.49	0.18	0.017	$1.3\cdot10^{-3}$
^{35}S	L.L.I.	Elemental	0.37	0.068	0.025	$7.2\cdot10^{-3}$
	T.B.	Other	9.3	1.7	0.63	0.18
^{36}Cl	T.B.		3.3	2.5	0.50	0.063
^{42}K	T.B.		$7.1\cdot10^{-3}$	$31\cdot10^{-6}$	-	-
^{45}Ca	T.B.		0.32	0.12	0.024	$8.1\cdot10^{-3}$
^{51}Cr	T.B.	Trivalent	0.21	0.11	$8.2\cdot10^{-3}$	$1.7\cdot10^{-3}$
	T.B.	Hexavalent	2.1	1.1	0.082	0.017
^{57}Co	T.B.	Inorganic	0.37	0.17	0.019	$6.0\cdot10^{-3}$
	T.B.	Organic	1.1	0.52	0.058	0.019
^{60}Co	T.B.	Inorganic	0.023	0.01	$1.2\cdot10^{-3}$	$0.42\cdot10^{-3}$
	T.B.	Organic	0.052	0.024	$2.8\cdot10^{-3}$	$0.96\cdot10^{-3}$
^{65}Zn	T.B.		0.014	0.012	$6.0\cdot10^{-3}$	$2.9\cdot10^{-3}$
^{67}Ga	T.B.		$2.2\cdot10^{-3}$	$0.6\cdot10^{-3}$	$0.8\cdot10^{-6}$	-
^{75}Se	T.B.	Elemental	0.12	0.039	$9.3\cdot10^{-3}$	$3.2\cdot10^{-3}$
	T.B.	Inorganic	0.67	0.21	0.05	0.017
^{85}Sr	T.B.	Titanate	0.021	$5.6\cdot10^{-3}$	$0.32\cdot10^{-3}$	$0.11\cdot10^{-3}$
	T.B.	Other	0.42	0.11	$6.4\cdot10^{-3}$	$2.2\cdot10^{-3}$
^{90}Sr	T.B.	Titanate	$2.7\cdot10^{-3}$	$0.76\cdot10^{-3}$	$55\cdot10^{-6}$	$27\cdot10^{-6}$
	B.S.	Other	$4.8\cdot10^{-3}$	$1.3\cdot10^{-3}$	$0.1\cdot10^{-3}$	$47\cdot10^{-6}$
^{99}Mo	T.B.	Sulfide	0.010	$2.1\cdot10^{-3}$	$5.0\cdot10^{-6}$	-
	T.B.	Other	0.24	0.051	$0.12\cdot10^{-3}$	-
^{99m}Tc	T.B.		0.074	-	-	-
^{125}I	Thyroid		$3.2\cdot10^{-3}$	$0.8\cdot10^{-3}$	$0.54\cdot10^{-3}$	$0.34\cdot10^{-3}$
^{131}I	Thyroid		$2.6\cdot10^{-3}$	$0.46\cdot10^{-3}$	$57\cdot10^{-6}$	$3.7\cdot10^{-6}$
^{137}Cs	T.B.		0.055	0.026	0.014	0.012
^{204}Tl	T.B.		0.87	0.58	0.059	$3.0\cdot10^{-3}$
^{226}Ra	B.S.		$32\cdot10^{-6}$	$8.6\cdot10^{-6}$	$0.6\cdot10^{-6}$	$0.3\cdot10^{-6}$
^{238}U	B.S.	Hexavalent	$0.18\cdot10^{-3}$	$86\cdot10^{-6}$	$16\cdot10^{-6}$	$4.3\cdot10^{-6}$
	T.B.	Tetravalent	$0.1\cdot10^{-3}$	$48\cdot10^{-6}$	$8.9\cdot10^{-6}$	$2.4\cdot10^{-6}$

REFERENCES

1. Annals of the
2. ICRP Publ.
3. ICRP Publ.
4. Adams, N., H
Harwell.
5. ICRP Publ.

REFERENCES

1. Annals of the ICRP, ICRP Publ. 30 (1979).
2. ICRP Publ. 6 (1962).
3. ICRP Publ. 10 (1968).
4. Adams, N., Hunt, B.W. and Reissland, J.A. (1978):NRPB-R 82, Harwell.
5. ICRP Publ. 23 (1974).

10-95-107

Environmental
Medical
Service

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
MEDICAL DEPARTMENT
77 MASSACHUSETTS AVENUE, 20B-238
CAMBRIDGE, MASSACHUSETTS 02139-4307

RADIATION PROTECTION OFFICE

To : Susumu Tonegawa, Professor, Biology
From : Donald Haes, Assistant Radiation Protection Officer
Subject : Radioactive Materials Waste Storage in Registered Laboratories
Date : December 22, 1993

On 12/22/93 I performed an inspection of the laboratories registered to your M.I.T. authorization to use and possess radioactive material (CCR-M). This inspection served to address the concerns of a member of your lab that a radioactive materials waste containers had an "excessively high" dose-rate. The concern was brought to the attention of a RPO technician, who notified me that a waste container was found in the laboratory that although full, had no summary record of radioactive material disposed.

During this routine inspection, I noticed that nearly <u>every</u> radioactive materials waste container that was full or near full had an improper summary record. For example, a ^{32}P waste container was full of material and had a measured dose-rate of 10 mR/hr at the opening, but the summary record indicated that 50 μCi of ^{32}P was disposed in July 1993. In other cases, waste containers were full of material, and had a measured dose-rate at the opening, but the summary record was completely blank. In addition to the problems associated with the disposal of solid radioactive waste, I also found that the summary record of the disposal of radioactive liquids via the sanitary sewer system was also void of proper entries. Further discussion with laboratory personnel indicated that, although they are aware of this policy, compliance is noncompulsory.

The failure to provide summary records of radioactive materials in waste containers or registered laboratory sinks is in violation of M.I.T.'s *Nuclear Regulatory Commission* license, and jeopardizes M.I.T.'s privilege to use and possess radioactive material.

Feel free to contact me or Mitchell Galanek, Associate Radiation Protection Officer, at X3-2180 if you have any questions.

xc. F. Massé, Radiation Protection Officer
M. Galanek, Associate Radiation Protection Officer
CCR-M File

10-95-107

RADIATION PROTECTION COMMITTEE

CAMBRIDGE, MASSACHUSETTS 02139

To: Professor Susumu Tonnegawa

From: MIT Radiation Protection Committee
Professor Harold Hemond, Chair

Subject: Renewal Authorization CCR-M-4

Date: March 6, 1994

At the 111th meeting of the MIT Committee on Radiation Protection (RPC), your renewal authorization, CCR-M-4, was submitted to the committee for approval. The Radiation Protection Office recommended the renewal be approved for the standard two year period. As is commonly the case, RPC members asked the RPO staff for a review of the project's operational and safety compliance during the previous two years. During the discussion of your authorized uses, the RPO reported a recurring problem with respect to your laboratories compliance with MIT procedures for the safe disposal of low level radioactive waste. These problems were reviewed with your entire group during the annual retraining meeting held on January 13, 1994, at which time your group agreed to do a better job of compliance in the future. Due to the recurring nature of these problems with respect to low level radioactive waste disposal, the committee voted to renew your authorization for a restricted period of three months and instructed the RPO to closely monitor your laboratories' compliance. RPO will report to the committee at the next quarterly meeting (expected schedule is late April).

Failure on the part of any research group to comply with the MIT required procedures for radiation protection could jeopardize the Institute's Nuclear Regulatory Commission licenses or expose the Institute to substantial fins. One of the RPC 's responsibilities to the Institute is to ensure the safe use of radioactive material through compliance with applicable regulations and the programs established by the radiation protection office.

The RPC strongly encourages you to discuss this matter with your research group and resolve to work with radioactive materials in full compliance with the established MIT procedures.

We ask that you respond in writing to the MIT Radiation Protection Committee outlining the steps taken to ensure future compliance with the low level radioactive waste program. Please contact Mitchell Galanek at the Radiation Protection Office if you have any questions about the specifics of the MIT low level radioactive waste program.

Thank you in advance for your cooperation in this matter.

xc: RPC files

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

CENTER FOR CANCER RESEARCH

77 MASSACHUSETTS AVENUE, CAMBRIDGE, MASSACHUSETTS 02139

TO: MIT Radiation Protection Committee
Professor Harold Hemond, Chair

FROM: Professor Susumu Tonegawa S.T.

SUBJECT: Renewal Authorization CCR-M-4

DATE: March 15, 1994

After receiving notification of the term-restricted renewal, I called a meeting of the entire lab to discuss the issue. I stressed the extreme importance of strict adherence to protocol for all radioactive procedures, especially those for low level waste disposal. Even though I was assured by all personnel that they had been practicing correct disposal procedures ever since their January retraining session, we all saw the need to set up a monitoring system. We have now designated a supervisor in each room of the lab to oversee regulatory compliance in all radioactive procedures. Everyone in my lab wants to employ all possible measures to fulfill our obligation for safe use of radioactive materials.

.12/87.

10-95-108

Type of Survey Requested: Contamination

Location (room #): E17-329 Person Requesting Survey Brian Laffey

Date: 7/22/94 Time 3pm Telephone Ext: 3-6483

Person Receiving Request Doreen

Description of Findings: High count rate from room meter heard upon entry into room. Reading was around 5k cpm with the probe in the upright position attached to the meter case.

Names of Persons Involved: Brian Laffey

Perry Spearman

RADIATION SURVEY RESULTS

Wipe Test Results: Centrifuge interior - 5E6 dpm (2.25uCi)

" exterior - 8E3 dpm (3.6nCi)

Survey Meter Results: Don Haes' meter w/ NaI probe, cal. date of 2/22/94 greater than 400k cpm on contact, 100k cpm @ 1ft, 10k cpm @ 3 ft

Recommendations and Actions Taken: Cautionary sign attached to the centrifuge. Assistant RSO assigned to room notified of problem. Radiation Worker list for period 7/20/94 thru 7/23/94:

D. Litwack 6 mCi on 7/20, Therese 3 mCi on 7/21, A. Kumbasor 10 mCi on 7/21

Vabril 5 mCi on 7/23. This is a list of the iodinations performed during the week.

Survey Performed By: Perry Spearman Date: 7/22/94

Staff Review By: [signature] Date: 7/27/94

22 Jul 94 15:31 User :

Protocol #:11

I-125 WIPE TEST

Time: 2.00
Mode: DPM Nuclide: 125I Quench Set: 125I
Background Subtract: None

	LL	UL	LCR	2S%	BKG
Region A:	0.0 -	70.0	0	0.0	0.00
Region B:	6.0 -	70.0	0	0.0	0.00
Region C:	0.0 -	0.0	0	0.0	0.00

Quench Indicator: tSIE/AEC
Ext Std Terminator: Count

Luminescence Correction On

S#	TIME	CPMA	DPM1	SIS	tSIE	FLAG	
1	2.00	5335.00	8049.21	21.802	380.66		outside
2	2.00	3738685	5475176	23.474	416.85		INside

RP 101
12/87

Type of Survey Requested: Re-check

Location (room #): E1731C Person Requesting Survey G. Sirr

Date: 9.12.95 Time 9:00 Telephone Ext: 32180

Person Receiving Request NA

Description of Findings: found two 12" X 12" area's on floor S-35 contamination, Instructed lab technician to clean up area. Re-check occurred at 1:00, checked OK.

Names of Persons Involved:

RADIATION SURVEY RESULTS

Wipe Test Results: <MDA

Survey Meter Results: <MDA

Recommendations and Actions Taken: wipe test results from 9.6.95 identified hot spot on back floor, this survey was utilized to correct contamination and minimize transfer of Radio Isotopes to public access.

Survey Performed By: [signature] Date: 9.12.95

Staff Review By: [signature] Date: 9/13/95

13 Sep 95 13:41
Protocol #:10 3H/14C/35S/32P Page #1
User :

Time: 2.00
Data Mode: CPM Nuclide: MANUAL
Background Subtract: None

	LL	UL	LCR	2S%	BKG
Region A:	0.0 -	12.0	0	0.0	0.00
Region B:	12.0 -	110	0	0.0	0.00
Region C:	120 -	900	0	0.0	0.00

Quench Indicator: SIS

S#	TIME	CPMA	CPMB	CPMC
1	2.00	21.00	18.00	8.00
2	2.00	34.50	23.50	8.50

RP 101
12/87

Type of Survey Requested: (non) request / due to wipe test Results

Location (room #): E1752A Person Requesting Survey NA.

Date: 6.27.95 Time 10:15 Telephone Ext:

Person Receiving Request NA

Description of Findings: floor had been cleaned of radioactive contamination prior to arrival

Names of Persons Involved:

RADIATION SURVEY RESULTS

Wipe Test Results: ⊂ MDA

Survey Meter Results: ≈ .10 - .20 mR/hr @ contact
Fixed contamination

Recommendations and Actions Taken: Individuals in lab had a responsive handle on radioactive spill. They were aware of contamination prior to my arrival + properly decontaminated area. I tested for removable contamination and also took several wipes.

Survey Performed By: [signature] Date: 6.27.95

Staff Review By: [signature] Date: 6/27/95

Jun 95 13:22 Page #1
Protocol #:10 3H/14C/35S/32P User :

T e: 1.00
Data Mode: CPM Nuclide: MANUAL
Background Subtract: None

	LL	UL	LCR	2S%	BKG
Region A:	0.0 -	12.0	0	0.0	0.00
Region B:	12.0 -	110	0	0.0	0.00
Region C:	120 -	900	0	0.0	0.00

Quench Indicator: SIS

S#	TIME	CPMA	CPMB	CPMC
1	1.00	177.00	62.00	4.00
2	1.00	158.00	60.00	3.00
3	1.00	72.00	49.00	3.00

over 225cm2

FRANCIS X. MASSE

[redacted]

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[redacted]

EDUCATION

Northeastern University, Boston, Massachusetts 1956
Bachelor of Science, Physics and Mathematics

Certified by the American Board of Health Physics 1962
Recertified 1982, 1985, 1989

Certified by the American Board of Medical Physics 1990

PROFESSIONAL ACTIVITIES

Primary Employment

Institute Radiation Protection Officer and Director of Radiation Protection Programs, Massachusetts Institute of Technology	1981-
Radiation Protection Officer, MIT Bates Linear Accelerator	1971-
Senior Lecturer, MIT Nuclear Engineering Department	1987-
Associate Radiation Protection Officer, MIT	1959-1971
Radiation Safety Officer, Tufts, New England Medical Center	1956-

Government Affairs and Standards Activities

Nuclear Incidents Advisor, Massachusetts Department of Public Health	1964-
Member, Massachusetts Department of Public Health, Division Medical Care, Advisory Committee on Nuclear Medicine	1971-1972
Member, American National Standards Institute Subcommittee N42.2;	1974-
Chairman	1983-
Chairman, ANSI Subcommittee N42.2.2 on Dose Calibrator Ion Chambers	1975-
Member, Ad Hoc Committee on Low Level Rad Waste, Massachusetts Advisory Council on Radiation Protection	1979-1980
Member and Vice Chairman, NELRAD (New England Low-Level Rad Waste Consortium)	1981-1983
NELRAD President and Board Chairman	1983-1993
Member, Governors Ad Hoc Advisory Task Group on Low-Level Rad Waste Facility Siting in Massachusetts	1983-1988
Member, DOE Committee on Determining Quality Factor for Neutrons	1985-1986
Chairman, National Academy of Sciences, Committee on Film Badge Dosimetry in Atmospheric Nuclear Tests	1987-1989
Member, Veterans Administration National Advisory Group for Radiation Safety	1987-1989
Member, Ad Hoc Nuclear Regulatory Commission Research Advisory Committee	1988-1990
Member, Massachusetts Low Level Waste Management Board (representing Mass. Dept. of Health & Human Services)	1993

Other Professional Activities

Consultant in Health Physics to approximately 80 hospitals, universities, or industrial firms.
Author of fifteen published papers and numerous additional papers presented at professional society meetings.

PROFESSIONAL SOCIETIES

Member, Health Physics Society	1959-
Awarded Fellow Status Membership	1986-
Member, New England Chapter of the Health Physics Society	1960-
Executive Board Member	1963-1969
President	1967-1968
Charter Member, American Association of Physicists in Medicine	1960-
Member, New England Chapter AAPM	1960-
Chairman	1967-1968
Member, Society of Nuclear Medicine	1968-
Member, Nuclear Medicine Standards Joint Committee of the New England Chapter Society of Nuclear Medicine and the	1970-1975
New England Radiological Physics Organization; Co-chairman	1973-1975
General Chairman, HPS 14th Midyear Symposium	1976-1980
Chairman, HPS Symposium Committee	1981-1983
Member, AAPM Committee on Radiation Protection	1980-1983, 1985-1988
Member, HPS Board of Directors	1983-1986, 1987-1993
Member, HPS Committee on Scientific and Public Issues	1983-1986, 1990-1993
Member, HPS Ad Hoc Committee on 10CFR20 amendment and	1983-1985
EPA Occupational Exposure Guidance Review, Chairman	1984-1985
HPS Board Delegate to International Radiation Protection Association Congress	1984-1988, 1988-1992, 1992-1996
Chairman, HPS Ad Hoc Committee on NBS Secondary Standards Laboratories for Calibration of Portable Health Physics Instruments	1985-1986
Chairman, HPS Standing Committee on Accreditation of Calibration Laboratories	1986-1988
Member, HPS Laboratory Accreditation Working Group	1986-1988
HPS Treasurer, Member of Executive Board	1987-1989
Chairman, HPS Finance Committee	1988-1990
Chairman, HPS Ad Hoc Committee on IRPA Involvement	1987-1988
Member, Finance Chair, HPS Local Arrangements Committee (Boston Meeting)	1987-1988
Member, HPS Ad Hoc Committee on Local Arrangements Standard Operating Procedures	1988-1989
Member, HPS Ad Hoc Committee on 1995 HPS-AAPM Joint Meeting	1988-1989
HPS President-Elect, President, Past-President	1990-91, 1991-92, 1992-1993
Member, IRPA Executive Committee	1992-2000
Member, Council of Scientific Society Presidents	1990-1996
CSSP, Treasurer	1993-1994
CSSP, Chair-Elect, Chair, Past Chair	1994,'95,'96
Member, American Academy of Health Physics Executive Board	1995-1997

BUSINESS ACTIVITIES

North Cambridge Co-operative Bank, Director	1963-
Finance Committee Member	1967-
Finance Committee Chairman	1972-
First Vice President	1982-
Board Chairman	1991-
President and Co-Founder, F.X. Massé Associates, Inc.	1974-
President and Co-Founder, Medical Imaging Corporation	1976-1979

Curriculum Vitae

MITCHELL S. GALANEK, CHP

[redacted]

[redacted]

Education:

University of Massachusetts, Amherst, MA; B.S. Zoology; 1975

Northeastern University, Boston, MA; graduate studies in Environmental Engineering; 1980 - 1985

University of Lowell, Lowell, MA; Several graduate health physics courses.

Professional Experience:

Associate Radiation Protection Officer; M.I.T.; 1986 - present

Assistant Radiation Protection Officer; M.I.T.; 1978-1986

Commonwealth of Massachusetts Nuclear Incident Advisory Team (N.I.A.T.) 1980 to present.

Professional Associations:

Health Physics Society; National and New England Chapter;
American Academy of Health Physics; Member
Laser Institute of America; Member
Campus Radiation Safety Officers (CRSO); Member
Town of Plymouth Hazardous Waste Committee; 1985-89

Professional Certification

American Board of Health Physics: Comprehensive Certification 1988; Recertification 1993.

William E. Irwin

Experience

Massachusetts Institute of Technology, October 1992 - Present
Assistant Radiation Protection Officer

Manage the use of radioactive materials, and ionizing and non-ionizing radiation producing devices for campus research laboratories. Supervise six technicians.

Private Health Physics Consultant, June 1993 - Present

Provide safety analyses, training and regulatory compliance advice for manufacturing and research uses of ionizing radiation and lasers.

Seabrook Station, July 1990 - September 1992
Senior Training Instructor

Training development and instruction for the Health Physics Technician, Management and Supervisor, and Radiation Worker Training Programs.

Palo Verde Nuclear Generating Station, December 1985 - July 1990
Lead Technical Instructor

Supervisor of the Chemistry Technician and Radiation Monitoring Technician Training Programs. Lead a staff of thirteen instructors and training developers. Designed and implemented corrective actions for removal of probationary accreditation status from the Chemistry Training Program. As **Technical Staff Training Senior Instructor**, directed job analysis, program design, course development and training implementation for plant engineering personnel. Coordinated activities of both plant staff and contractors. As **Radiation Protection Technical Instructor III**, produced a complete revision of the Radiological Work Practices Training course and the Plant Systems Training course.

Education

University of Massachusetts Lowell, Current Student
Doctor of Science in Work Environment Engineering

University of Massachusetts Lowell, June 1994
Master of Science in Radiological Sciences

New Hampshire College, September 1992
Master of Business Administration

Christopher Newport College of the College of William & Mary, January 1980
Bachelor of Arts in Philosophy and History

JUDITH M. REILLY, MS

[redacted]

ACADEMICS:

* Part I Certified - American Board of Health Physics 1990

* U-Mass at Lowell - Graduate Studies in Work Environment
  Lowell, Massachusetts

* University of Lowell - MS in Radiological Sciences - 1985
  Lowell, Massachusetts

* University of Lowell - BS in Health Service Administration - 1982
  Lowell, Massachusetts

EMPLOYMENT:

* Massachusetts Institute of Technology - 1984 to Present
  Assistant Radiation Protection Officer

Duties include review of applications to use radioactive materials; instruction and training of MIT personnel as to the appropriate radiation protection and radionuclide handling techniques; continued surveillance of approved laboratories to ascertain compliance with regulations; personnel training and systems inspections of LASER safety; inspection of radiation producing equipment; and supervision of RPO technicians involved in all facets of MIT's radiation safety program.

* Health Physicist Consultant - 1986 to Present

Experience in ionizing radiation safety hazard evaluation and training; radiation safety program development and licensure compliance; X-ray audits in diagnostic radiology for JCAHO, FDA and State compliance; X-ray shielding design and analysis; LASER safety hazard evaluation, training and program development.

* Pilgrim Nuclear Power Station - Summer 1984
  Health Physics Summer Intern

CONTINUING EDUCATION:

* Certification Review Course in Health Physics
  Skrable Enterprise, 1990 & 1995

* Laser Safety: Hazard, Inspection & Control
  Laser Institute of America - 1991

PROFESSIONAL AFFILIATIONS:

* Health Physics Society - Plenary Member since 1988
* New England Chapter Health Physics Society - Member 1985
* American Academy of Health Physics - Associate Member 1990
* New England Chapter Health Physics Society:
  1995 - Local Arrangements Committee - Boston HPS Meeting
  1990, 1988, 1986 - Programs Committee Member
  1986-1988 - Executive Board of Directors
  1987 - Newsletter Editor

THOMAS P. FULLER
[redacted]

HIGHLIGHTS OF QUALIFICATIONS

- Radiological Health Physicist with over 15 years experience in radiation protection, environmental engineering, emergency planning, quality assurance, and laser safety.
- Experienced in coordination of activities between public and private organizations.
- Comprehensive procedure and program development expertise.
- Excellent speaking, teaching, and writing capabilities.
- Strong organizational and managerial skills.
- ANSI qualified lead auditor.

EDUCATION

- Master of Business Administration, Suffolk University, Boston, MA, 1989
- Master of Science in Public Health, University of North Carolina, Chapel Hill, NC, 1979 (Department of Environmental Science and Engineering, Radiological Hygiene Section)
- Bachelor of Science, Ohio State University, Allied Medical Professions, Columbus, OH, 1977

PROFESSIONAL EXPERIENCE

1991 - present **Massachusetts Institute of Technology**, Cambridge, MA
Assistant Radiation Protection Officer, Environmental Medical Service

- Responsible for the development and implementation of the health physics program for the MIT Plasma Fusion Center.
- Ensures center compliance with NRC, DOE and OSHA for radiation protection, environmental effluents, ALARA, and radwaste.
- Develops and implements programs for control and surveillance of non-ionizing sources of radiation including lasers, microwaves, and magnets.
- Trains and supervises personnel in radiation protection and laser safety.
- Represents the Radiation Protection Office on the Plasma Fusion Center Safety Committee.
- Performs technical consulting to nuclear utilities in emergency preparedness, environmental monitoring, quality assurance and radiation protection.

Massasoit Community College and Northeastern University, MA
Faculty, Radiologic Technology

- Teaches college courses in Radiation Protection, Radiobiology, Diagnostic Quality Control, and Radiographic Photography.

1990 - 1991 **United Energy Services Corporation**, Marietta, GA
Supervising Engineer, Nuclear Safety and Licensing Division

- Coordinated division activities, business plan development, scheduling and proposal preparation.
- Supervised teams conducting environmental, radiation protection, and emergency preparedness audits and program reviews at nuclear power stations (North Anna, Surry, Millstone, Haddam Neck, Gentilly, and Palo Verde).
- Marketed company support services.

1982 - 1990 **Yankee Atomic Electric Company**, Bolton, MA
Lead Auditor, Quality Assurance Department

- Managed in-plant and vendor audit teams.
- Audited areas of environmental science, chemistry, radiation protection, radwaste, and training at nuclear power plants (Yankee, Vermont Yankee, Seabrook, and Maine Yankee).

Senior Engineer, Environmental Engineering Department

- Supervised the activities of emergency exercise scenario development teams and task forces.
- Coordinated emergency exercise activities with federal, state, and local governments.
- Provided ongoing support in emergency plan and procedure development.
- Tracked and resolved regulatory inspection items.

1979 - 1982 **Stone and Webster Engineering Corporation**, Boston, MA
Assistant Project Engineer/Environmental Health Physicist, Nuclear Technology

- Coordinated radiological emergency plan development and training.
- Completed environmental reports and calculations for nuclear power plant effluents.
- Developed Standard Operating Procedures for environmental field monitoring and sample collection and performed correlations to offsite dose rates from nuclear plant releases.

1979 **Sargent and Lundy Engineers**, Chicago, IL
Health Physicist, Nuclear Safeguards and Licensing

- Performed health physics analysis of nuclear power station design.
- Managed thermoluminescent dosimetry and exposure control for radiological workers.

1978 **Oak Ridge National Laboratories**, Oak Ridge, TN
Research Assistant, Health and Safety Research Division

- Performed environmental sampling of atmosphere and biota.

AFFILIATIONS

Health Physics Society
New England Chapter Health Physics Society - past Treasurer
American Nuclear Society
American Registry of Radiologic Technologists

PUBLICATIONS

Barbanel, Cheryl S., A.M. Ducatman, M.J. Garston, T.P. Fuller, Laser Hazards In Research Laboratories, Journal of Occupational Medicine, Volume 35, Number 4, April 1993.

Fiore, C.L., R. Boivan, R.S. Granetz, T. Fuller, and C. Kurz, Status of the Neutron Diagnostic Experiment for Alcator C-Mod, Rev. Sci. Instrum. 63 (10), October 1992.

Fuller, T.P., C.E. Fiore, Alcator C-Mod Safety and Radiation Program, paper presented to the 14th IEEE/NPSS Symposium on Fusion Engineering, San Diego (1991).

Fuller, T.P., A Symptom Based Approach to Emergency Classification At Seabrook Station, paper presented to the 30th Annual Meeting of the Health Physics Society, Chicago (1985).

Fuller, T.P., Stone and Webster Engineering Corporation, Protective Ventilation Suits, paper presented to the 26th Annual Meeting of the Health Physics Society, Louisville (1981).

Fuller, T.P., C.E. Easterly, Tritium Protective Clothing, ORNL/TM-6671, ORNL (1979).

CURRICULUM VITAE

DONALD L. HAES, Jr., MS, CHP

<u>Academic Training</u> -

- Naval Nuclear Power School, 1976.

- Naval Nuclear Prototype Training Unit, Knolls Atomic Power Laboratory, Windsor, Connecticut, 1977. Qualification - Nuclear Reactor Plant Mechanical Operator and Engineering Laboratory Technician (ELT).

- Bachelor of Science Degree from University of Lowell, 1987. Major - Health Physics; Magna Cum Laude.

- Master of Science Degree from University of Lowell, 1988. Major - Radiological Sciences and Protection.

- Board Certified by the American Board of Health Physics.

<u>Continuing Education</u> -

- <u>Hazardous RF Electromagnetic Radiation: Evaluation, Control, Effects, and Standards</u>; George Washington University.

- <u>Certification Review for Health Physicists</u>; Skrable Enterprises, Inc.

- <u>Non-ionizing Radiations: Health Physics and Radiation Protection</u>; Massachusetts Institute of Technology. [Lecturer]

- <u>Assessing Non-Ionizing Radiation Hazards</u>; 1990 Health Physics Society Summer School.

- <u>EPRI Power System Magnetic Field Measurement Workshop</u>; Conducted by G.E. Company at the High Voltage Transmission Research Center.

- <u>Laser Safety</u>; Engineering Technology Institute.

- <u>Advanced Laser Safety</u>; Engineering Technology Institute.

Employment History -

- United States Navy; Nuclear Power Qualifications, 1975 - 1981.

- Radiopharmaceutical Production Supervisor - DuPont/NEN, 1981 - 1988.

- Assistant Radiation Safety Officer; Nonionizing Radiation Safety Officer; Campus Special Nuclear Material Accountability Officer - Massachusetts Institute of Technology, 1988 - present.

- Consulting Health Physicist; Ionizing and Nonionizing Radiation, 1988 - present.

Professional Societies -

- Health Physics Society; Plenary Member, National Chapter; Member of the Board of Directors, New England Chapter.

- Member American Academy of Health Physics.

- Member IEEE Standards Coordinating Committee (SCC28) - Non-Ionizing Radiation; Subcommittee SC-2: Terminology and Units of Measurement; SC-3: Safety Levels With Respect to Human Exposure, 0-3 kHz; SC-4 Safety Levels With Respect to Human Exposure, 3 kHz-300 GHz.

Publications -

- **Haes, D.L.**; Are VDTs Safe?. Information Display, pp. 17-27, June 1991.

- **Haes, D.L.**; VDT 'Radiation' Protection Products - Protection or Pacification?. Health Physics Newsletter, Vol XIX, No 12, pp. 19-21.

- **Haes, D.L.**; ELF Magnetic Field Measurements: Units of bedlam. Health Physics, 63(5), p. 591, 1992.

- **Haes, D.L.**, Ducatman, A.; Textbook of Clinical Occupational and Environmental Medicine. Chp 23 Nonionizing Radiation, pp. 646-657. W.B. Saunders Company, 1993.

- **Haes, D.L.**, Fitzgerald, M.F.; VDT VLF Measurements: The Need for Protocols in Assessing VDT User "Dose". Health Physics, 68(4), pp. 572-578, 1995.

DEYING SUN
7 Lee Terrace
Arlington, MA 02174
617-643-3946

education

Master of science, majoring in Radiological Science. University of Lowell, Mass., 1987-1989
Bachelor of science, majoring in Physics. East China Teachers University, Shanghai, China, 1963-1968.

work experience

1991-present
Health Physicist. MIT Radiation Protection Office.

1987-1991 Research Assistant. Department of Health Physics, University of lowell, Mass.
Accelerator Operator. Van De Graaff Accelerator, University of Lowell, Mass.

1969-1985 Physics Teacher. Guiyang Coal Mine High School, Guichou, China.

professional skill and knowledge

Radiation Protection--radiation dose calculation and dose measurement;radiation protection techniques; monitoring methods and instruments; contamination control and hazards analysis.

Radiation Dosimetry--Calculations of chronic and acute radiation doses and their effects; alpha, beta, gamma, and neutron dosimetry; use calibration of instruments.

Mathematical Methods and Skills in Health Physics--Special Calculation and numerical techniques used in radiation physics, radiation dosimetry and radiation shielding.

Radioisotope Techniques--Lab experience in tracer techniques including use of GM, proportional and various scintillation systems for counting alpha beta and gamma radiation,

Knowledge of basic general government standard and regulatory requirements.

Computer Skill--Calculating and analyzing data with health physics software and application of BASIC and FORTRAN languages.

reference Available on request.

Employment History -

- United States Navy; Nuclear Power Qualifications, 1975 - 1981.
- Radiopharmaceutical Production Supervisor - DuPont/NEN, 1981 - 1988.
- Assistant Radiation Safety Officer; Nonionizing Radiation Safety Officer; Campus Special Nuclear Material Accountability Officer - Massachusetts Institute of Technology, 1988 - present.
- Consulting Health Physicist; Ionizing and Nonionizing Radiation, 1988 - present.

Professional Societies -

- Health Physics Society; Plenary Member, National Chapter; Member of the Board of Directors, New England Chapter.
- Member American Academy of Health Physics.
- Member IEEE Standards Coordinating Committee (SCC28) - Non-Ionizing Radiation; Subcommittee SC-2: Terminology and Units of Measurement; SC-3: Safety Levels With Respect to Human Exposure, 0-3 kHz; SC-4 Safety Levels With Respect to Human Exposure, 3 kHz-300 GHz.

Publications -

- **Haes, D.L.**; Are VDTs Safe?. Information Display, pp. 17-27, June 1991.
- **Haes, D.L.**; VDT 'Radiation' Protection Products - Protection or Pacification?. Health Physics Newsletter, Vol XIX, No 12, pp. 19-21.
- **Haes, D.L.**; ELF Magnetic Field Measurements: Units of bedlam. Health Physics, 63(5), p. 591, 1992.
- **Haes, D.L.**, Ducatman, A.; Textbook of Clinical Occupational and Environmental Medicine. Chp 23 Nonionizing Radiation, pp. 646-657. W.B. Saunders Company, 1993.
- **Haes, D.L.**, Fitzgerald, M.F.; VDT VLF Measurements: The Need for Protocols in Assessing VDT User "Dose". Health Physics, 68(4), pp. 572-578, 1995.

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Master of science, majoring in Radiological Science. University of Lowell, Mass., 1987-1989
Bachelor of science, majoring in Physics. East China Teachers University, Shanghai, China, 1963-1968.

work experience

1991-present
Health Physicist. MIT Radiation Protection Office.

1987-1991 Research Assistant. Department of Health Physics, University of lowell, Mass.
Accelerator Operator. Van De Graaff Accelerator, University of Lowell, Mass.

1969-1985 Physics Teacher. Guiyang Coal Mine High School, Guichou, China.

professional skill and knowledge

Radiation Protection--radiation dose calculation and dose measurement;radiation protection techniques; monitoring methods and instruments; contamination control and hazards analysis.

Radiation Dosimetry--Calculations of chronic and acute radiation doses and their effects; alpha, beta, gamma, and neutron dosimetry; use calibration of instruments.

Mathematical Methods and Skills in Health Physics--Special Calculation and numerical techniques used in radiation physics, radiation dosimetry and radiation shielding.

Radioisotope Techniques--Lab experience in tracer techniques including use of GM, proportional and various scintillation systems for counting alpha beta and gamma radiation,

Knowledge of basic general government standard and regulatory requirements.

Computer Skill--Calculating and analyzing data with health physics software and application of BASIC and FORTRAN languages.

reference Available on request.

MIT Radiation Protection Office
Technician Education and Experience

25 October 1995

Full Name: GEOFFREY C. SIRR

Degrees with Institution and Degree Date: B.S. RADIOLOGICAL HEALTH PHYSICS, UNIVERSITY OF MASS. LOWELL,
M.S. STUDENT RADIOLOGICAL

Radiation Safety Experience by Employer with Dates: PORTSMOUTH NAVAL SHIPYARD 8/86 TO 5/89
MIT RPO 11/93 TO PRESEN

Number of Years at MIT RPO: 2

Total Years in Radiation Safety: 5

MIT Radiation Protection Office
Technician Education and Experience

25 October 1995

Full Name: Scott William McLaughlin

Degrees with Institution and Degree Date: B.S. Physics, 12/81, Univ. of Fla. Gainesville, Fla.

Radiation Safety Experience by Employer with Dates:

5/91 - 5/92: Goddard Memorial Hospital, Stoughton, Ma.
5/92 - 6/94: New England Medical Ctr. Hospital, Boston, Ma.
9/94 - Present: MIT RPO

Number of Years at MIT RPO: 1

Total Years in Radiation Safety:

4

MIT Radiation Protection Office
Technician Education and Experience

25 October 1995

Full Name: KEVIN MICHAEL WHITE

Degrees with Institution and Degree Date: Associates in Electrical Engineering, Wentworth Institute

Bachelor's of Science in Engineering Physics, Wentworth Institute

MASTER OF SCIENCE IN RADIOLOGICAL SCIENCE EXPECTED IN JUNE OF 1996 FROM UMASS LOWELL.

Radiation Safety Experience by Employer with Dates:

PORTSMOUTH NAVAL SHIPYARD
11/88 TO 10/89

MIT RADIATION PROTECTION OFFICE
11/89 to PRESENT

Number of Years at MIT RPO: 6 YRS.

Total Years in Radiation Safety: 7 YRS.

MIT Radiation Protection Office
Technician Education and Experience

25 October 1995

Full Name:
ROBERT K. BURGESS

Degrees with Institution and Degree Date: ASSOCIATE IN NUCLEAR ENGINEERING
WENTWORTH INSTITUTE
6/93

Radiation Safety Experience by Employer with Dates: MIT 3/64

Number of Years at MIT RPO: 31

Total Years in Radiation Safety: 31

MIT Radiation Protection Office
Technician Education and Experience

25 October 1995

Full Name: WILLIAM ERNEST PRESCOTT

Degrees with ELECTRONIC Technology
Institution WENTWORTH INSTITUTE of Technology
and Degree Date: 1992

Radiation
Safety Experience 9 yrs. / MIT
by Employer with Dates: (9.15.86)

Number of Years at MIT RPO: 9 years

Total Years in Radiation Safety: 9 years

MIT Radiation Protection Office
Technician Education and Experience

25 October 1995

Full Name: Steven C. Greenlaw

Degrees with
Institution
and Degree Date:

Radiation
Safety Experience
by Employer with Dates: MIT October 1964 to Present

Number of Years
at MIT RPO: 31 MIT October 1964 to Present

Total Years
in Radiation Safety: 31

NRC collected the following bioassay collection, processing, and analysis information from NIH and would appreciate the same type of information from MIT in order to facilitate an equivalent comparison and evaluation of the dose estimates:

A. Description of specimen preparation

1. Volume of alliquots counted

   1 milliliter

2. Description of special procedures such as bleaching, quenching agents, treatment with biological agents, ashing, and other handling procedures.

   None used.

3. If appropriate, description of liquid scintillation cocktail (include manufacturer and brand) and volume used.

   Packard Instruments Opti-Fluor; 10 milliliters per sample

B. Description of counting technique

1. Identify the counting device by make and model.

   Packard Model 2500TR Liquid Scintillation Counter

2. Describe the counting parameters used.

   We used the direct DPM option which allows the analyzer to apply the appropriate efficiency/quench curves dependent on the spectral analysis of the sample. The protocol basically uses an open window approach for activity detection.

3. If spectral data is collected describe the energy windows and identify all axis in spectral plots

   Spectral data was used for whole body counting.

C. Calibration of the counting device

1. Describe how the device was calibrated

The analyzer was factory calibrated for tritium, carbon-14, phosphorus-32 and iodine-125. In addition, the analyzer is calibrated by RPO for tritium and carbon-14. The calibration is performed using a set of 10 quenched standards. The analyzer stores all efficiency/quench curves for use in activity calculations.

2. Describe specific procedures, if any, used to calibrate the device for P-32

The analyzer was calibrated for P-32 by Packard instruments, the manufacturer.

3. Identify radioisotopes used as standards and if they are NIST traceable.

We used Packard Instrument standards of tritium and C-14 for routine calibration and quality control measurements.

4. Describe periodic checks used to assure device is operating correctly and remains in calibration

The Model 2500TR is equipped with a measurement control protocol to assess the operability of the instrument. We use the tritium, carbon-14, and background control standards routinely to check the instrument. Attached are the results of these quality checks. If the instrument is consistently operating within acceptable parameters for these radionuclides, it is inferred that the instrument is also operating correctly for other radionuclides such as p-32 and iodine-125.

D. Raw Data

1. Date, time, and measure of volume or weight as appropriate of all urine or fecal bioassay specimens collected.

See attached table of date, time and volume measurements.

2. Date, time and counts for all specimens (preferred format is copy of actual counting output sheet from liquid scintillation counter with date, time, specimen identification provided on the sheet).

See attached copy of actual liquid scintillation counter results.

E. Data Processing

1. Describe adjustments made to the raw data (conversions from counts per minute to disintegrations per minute, decay correction, volume corrections, pooling of specimen results to single data point or calculations to split data, etc.)

   The adjustments to raw data are as follows in the attached table:

Column 1:	Sample date is day collection ended. All samples are 24 hour urines form noon to non.
Column 2:	LSC Result: All samples prepared in duplicate. Results are average of both samples.
Column 3:	Date counted is the date the sample was analyzed.
Column 4:	Time counted is he time of day sample was analyzed.
Column 5:	Time correction is the amount of time elapsed form time of analysis to noon end of sample collection.
Column 6:	LSC correction is the radiological decay correction for the time period between end of collection (noon) and the time of analysis. The analysis time (2 or more minutes) was not accounted for in the correction.
Column 7:	LSC background correction is a subtraction of the background activity for each sample. Background was measured as 30 dpm per sample.
Column 8:	Volume of urine submitted for each 24 hour sample.
Column 9:	Activity in microcuries by converting the dpm/ml rate in column 7 to microcuries/ml and multiplying by the volume of sample submitted.

2. Describe or identify programs used to plot and analyze the data

   Attached please find copies of the various estimates obtained from the INDOS computer code (NUREG 4884), an ICRP 30 proceedings paper, and consultant's report.

3. Describe and provide weighing schemes used fit the data, if appropriate

4. Describe methods used to convert estimated microcuries of ingested P-32 to dose for the researcher

   Value of ALI listed in 10 CFR Part 20 for ^{32}P (600 uCi = 5000 mrem).

Date	LSC Result (dpm/ml)	Date Counted	Time Counted	Time Correct (hours)	LSC Correct (dpm/ml)	LSC Bkg Correct (dpm/ml)	Volume (ml)	Activity (uCi)
8/26/95	1126	8/28/95	15:12	51.0	1248	1218	2670	1.456
8/27/95	949	8/28/95	15:12	27.0	979	949	3780	1.616
8/28/95	1339	8/28/95	15:12	3.0	1347	1317	3420	2.029
8/29/95	1623	8/29/95	13:02	1.0	1626	1596	2880	2.070
8/30/95	1274	8/30/95	15:41	3.75	1283	1253	2760	1.558
8/31/95	1514	8/31/95	13:30	1.5	1518	1488	2180	1.461
9/01/95	1488	9/01/95	16:06	4.0	1500	1470	2270	1.503
9/02/95	883	9/05/95	16:21	76.34	1030	1000	2940	1.324
9/03/95	561	9/05/91	16:21	52.34	623	593	3680	0.983
9/04/95	822	9/05/95	16:21	28.34	870	840	3250	1.230
9/05/95	892	9/05/95	16:21	4.34	900	870	2500	0.980
9/06/95	756	9/06/95	15:04	3.0	760	730	2720	0.894
9/07/95	800	9/08/95	8:22	20.34	833	803	2205	0.798
9/08/95	583	9/08/95	20:31	8.5	593	563	2750	0.697
9/09/95	447	9/13/95	7:40	91.75	538	508	2610	0.597
9/10/95	640	9/13/95	7:40	67.75	733	704	2490	0.790
9/11/95	593	9/13/95	7:40	43.75	647	618	2540	0.707
9/12/95	600	9/13/95	7:40	19.75	624	594	2520	0.674
9/13/95	450	9/14/95	7:34	19.5	468	438	2870	0.566
9/14/95	566	9/14/95	14:24	2.5	569	539	2150	0.522

9/15/95	276	9/19/95	7:27	91.5	332	302	3140	0.427
9/16/95	333	9/19/95	7:27	67.5	382	352	2420	0.385
9/17/95	244	9/19/95	7.27	43.5	266	236	3240	0.344
9/18/95	332	9/19/95	7:27	19.5	345	315	2220	0.315
9/19/95	287	9/20/95	8:23	20.5	299	269	2750	0.333
9/20/95	356	9/21/95	7:27	19.5	370	340	2500	0.383
9/21/95	286	9/22/95	7:59	20.0	298	268	2960	0.357
9/22/95	340	9/22/95	15:31	3.5	342	312	2120	0.298
9/23/95	226	9/26/96	9:04	69.0	260	230	2860	0.296
9/24/95	182	9/26/95	9:04	45.0	199	169	3250	0.247
9/25/95	197	9/26/95	9:04	21.0	205	175	3080	0.243
9/26/95	202	9/26/95	14:22	2.33	203	173	2660	0.07
9/27/95	202	9/28/95	16:15	28.25	214	184	2250	0.186
9/28/95	175	9/28/95	16:15	4.25	176	146	3230	0.212
9/29/95	180	10/2/95	15:39	75.75	209	180	2510	0.203
9/30/95	170	10/2/95	15:39	51.75	189	159	2800	0.200
10/1/95	177	10/2/95	15:39	27.75	187	157	2250	0.159
10/2/95	148	10/2/95	15:39	3.75	149	119	2800	0.150
10/3/95	156	10/3/95	15:35	3.5	157	127	2510	0.144
10/4/95	185	10/5/95	8:45	20.75	193	163	1750	0.128

Protocol #:30 DIRECT DPM User :

Time: 10.00

Mode: Direct DPM Nuclides:DIRECT-DPM

Background Subtract: None

	LL	UL	LCR	2S%	BKG
Region A:	0.0 -	2000	0	0.0	0.00
Region B:	0.0 -	0.0	0	0.0	0.00
Region C:	0.0 -	0.0	0	0.0	0.00

BREATH TEST

S#	TIME	CPMA	DPM1	tSIE	FLAG	EXCPTN
1	10.00	28.40	31.85	462.22		
2	10.00	29.70	34.80	467.34		

> BKGD.

^{32}P counting efficiency ≈ 99 %

P[illegible]ol #:30 DIRECT DPM User :

[illegible]e: 2.00
[illegible] Mode: Direct DPM Nuclides:DIRECT-DPM
Background Subtract: None

	LL	UL	LCR	2S%	BKG
Region A:	0.0 - 2000		0	0.0	0.00
Region B:	0.0 - 0.0		0	0.0	0.00
Region C:	0.0 - 0.0		0	0.0	0.00

BREATH TEST

S#	TIME	CPMA	DPM1	[illegible]			Vol
1	2.00	13576.5	[illegible]	[illegible]	> 8/19/95	10:00 PM	600
[illegible]	2.00	14166.5	[illegible]	[illegible]			
[illegible]	2.00	4140.50	[illegible]	[illegible]	> 8/20/95	0:45 AM	600
4	2.00	[illegible]	[illegible]	[illegible]			
[illegible]	2.00	145[illegible]	[illegible]	[illegible]	> 8/20/95	2:00 AM	600
[illegible]	2.00	[illegible]	[illegible]	[illegible]			
7	2.00	695.50	700.09	255.7[illegible]	> 8/20/95	8:20 AM	600
8	2.00	579.50	583.40	322.09			
9	2.00	914.00	920.06	[illegible]	> 8/20/95	5:10 AM	600
[illegible]	2.00	864.50	[illegible]	[illegible]			
11	2.00	3651.00	[illegible]	[illegible]	> 8/20/95	8:30 AM	600
12	2.00	3733.00	[illegible]	334.50			
13	2.00	40.00	47.36	308.76	> 8/20/95	2:55 AM	600
14	2.00	56.50	[illegible]	[illegible]			
15	2.00	1834.00	1841.87	344.22	> 8/20/95	4:22 AM	90
16	2.00	1910.00	1915.81	339.23			
17	2.00	3214.50	3231.01	[illegible]	> 8/20/95	9:00 PM	570
18	2.00	3313.00	3334.22	338.50			
19	2.00	3711.50	3739.98	348.[illegible]	> 8/21/95	6:30 AM	590
20	2.00	3892.00	3917.23	344.8[illegible]			
21	2.00	1227.00	1231.20	[illegible]	> 8/21/95	10:00 AM	440
22	2.00	1225.50	1236.36	[illegible]			
23	2.00	6186.5	6228.80	385.4[illegible]	>		5 ml
24	2.00	6284.50	[illegible]	[illegible]			

8/20/95 Total excretion 1290 ml

8/21/95

Time: 2.00
Data Mode: Direct DPM Nuclides:DIRECT-DPM
Background Subtract: None

	LL	UL	LCR	2S%	BKG
Region A:	0.0 - 2000		0	0.0	0.00
Region B:	0.0 - 0.0		0	0.0	0.00
Region C:	0.0 - 0.0		0	0.0	0.00

AREA H TEST

#	TIME	CPMA	DPM1	[illegible]
1	2.00	3496.00	3521.18	328.9[illegible]
2	2.00	3519.50	3533.19	[illegible]
3	2.00	1319.50	1330.27	[illegible]
4	2.00	1394.00	1403.27	[illegible]
5	2.00	1983.50	1994.45	344.57
6	2.00	2006.50	2017.56	341.80
7	2.00	524.50	528.02	[illegible]
8	2.00	1048.50	1053.12	[illegible]

8/21
1200
> 8-22-95 6:20 Am
> 8-22-95 1:45 pm
600 ml
> 8-22-95 4:00 pm – 8-23-95 noon
(7,77. ml)
1.94 uCi
> 8-23-95 noon – 8/23/95 3 pm (180 ml)

Time: 2.00
Data Mode: Direct DPM Nuclides:DIRECT-DPM
Background Subtract: None

	LL	UL	LCR	2S%	BKG
Region A:	0.0 - 2000	0	0.0	0.00
Region B:	0.0 - 0.0	0	0.0	0.00
Region C:	0.0 - 0.0	0	0.0	0.00

BREATH TEST

		TIME	CPMA	DPM1	[illegible]		
1ml	1	2.00	492.50	493.98	368.4[illegible]	8/23	12:00 - 3pm
	2	2.[illegible]	525.[illegible]	527.8[illegible]	[illegible]		
1ml	3	2.00	1155.50	1171.45	[illegible]	8/23	4:00pm → 8/24 12:00
	4	2.00	[illegible]	12[illegible]	[illegible]		

25 Aug 95 16:11 Page #1
Protocol #:30 DIRECT DPM User :

Time: 2.00
Data Mode: Direct DPM Nuclides:DIRECT-DPM
Background Subtract: None

	LL	UL	LCR	2S%	BKG
Region A:	0.0 - 2000	0	0.0	0.00
Region B:	0.0 - 0.0	0	0.0	0.00
Region C:	0.0 - 0.0	0	0.0	0.00

BREATH TEST

8/24 @ 1:40pm -
8/25 @ 10:45PM
3000ml SAMPLE

[illegible]	[illegible]	CPM	DPM	[illegible]
1	2.00	[illegible]	1944.45	[illegible]
[illegible]	2.00	[illegible]	1889.84	[illegible]

28 Aug 95 15:12 _Page #1
Protocol #:30 DIRECT DPM User :

Time: 2.00
Data Mode: Direct DPM Nuclides: DIRECT-DPM
Background Subtract: None

	LL	UL	LCR	[illegible]	[illegible]
Region A:	0.0 - 2000	0	0.0	0.00	
Region B:	0.0 - 0.0	0	0.0	0.00	
Region C:	0.0 - 0.0	0	0.0	0.00	

[illegible] TEST

#	TIME	CPMA	DPM1	[illegible]	FLAG	[illegible]
[illegible]	2.00	[illegible]	[illegible]	[illegible]		
[illegible]	2.00	[illegible]	[illegible]	[illegible]		
[illegible]	2.00	476.50	[illegible]	[illegible]		
[illegible]	2.00	746.00	[illegible]	[illegible]		
[illegible]	2.00	1288.00	[illegible]	[illegible]		
[illegible]	2.00	1292.00	1502.74	306.50		

> 8/25 – 8/26 3
> 8/26 – 8/27 2
> 8/27 – 8/28 1

29 Aug 95 13:02 — Page #1

Protocol #:30 — DIRECT DPM — User :

Time: 2.00

Data Mode: Direct DPM — Nuclides:DIRECT-DPM

Background Subtract: None

	LL	UL	LCR	2S%	BKG
Region A:	0.0 - 2000	0	0.0	0.00	
Region B:	0.0 - 0.0	0	0.0	0.00	
Region C:	0.0 - 0.0	0	0.0	0.00	

BREATH TEST

	TIME	CPMA	DPM1	[illegible]	
380mls	2.00	1370.50	1581.28	532.74	>8/28/95 – 8/29
	2.00	1451.00	1665.57	530.78	

Time: 2.00
[illegible] Mode: Direct DPM Nuclides:DIRECT-DPM
[illegible]ckground Subtract: None

	LL	UL	LCR	[illegible]	BKG
Region A:	0.0 - 2000		0	0.0	0.00
Region B:	0.0 - 0.0		0	0.0	0.00
Region C:	[illegible]0.0 - 0.0		0	0.0	0.00

[illegible] TEST

[illegible]	TIME	CPM	DPM	[illegible]	[illegible]
[illegible]	2.00	[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	

760 mls

> 8/29 - 8/30

8/29 -
8/30
12:00

31 Aug 95 13:30

Protocol #:30

DIRECT DPM

Page #1

User :

Time: 2.00

Data Mode: Direct DPM   Nuclides:DIRECT-DPM

Background Subtract: None

	LL	UL	LCR	2S%	BKG
Region A:	0.0 - 2000		0	0.0	0.00
Region B:	0.0 - 0.0		0	0.0	0.00
Region C:	0.0 - 0.0		0	0.0	0.0

BREATH TEST

S#	TIME	CPMA	DPM1	[illegible]	[illegible]
1	2.00	[illegible].00	1160.32	328.05	
2	2.00	1052.00	[illegible]	302.43	

2180 ml

8/30 - 8/31

12:00

Time: 2.00
Data Mode: Direct DPM Nuclides:DIRECT-DPM
Background Subtract: None

	LL	UL	LCR	2S%	BKG
Region A:	0.0 - 2000		0	0.0	0.00
Region B:	0.0 - 0.0		0	0.0	0.00
Region C:	0.0 - 0.0		0	0.0	0.00

BREATH TEST

S#	TIME	DPMA	DPM1	tSIE	FLAG	EXCPTN
1	2.00	1416.50	1427.96	345.25		
2	2.00	1547.00	1549.31	341.72		

} 1488

2270 ml 8/31- 9/1/95
12:00 - 12:00

05 Sep 95 16:21
Protocol #:30

DIRECT DPM

User :

Time: 2.00
Data Mode: Direct DPM   Nuclides:DIRECT-DPM
Background Subtract: None

	LL	UL	LCR	2S%	BKG
Region A:	0.0 - 2000	0	0.0	0.00	
Region B:	0.0 - 0.0	0	0.0	0.00	
Region C:	0.0 - 0.0	0	0.0	0.00	

BREATH TEST

S#	TIME	DPMA	DPM1	[illegible]	
940 ml <	2.00	934.50	934.13	[illegible]	> 9/1 - 9/2
	2.00	519.50	[illegible]	[illegible]	
680 ml <	2.00	841.50	[illegible]	[illegible]	> 9/2 - 9/3
	2.00	561.00	571.77	[illegible]	
250 <	2.00	[illegible]	[illegible]	[illegible]	> 9/3 - 9/4
	[illegible]	[illegible]	582.25	[illegible]	
500 ml <	2.00	[illegible]	[illegible]	[illegible]	> 9/4 - 9/5
	2.00	302.00	292.05	[illegible]	

9/5
16:20

06 Sep 95 15:04
Protocol #:30

DIRECT DPM

Page #1
User :

[illegible]: 2.00

[illegible] Mode: Direct DPM   Nuclides:DIRECT-DPM

[illegible]ground Subtract: None

	LL	UL	LCR	2S%	BKG
Region A:	[illegible].0 - 2000		0	0.0	[illegible].00
Region B:	0.0 - 0.0		0	0.0	0.00
Region C:	0.0 - 0.0		0	0.0	0.00

[illegible] TEST

	S#	TIME	CPMA	DPM1	[illegible]
720	1	[illegible].00	771.00	770.24	352.83
ml	2	[illegible].00	722.06	723.90	327.87

> 9/5 - 9/6

08 Sep 95 08:22 Page #1
Protocol #:30 DIRECT DPM User :

Time: 2.00
Data Mode: Direct DPM Nuclides:DIRECT-DPM
Background Subtract: None

	LL	UL	LCR	2S%	BKG
Region A:	0.0 -	2000	0	0.0	0.00
Region B:	0.0 -	0.0	0	0.0	0.00
Region C:	0.0 -	0.0	0	0.0	0.00

BREATH TEST

	S#	TIME	CPMA	DPM1	COUNT FLAG	EXCPTN
2205 ml	[illegible]	2.00	771.00	[illegible]	781.09	> 9/6 -- 9/7
	[illegible]	2.00	[illegible]	[illegible]	345.40	

Protocol #:30 DIRECT DPM User :

Time: 2.00

'ta Mode: Direct DPM Nuclides:DIRECT-DPM

9/7- 9/8

ackground Subtract: None

	LL	UL	LCR	2S%	BKG
Region A:	0.0 -	2000	0	0.0	0.00
Region B:	0.0 -	0.0	0	0.0	0.00
Region C:	0.0 -	0.0	0	0.0	0.00

BREATH TEST

S#	TIME	CPMA	DPM1	tSIE	FLAG	EXCPTN
1	2.00	573.50	575.08	359.83		
2	2.00	584.00	591.98	359.28		

2750ml

13 Sep 95 07:40

Protocol #:30 DIRECT DPM

User :

Time: 2.00
ta Mode: Direct DPM Nuclides:DIRECT-DPM
background Subtract: None

	LL	UL	LCR	2S%	BKG
Region A:	0.0 -	2000	0	0.0	0.00
Region B:	0.0 -	0.0	0	0.0	0.00
Region C:	0.0 -	0.0	0	0.0	0.00

BREATH TEST

	S#	TIME	CPMA	DPM1	tSIE	FLAG	EXCPTN	
	1	2.00	438.50	443.88	354.98	> 9/8 - 9/9		t=4.5
2610	2	2.00	448.50	451.89	355.92			
	3	2.00	631.50	636.07	354.21	> 9/9 - 9/10		t=3.5
2490	4	2.00	632.00	643.85	351.90			
	5	2.00	574.00	584.30	354.30	> 9/10 - 9/11		t=2.5
2540	6	2.00	598.00	602.82	351.93			
	7	2.00	582.50	586.71	361.64	> 9/11 - 9/12		t=1.5
2520	8	2.00	610.00	614.88	356.75			

14 Sep 95 07:34

Protocol #:30 DIRECT DPM Page #1

User :

Time: 2.00

Data Mode: Direct DPM Nuclides:DIRECT-DPM

Background Subtract: None

	LL	UL	LCR	2S%	BKG
Region A:	0.0 -	2000	0	0.0	0.00
Region B:	0.0 -	0.0	0	0.0	0.00
Region C:	0.0 -	0.0	0	0.0	0.00

BREATH TEST

S#	TIME	CPMA	DPM1	tSIE	FLAG	EXCPTN
1	2.00	438.50	444.78	361.22		
2	2.00	452.00	456.64	364.88		

9/12 - 9/13 t=1.5

2870 ml

14 Sep 95 14:24 Page #1

Protocol #:30 DIRECT DPM User :

Time: 2.00

Data Mode: Direct DPM Nuclides:DIRECT-DPM

Background Subtract: None

	LL	UL	LCR	2S%	BKG
Region A:	0.0 -	2000	0	0.0	0.00
Region B:	0.0 -	0.0	0	0.0	0.00
Region C:	0.0 -	0.0	0	0.0	0.00

BREATH TEST

S#	TIME	CPMA	DPM1	tSIE	FLAG	EXCPTN
1	2.00	562.00	565.74	345.89	> 9/13 - 9/14	
2180 ml 2	2.00	559.00	566.90	349.17		

19 Sep 95 07:27

Protocol #:30 DIRECT DPM Page #1

User :

Time: 2.00

Data Mode: Direct DPM Nuclides:DIRECT-DPM

Background Subtract: None

	LL	UL	LCR	2S%	BKG
Region A:	0.0 -	2000	0	0.0	0.00
Region B:	0.0 -	0.0	0	0.0	0.00
Region C:	0.0 -	0.0	0	0.0	0.00

BREATH TEST

	S#	TIME	CPMA	DPM1	tSIE	FLAG	EXCPTN	
3140	1	2.00	256.50	263.04	356.83	> 9/14 - 9/15		[illegible]
	2	2.00	283.00	289.86	375.06			
2420	3	2.00	339.50	343.34	356.38	> 9/15 - 9/16		[illegible]
	4	2.00	319.00	323.38	358.02			
3240	5	2.00	243.50	246.98	374.70	> 9/16 - 9/17		[illegible]
	6	2.00	233.00	242.07	372.24			
2220	7	2.00	336.00	346.74	356.61	> 9/17 - 9/18		[illegible]
	8	2.00	312.00	317.31	355.12			

2 MISSING TUBE(S)

	S#	TIME	CPMA	DPM1	tSIE	FLAG	EXCPTN
	11	2.00	328.50	336.13	354.86	> 9/8 - 9/9	
	12	2.00	310.50	318.42	353.60		

20 Sep 95 08:23

Page #1

Protocol #:30 DIRECT DPM User :

,e: 2.00

Data Mode: Direct DPM Nuclides:DIRECT-DPM

Background Subtract: None

	LL		UL	LCR	2S%	BKG
Region A:	0.0	-	2000	0	0.0	0.00
Region B:	0.0	-	0.0	0	0.0	0.00
Region C:	0.0	-	0.0	0	0.0	0.00

BREATH TEST

S#	TIME	CPMA	DPM1	tSIE	FLAG	EXCPTN
1	2.00	284.50	290.83	375.37		
2	2.00	271.50	285.61	372.33		

> 9/15 - 9/19

ıe: 2.00
Data Mode: Direct DPM Nuclides:DIRECT-DPM
Background Subtract: None

	LL	UL	LCR	2S%	BKG
Region A:	0.0 -	2000	0	0.0	0.00
Region B:	0.0 -	0.0	0	0.0	0.00
Region C:	0.0 -	0.0	0	0.0	0.00

BREATH TEST

	S#	TIME	CPMA	DPM1	tSIE	FLAG	EXCPTN
2500	1	2.00	372.50	384.34	362.06	> 9/19 – 9/20	
ml	2	2.00	324.50	329.87	362.10		

ie: 2.00

Data Mode: Direct DPM Nuclides:DIRECT-DPM

Background Subtract: None

	LL	UL	LCR	2S%	BKG
Region A:	0.0 -	2000	0	0.0	0.00
Region B:	0.0 -	0.0	0	0.0	0.00
Region C:	0.0 -	0.0	0	0.0	0.00

BREATH TEST

	S#	TIME	CPMA	DPM1	tSIE	FLAG	EXCPTN
960	1	2.00	282.50	292.46	355.94	9/20 - 9/21	
ml	2	2.00	273.50	280.29	354.58		

Protocol #:30 DIRECT DPM User :

e: 2.00
Data Mode: Direct DPM Nuclides:DIRECT-DPM
Background Subtract: None

	LL	UL	LCR	2S%	BKG
Region A:	0.0 -	2000	0	0.0	0.00
Region B:	0.0 -	0.0	0	0.0	0.00
Region C:	0.0 -	0.0	0	0.0	0.00

BREATH TEST

S#	TIME	CPMA	DPM1	tSIE	FLAG	EXCPTN
1	2.00	336.50	338.73	340.65		
2	2.00	337.50	341.19	340.24		

2120ml 9/21-9/22

26 Sep 95 09:04

Protocol #:30 DIRECT DPM Page #1

User :

Time: 2.00

a Mode: Direct DPM Nuclides:DIRECT-DPM

..ckground Subtract: None

	LL	UL	LCR	2S%	BKG
Region A:	0.0 -	2000	0	0.0	0.00
Region B:	0.0 -	0.0	0	0.0	0.00
Region C:	0.0 -	0.0	0	0.0	0.00

BREATH TEST

S#	TIME	CPMA	DPM1	tSIE	FLAG	EXCPTN		
1	2.00	228.50	235.57	354.72	> 2880 ml		9/22 - 9/23	12:00 - 12:00
2	2.00	214.50	217.50	350.97				
3	2.00	172.50	175.50	356.98	> 3250 ml		9/23 - 9/24	" "
4	2.00	184.00	188.79	353.51				
5	2.00	187.50	189.39	356.90	> 3080 ml		9/24 - 9/25	" "
6	2.00	198.50	204.38	355.51				

Protocol #:30 DIRECT DPM User :

Time: 2.00

Mode: Direct DPM Nuclides:DIRECT-DPM

Background Subtract: None

	LL	UL	LCR	2S%	BKG
Region A:	0.0 -	2000	0	0.0	0.00
Region B:	0.0 -	0.0	0	0.0	0.00
Region C:	0.0 -	0.0	0	0.0	0.00

BREATH TEST

S#	TIME	CPMA	DPM1	tSIE	FLAG	EXCPTN
1	2.00	205.50	211.58	351.56		
2	2.00	183.50	193.01	345.58		

>2660ml 9/25 - 9/26 12:00 - 12:00

Protocol #:30 DIRECT DPM User :

Time: 2.00

Mode: Direct DPM Nuclides:DIRECT-DPM

Background Subtract: None

	LL	UL	LCR	2S%	BKG
Region A:	0.0 -	2000	0	0.0	0.00
Region B:	0.0 -	0.0	0	0.0	0.00
Region C:	0.0 -	0.0	0	0.0	0.00

BREATH TEST

S#	TIME	CPMA	DPM1	tSIE	FLAG	EXCPTN	
1	2.00	195.00	201.22	345.91	> 9/26 - 9/27		2250 ml
2	2.00	197.00	203.10	346.51			
3	2.00	176.00	181.30	360.65	> 9/27 - 9/28		3230 ml
4	2.00	163.00	169.93	364.37			

02 Oct 95 15:39

Protocol #:30 DIRECT DPM Page #1

User :

Time: 2.00

Mode: Direct DPM Nuclides:DIRECT-DPM

Background Subtract: None

	LL	UL	LCR	2S%	BKG
Region A:	0.0 -	2000	0	0.0	0.00
Region B:	0.0 -	0.0	0	0.0	0.00
Region C:	0.0 -	0.0	0	0.0	0.00

BREATH TEST

S#	TIME	CPMA	DPM1	tSIE	FLAG	EXCPTN	
1	2.00	178.50	186.86	347.28	> 9/28 - 9/29		2510 ml
2	2.00	173.50	175.90	348.29			
3	2.00	163.50	167.70	348.76	> 9/29 - 9/30		2800 ml
4	2.00	173.50	173.75	354.84			
5	2.00	175.00	181.92	345.87	> 9/30 - 10/1		2250 ml
6	2.00	172.00	174.21	343.66			
7	2.00	150.50	156.59	356.30	> 10/1 - 10/2		2800 ml
8	2.00	133.50	140.03	356.80			

Protocol #:30

DIRECT DPM

User :

Time: 2.00

Data Mode: Direct DPM Nuclides:DIRECT-DPM

Background Subtract: None

	LL	UL	LCR	2S%	BKG
Region A:	0.0 -	2000	0	0.0	0.00
Region B:	0.0 -	0.0	0	0.0	0.00
Region C:	0.0 -	0.0	0	0.0	0.00

BREATH TEST

S#	TIME	CPMA	DPM1	tSIE	FLAG	EXCPTN
1	2.00	144.00	151.29	351.76		
2	2.00	158.00	162.99	347.92		

> 10/2 -10/3 2510 ml

Protocol #:30 DIRECT DPM User :

Time: 2.00

[illegible] Mode: Direct DPM Nuclides:DIRECT-DPM

[illegible]ground Subtract: None

	LL	UL	LCR	2S%	BKG
Region A:	0.0 -	2000	0	0.0	0.00
Region B:	0.0 -	0.0	0	0.0	0.00
Region C:	0.0 -	0.0	0	0.0	0.00

BREATH TEST

S#	TIME	CPMA	DPM1	tSIE	FLAG	EXCPTN
1	2.00	169.00	173.63	330.99		
2	2.00	191.00	197.22	321.76		

1750 ml
10/3 - 10/4

Protocol #:30 DIRECT DPM User :

Time: 2.00

Data Mode: Direct DPM Nuclides:DIRECT-DPM

Background Subtract: None

	LL	UL	LCR	2S%	BKG
Region A:	0.0 -	2000	0	0.0	0.00
Region B:	0.0 -	0.0	0	0.0	0.00
Region C:	0.0 -	0.0	0	0.0	0.00

BREATH TEST

S#	TIME	CPMA	DPM1	tSIE	FLAG EXCPTN	
1	2.00	102.50	106.59	344.86	> 10/4 - 10/5	2320 ml
2	2.00	118.50	127.44	344.74		
3	2.00	100.00	106.98	354.[illegible]	10/5 - 10/6	3130 ml
4	2.00	91.00	96.67	354.[illegible]		
5	2.00	101.50	108.07	344.36	> 10/6 - 10/7	2250 ml
6	2.00	89.00	91.41	341.12		
7	2.00	100.00	104.94	347.39	> 10/7 - 10/8	2280 ml
8	2.00	95.50	96.36	347.16		
9	2.00	105.00	109.29	348.01	> 10/8 - 10/9	2290 ml
10	2.00	114.00	121.82	347.12		
11	2.00	96.50	102.94	342.32	> 10/9 - 10/10	2450 ml
12	2.00	98.00	99.95	344.52		
13	2.00	103.50	107.09	348.99	> 10/10 - 10/11	2350 ml
14	2.00	113.00	116.80	346.13		
15	2.00	108.00	112.52	344.69	> 10/11 - 10/12	2050 ml
16	2.00	122.50	128.48	341.55		

Protocol #: 8 P-32 DPM User :

Time: 2.00

Mode: DPM Nuclide: 32P Quench Set: 32P

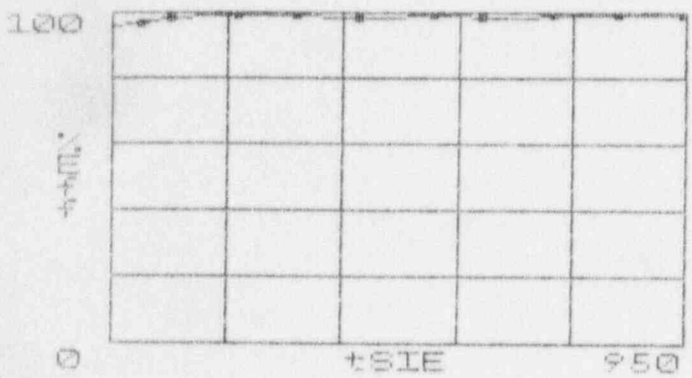
Background Subtract: IPA

	LL	UL	LCR	2S%	BKG
Region A:	5.0 -	1700	0	0.0	23.60
Region B:	50.0 -	1700	0	0.0	11.83
Region C:	0.0 -	0.0	0	0.0	0.00

Quench Indicator: tSIE/AEC

Ext Std Terminator: Count

Color Quench Correction On



tSIE	%Eff
943.52	99.39
836.67	98.91
726.67	98.79
609.66	98.69
526.90	98.94
403.14	98.52
300.63	99.02
203.67	99.18
98.98	98.37
48.71	97.04

S#	TIME	CPMA	DPM1	SIS	tSIE	FLAG		
1	2.00	128.90	130.55	785.66	347.69		9/28 - 9/29	2510 ml
2	2.00	154.40	156.38	756.14	347.82			
3	2.00	130.90	132.60	797.78	351.16		9/29 - 9/30	2800 ml
4	2.00	132.90	134.65	814.01	354.79			
5	2.00	141.40	143.20	758.43	345.94		9/30 - 10/1	2250 ml
6	2.00	133.40	135.09	749.82	345.33			
7	2.00	97.90	99.19	795.48	354.30		10/1 - 10/2	2800 ml
8	2.00	97.90	99.20	656.96	356.41			

Protocol #: 8 P-32 DPM User :

Time: 2.00

[illegible] Mode: DPM Nuclide: 32P Quench Set: 32P

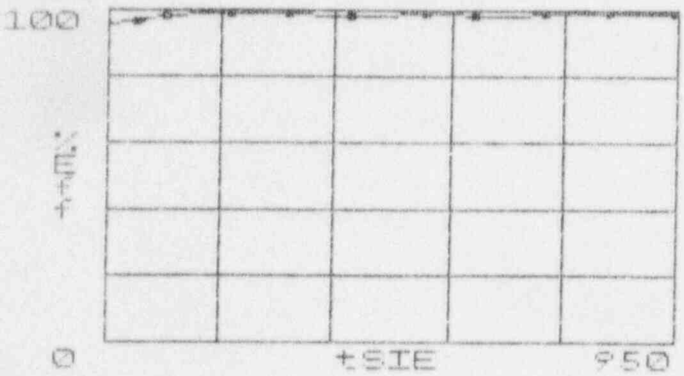
[illegible]ground Subtract: IPA

	LL	UL	LCR	2S%	BKG
Region A:	5.0 -	1700	0	0.0	23.65
Region B:	50.0 -	1700	0	0.0	11.95
Region C:	0.0 -	0.0	0	0.0	0.00

Quench Indicator: tSIE/AEC

Ext Std Terminator: Count

Color Quench Correction On



tSIE	%Eff
943.52	99.39
836.67	98.91
726.67	98.79
609.66	98.69
526.90	98.94
403.14	98.52
300.63	99.02
203.67	99.18
98.98	98.37
48.71	97.04

S#	TIME	CPMA	DPM1	SIS	tSIE	FLAG
1	2.00	136.35	137.96	728.38	329.31	
2	2.00	159.35	161.16	786.62	322.17	

> 10/3 - 10/4 1750 ml

Protocol #: 8 P-32 DPM User :

Time: 2.00

... Mode: DPM Nuclide: 32P Quench Set: 32P

...ground Subtract: IPA

	LL	UL	LCR	2S%	BKG
Region A:	5.0 -	1700	0	0.0	23.60
Region B:	50.0 -	1700	0	0.0	11.83
Region C:	0.0 -	0.0	0	0.0	0.00

Quench Indicator: tSIE/AEC

Ext Std Terminator: Count

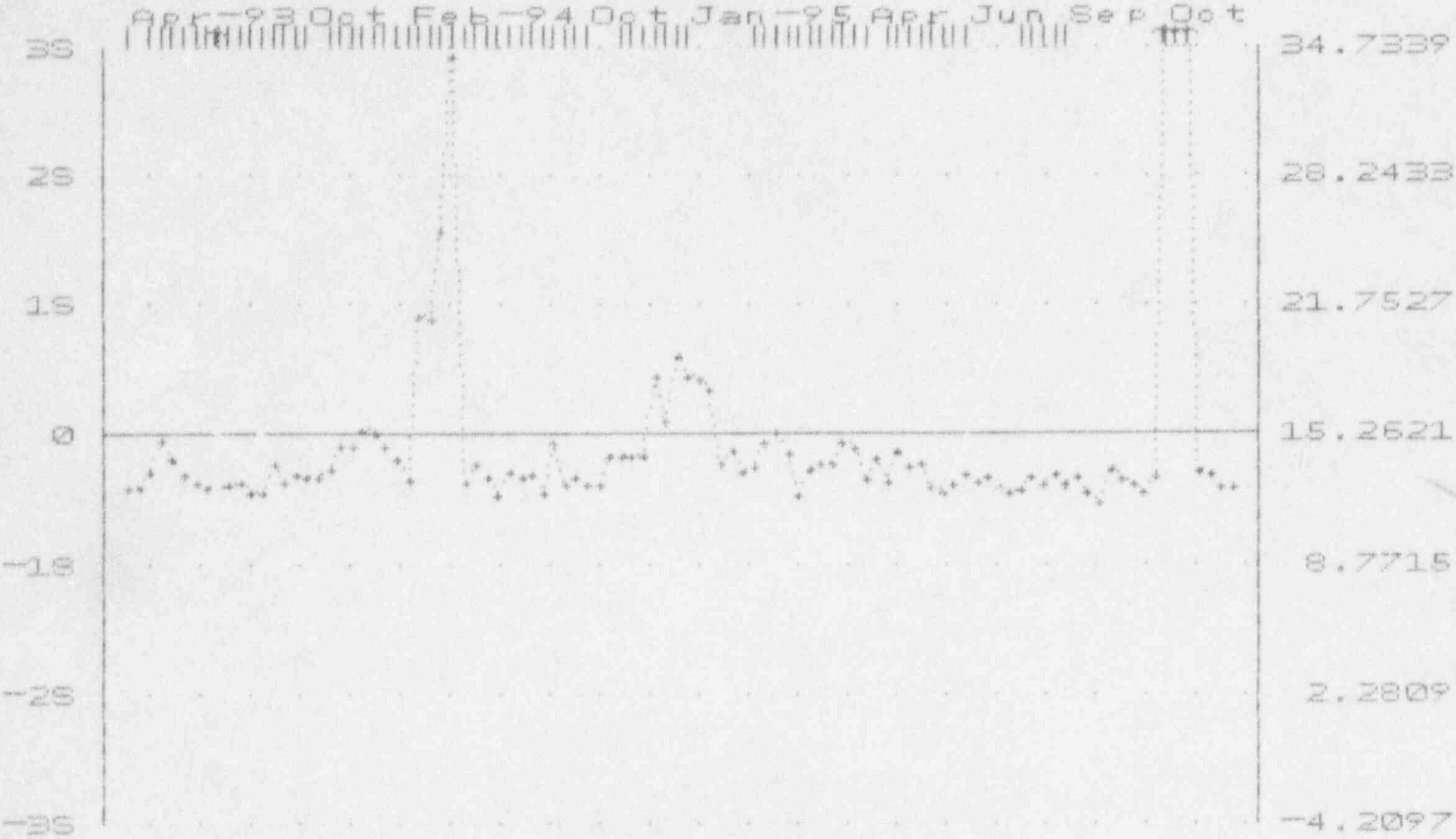
Color Quench Correction On

tSIE	%Eff
943.52	99.39
836.67	98.91
726.67	98.79
609.66	98.69
526.90	98.94
403.14	98.52
300.63	99.02
203.67	99.18
98.98	98.37
48.71	97.04

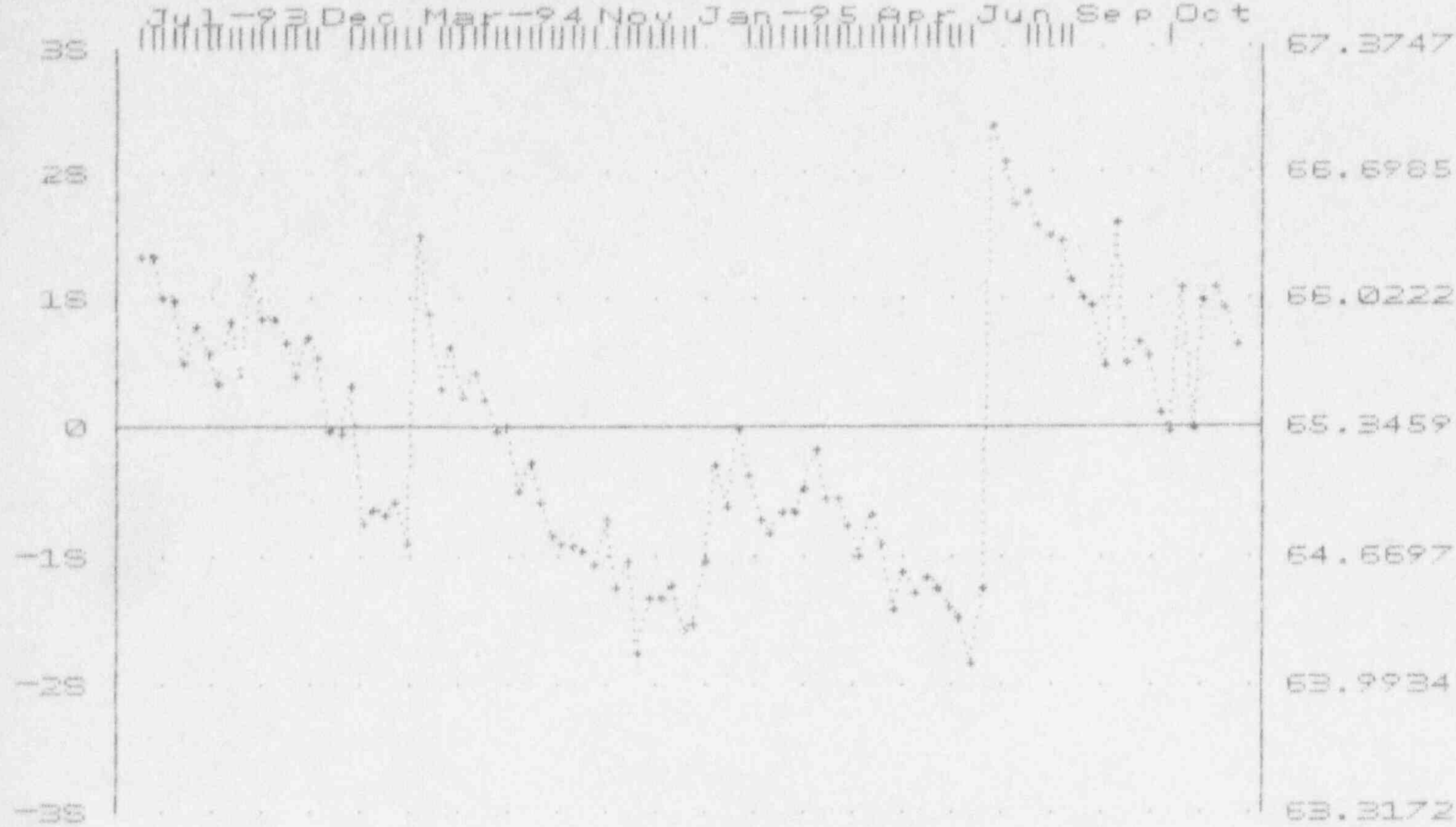
S#	TIME	CPMA	DPM1	SIS	tSIE	FLAG
1	2.00	163.40	165.52	572.30	350.98	
2	2.00	155.90	157.92	562.10	350.93	

> 10/4 - 10/5 2320 ml

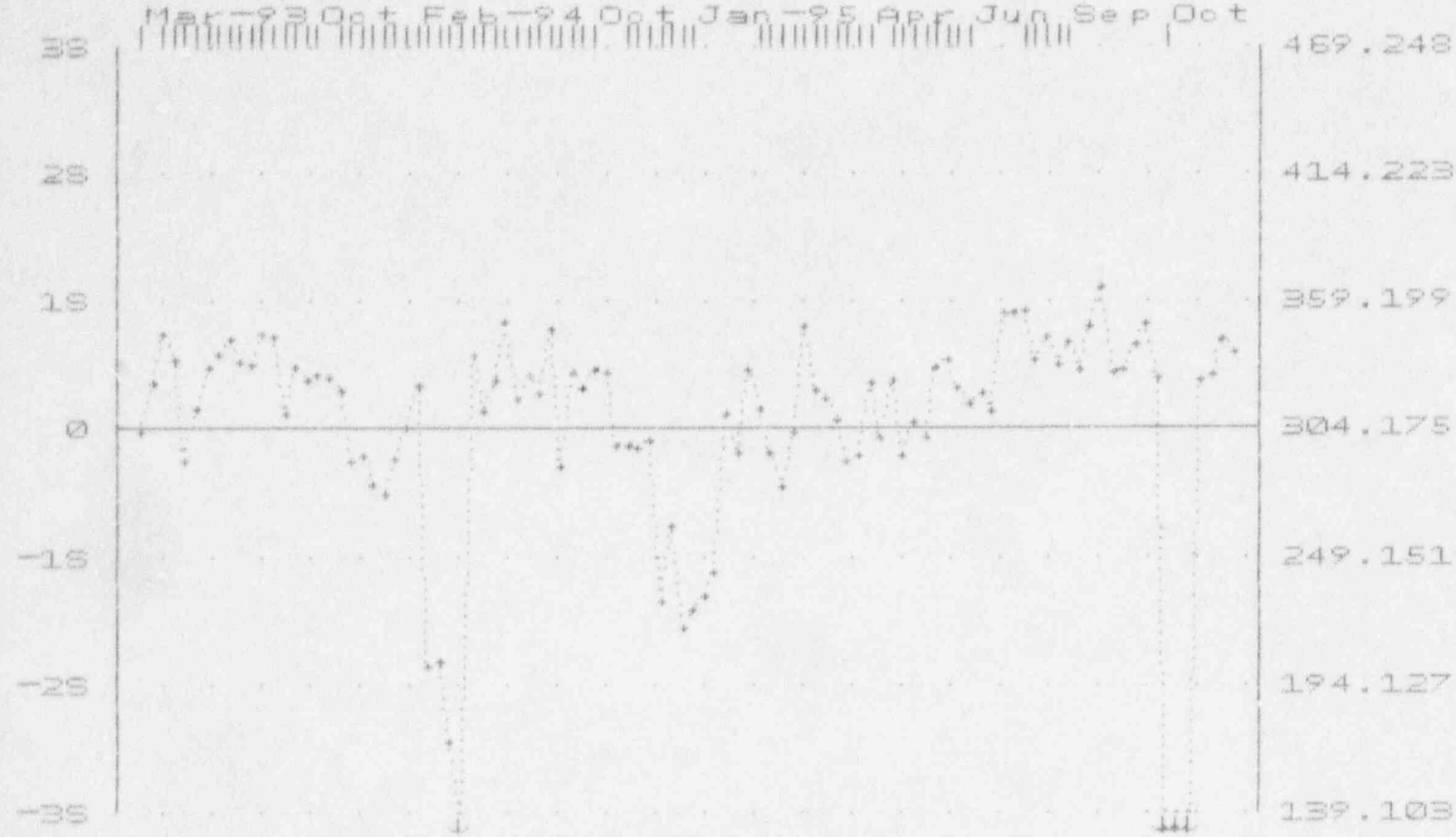
Parameter: 3H BACKGROUND
Total Points:100 Valid Points: 99 Mean: 15.26 SD: 6.491



Parameter: 3H EFFICIENCY
Total Points:100 Valid Points:100 Mean: 65.35 SD: 0.676

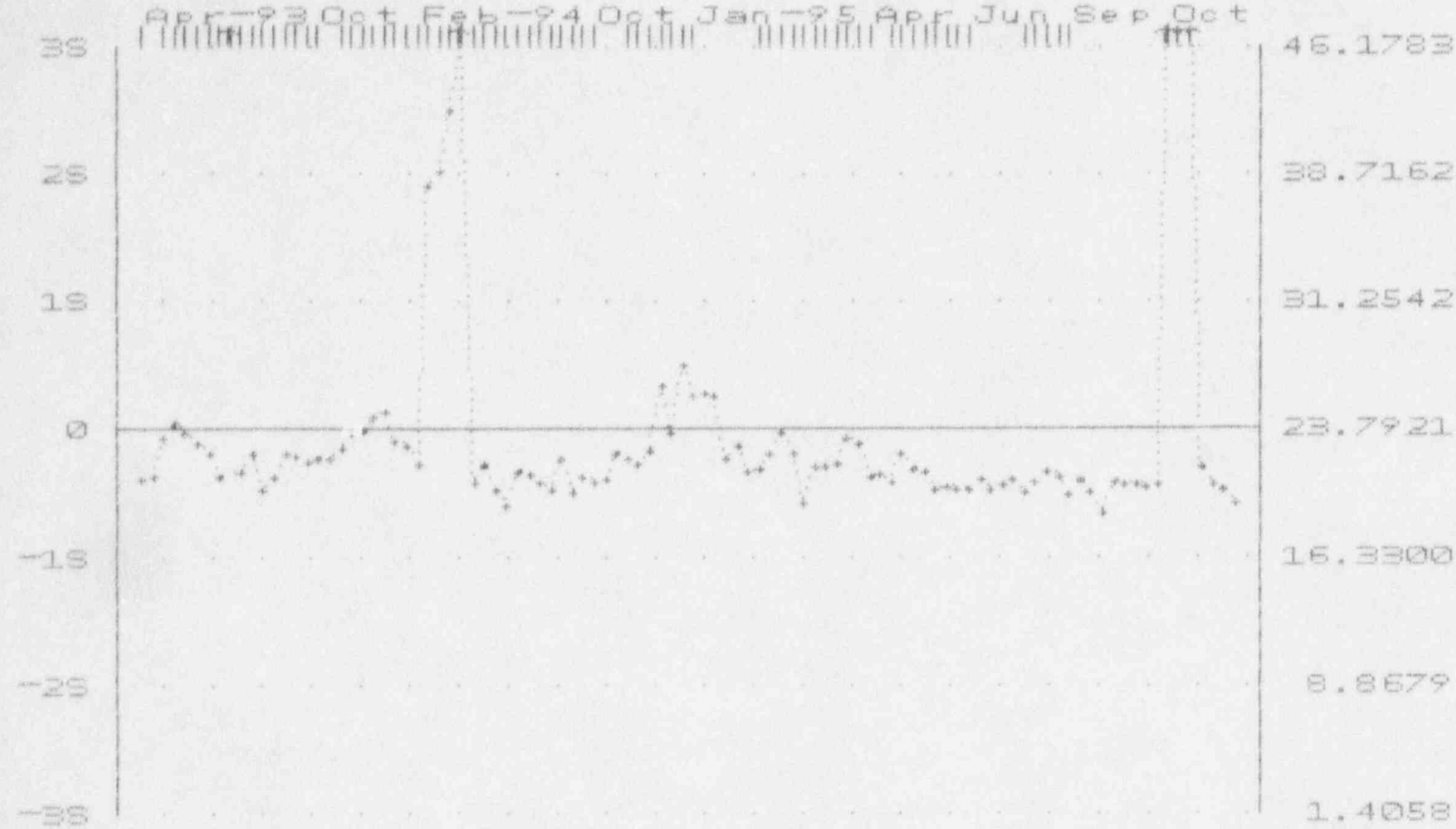


Parameter: 3H FIGURE OF MERIT (E^2/B)
Total Points:100 Valid Points:100 Mean: 304.18 SD: 55.024

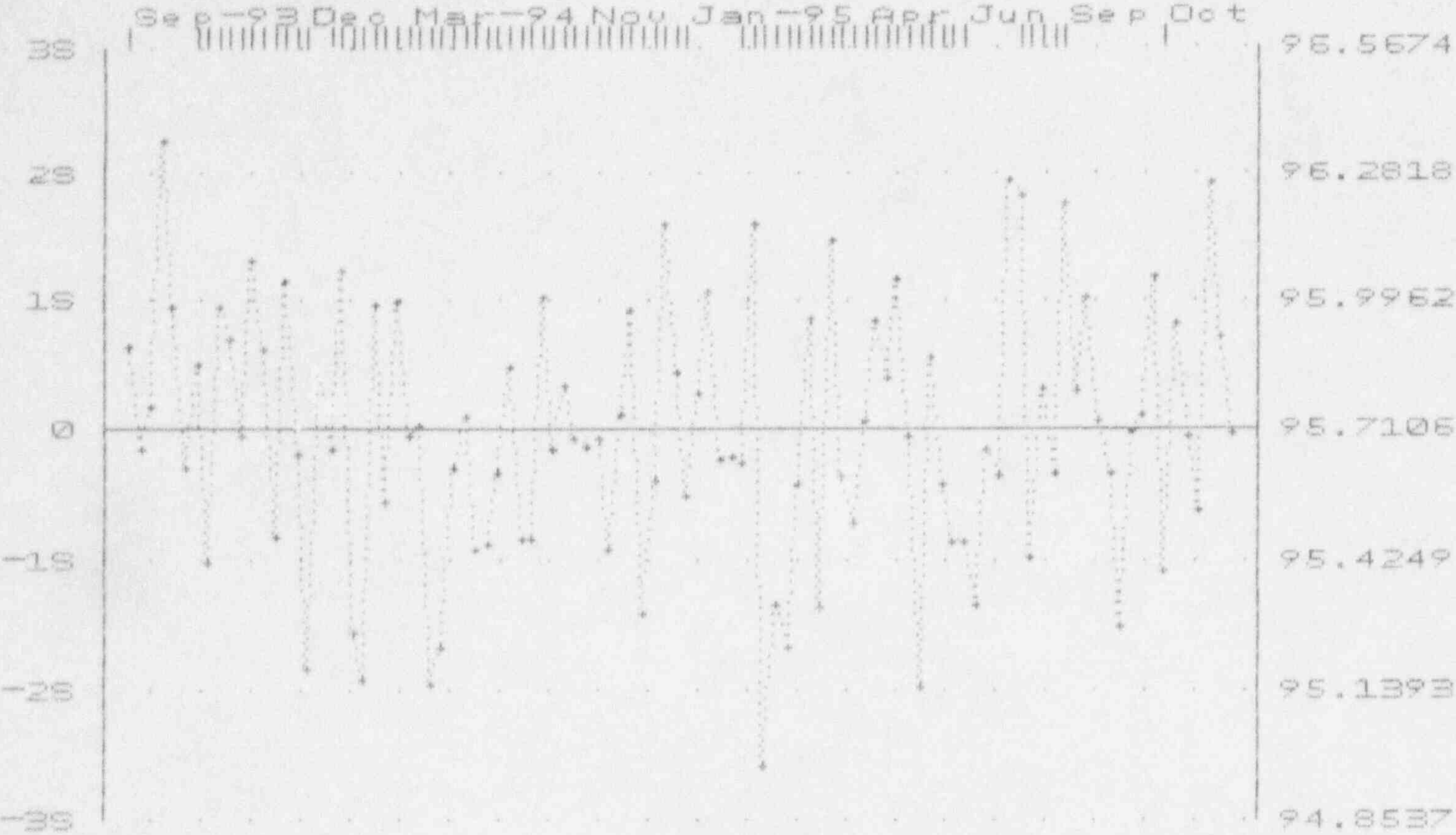


Parameter: 14C BACKGROUND

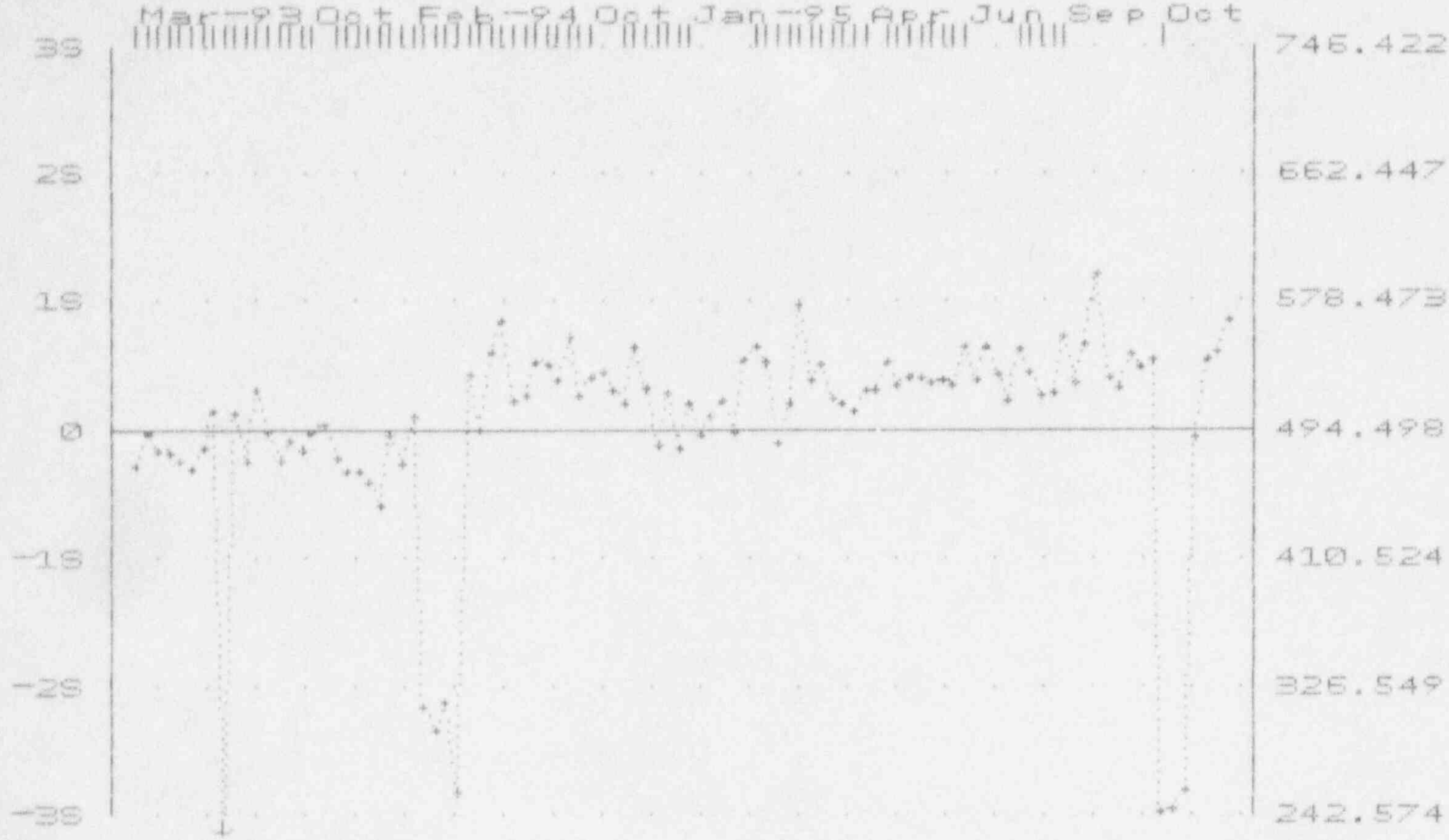
Total Points:100 Valid Points: 99 Mean: 23.79 SD: 7.462



Parameter: 14C EFFICIENCY
Total Points:100 Valid Points:100 Mean: 95.71 SD: 0.286



Parameter: 14C FIGURE OF MERIT (E^2/D)
Total Points:100 Valid Points:100 Mean: 494.50 SD: 83.975



Y.LI INTAKE FROM NOON

INTAKE EVALUATION

******************************** RADIONUCLIDE ********************************

P-32
PHYSICAL HALF-LIFE = 1.428E+001 DAYS

************ RESPIRATORY AND GI TRACT INPUT - DOSIMETRY INPUT ************

ACUTE INGESTION INTAKE

STANDARD ICRP 30 RESPIRATORY TRACT AND GI TRACT MODELS USED

WITH FRACTIONAL UPTAKE FROM GI TRACT (F1) = 8.000E-001
STOCHASTIC (INGESTION) ALI = 6.000E+002 uCi

**************************** SYSTEMIC EXCRETION ****************************

FRACTION OF SYSTEMIC EXCRETION THROUGH URINE = 0.90

********************** PARAMETERS FOR SYSTEMIC MODEL **********************

COMPARTMENT	COEFFICIENT	BIOLOGICAL HALF-LIFE (DAYS)
1	1.500E-001	5.000E-001
2	1.500E-001	2.000E+000
3	4.000E-001	1.900E+001
4	3.000E-001	1.500E+003

***************************** INTAKE ESTIMATE *****************************

INTAKE ESTIMATED FROM INCREMENTAL URINE DATA
ESTIMATE OF INTAKE FROM ITERATIVE
WEIGHTED FIT OF DATA = 5.642E+002 uCi
EXPERIMENTAL ERROR IN INTAKE ESTIMATE = 1.846E+001 uCi

**************************** DOSIMETRY RESULTS ****************************

FRACTION OF STOCHASTIC ALI = 9.4E-001
COMMITTED EFFECTIVE DOSE EQUIVALENT = 4.702E+000 rem

Y.LI INTAKE FROM NOON

INTAKE ESTIMATED FROM STATISTICAL EVALUATION OF
P-32 INCREMENTAL URINE DATA

TIME POST INTAKE (DAYS)	URINE COLLECTION PERIOD (DAYS)	BIOASSAY MEASUREMENT (uCi)	ERROR MEASUREMENT (uCi)	RETENTION FRACTION	ITERATIVE WEIGHTED-FIT EXPECTATION MEASUREMENT (uCi)
11.00	1.00	2.568E+000	1.602E+000	4.865E-003	2.745E+000
12.00	1.00	1.460E+000	1.208E+000	4.324E-003	2.440E+000
13.00	1.00	1.610E+000	1.269E+000	3.876E-003	2.187E+000
14.00	1.00	2.027E+000	1.424E+000	3.495E-003	1.972E+000
15.00	1.00	2.069E+000	1.438E+000	3.168E-003	1.787E+000
16.00	1.00	1.556E+000	1.248E+000	2.881E-003	1.626E+000
17.00	1.00	1.460E+000	1.209E+000	2.628E-003	1.483E+000
18.00	1.00	1.501E+000	1.225E+000	2.401E-003	1.355E+000
19.00	1.00	1.315E+000	1.147E+000	2.198E-003	1.240E+000
20.00	1.00	9.710E-001	9.854E-001	2.014E-003	1.136E+000
21.00	1.00	1.224E+000	1.107E+000	1.847E-003	1.042E+000
22.00	1.00	9.769E-001	9.884E-001	1.695E-003	9.561E-001
23.00	1.00	8.927E-001	9.448E-001	1.556E-003	8.778E-001
24.00	1.00	6.945E-001	8.334E-001	1.429E-003	8.061E-001
25.00	1.00	7.346E-001	8.571E-001	1.313E-003	7.405E-001
26.00	1.00	5.886E-001	7.672E-001	1.206E-003	6.804E-001
27.00	1.00	7.820E-001	8.843E-001	1.108E-003	6.253E-001
28.00	1.00	7.020E-001	8.379E-001	1.019E-003	5.747E-001
29.00	1.00	6.720E-001	8.198E-001	9.362E-004	5.282E-001
30.00	1.00	5.633E-001	7.505E-001	8.606E-004	4.855E-001
31.00	1.00	5.200E-001	7.211E-001	7.911E-004	4.464E-001
32.00	1.00	4.162E-001	6.451E-001	7.273E-004	4.104E-001
33.00	1.00	3.767E-001	6.138E-001	6.687E-004	3.773E-001
34.00	1.00	3.389E-001	5.822E-001	6.148E-004	3.469E-001
35.00	1.00	3.122E-001	5.587E-001	5.653E-004	3.190E-001
36.00	1.00	3.310E-001	5.753E-001	5.199E-004	2.933E-001
37.00	1.00	3.810E-001	6.173E-001	4.781E-004	2.697E-001
38.00	1.00	3.534E-001	5.945E-001	4.396E-004	2.480E-001
39.00	1.00	2.963E-001	5.443E-001	4.043E-004	2.281E-001
40.00	1.00	2.883E-001	5.369E-001	3.719E-004	2.098E-001
41.00	1.00	2.410E-001	4.909E-001	3.420E-004	1.930E-001
42.00	1.00	2.389E-001	4.888E-001	3.146E-004	1.775E-001
43.00	1.00	2.052E-001	4.530E-001	2.894E-004	1.633E-001
44.00	1.00	1.327E-001	3.643E-001	2.662E-004	1.502E-001
45.00	1.00	2.110E-001	4.593E-001	2.449E-004	1.382E-001
46.00	1.00	1.970E-001	4.438E-001	2.253E-004	1.271E-001
47.00	1.00	1.944E-001	4.409E-001	2.073E-004	1.170E-001
48.00	1.00	1.567E-001	3.959E-001	1.907E-004	1.076E-001
49.00	1.00	1.480E-001	3.847E-001	1.755E-004	9.902E-002

Y.LI INTAKE ESTIMATE from 8:00 pm on 8/1/95

INTAKE EVALUATION

******************************* RADIONUCLIDE *******************************

P-32
PHYSICAL HALF-LIFE = 1.428E+001 DAYS

************ RESPIRATORY AND GI TRACT INPUT - DOSIMETRY INPUT ************

ACUTE INGESTION INTAKE

STANDARD ICRP 30 RESPIRATORY TRACT AND GI TRACT MODELS USED

WITH FRACTIONAL UPTAKE FROM GI TRACT (F1) = 8.000E-001
STOCHASTIC (INGESTION) ALI = 6.000E+002 uCi

************************** SYSTEMIC EXCRETION ****************************

FRACTION OF SYSTEMIC EXCRETION THROUGH URINE = 0.90

******************** PARAMETERS FOR SYSTEMIC MODEL ********************

COMPARTMENT	COEFFICIENT	BIOLOGICAL HALF-LIFE (DAYS)
1	1.500E-001	5.000E-001
2	1.500E-001	2.000E+000
3	4.000E-001	1.900E+001
4	3.000E-001	1.500E+003

**************************** INTAKE ESTIMATE ****************************

INTAKE ESTIMATED FROM INCREMENTAL URINE DATA
ESTIMATE OF INTAKE FROM ITERATIVE
WEIGHTED FIT OF DATA = 5.467E+002 uCi
EXPERIMENTAL ERROR IN INTAKE ESTIMATE = 1.811E+001 uCi

*************************** DOSIMETRY RESULTS ***************************

FRACTION OF STOCHASTIC ALI = 9.1E-001
COMMITTED EFFECTIVE DOSE EQUIVALENT = 4.556E+000 rem

Y.LI INTAKE ESTIMATE

INTAKE ESTIMATED FROM STATISTICAL EVALUATION OF P-32 INCREMENTAL URINE DATA

TIME POST INTAKE (DAYS)	URINE COLLECTION PERIOD (DAYS)	BIOASSAY MEASUREMENT (uCi)	ERROR MEASUREMENT (uCi)	RETENTION FRACTION	ITERATIVE WEIGHTED-FIT EXPECTATION MEASUREMENT (uCi)
10.67	1.00	2.568E+000	1.602E+000	5.068E-003	2.771E+000
11.67	1.00	1.460E+000	1.208E+000	4.491E-003	2.455E+000
12.67	1.00	1.610E+000	1.269E+000	4.015E-003	2.195E+000
13.67	1.00	[illegible].027E+000	1.424E+000	3.614E-003	1.976E+000
14.67	1.00	2.069E+000	1.438E+000	3.271E-003	1.788E+000
15.67	1.00	1.556E+000	1.248E+000	2.972E-003	1.625E+000
16.67	1.00	1.460E+000	1.209E+000	2.708E-003	1.480E+000
17.67	1.00	1.501E+000	1.225E+000	2.473E-003	1.352E+000
18.67	1.00	1.315E+000	1.147E+000	2.263E-003	1.237E+000
19.67	1.00	9.710E-001	9.854E-001	2.073E-003	1.133E+000
20.67	1.00	1.224E+000	1.107E+000	1.900E-003	1.039E+000
21.67	1.00	9.769E-001	9.884E-001	1.743E-003	9.531E-001
22.67	1.00	8.927E-001	9.448E-001	1.600E-003	8.748E-001
23.67	1.00	6.945E-001	8.334E-001	1.469E-003	8.033E-001
24.67	1.00	7.346E-001	8.571E-001	1.350E-003	7.379E-001
25.67	1.00	5.886E-001	7.672E-001	1.240E-003	6.780E-001
26.67	1.00	7.820E-001	8.843E-001	1.140E-003	6.230E-001
27.67	1.00	7.020E-001	8.379E-001	1.047E-003	5.725E-001
28.67	1.00	6.720E-001	8.198E-001	9.626E-004	5.262E-001
29.67	1.00	5.633E-001	7.505E-001	8.848E-004	4.837E-001
30.67	1.00	5.200E-001	7.211E-001	8.134E-004	4.447E-001
31.67	1.00	4.162E-001	6.451E-001	7.478E-004	4.088E-001
32.67	1.00	3.767E-001	6.138E-001	6.875E-004	3.758E-001
33.67	1.00	3.389E-001	5.822E-001	6.321E-004	3.456E-001
34.67	1.00	3.122E-001	5.587E-001	5.812E-004	3.177E-001
35.67	1.00	3.310E-001	5.753E-001	5.344E-004	2.922E-001
36.67	1.00	3.810E-001	6.173E-001	4.915E-004	2.687E-001
37.67	1.00	3.534E-001	5.945E-001	4.520E-004	2.471E-001
38.67	1.00	2.963E-001	5.443E-001	4.156E-004	2.272E-001
39.67	1.00	2.883E-001	5.369E-001	3.823E-004	2.090E-001
40.67	1.00	2.410E-001	4.909E-001	3.516E-004	1.922E-001
41.67	1.00	2.389E-001	4.888E-001	3.234E-004	1.768E-001
42.67	1.00	2.052E-001	4.530E-001	2.975E-004	1.626E-001
43.67	1.00	1.327E-001	3.643E-001	2.736E-004	1.496E-001
44.67	1.00	2.110E-001	4.593E-001	2.517E-004	1.376E-001
45.67	1.00	1.970E-001	4.438E-001	2.316E-004	1.266E-001
46.67	1.00	1.944E-001	4.409E-001	2.131E-004	1.165E-001
47.67	1.00	1.567E-001	3.959E-001	1.960E-004	1.072E-001
48.67	1.00	1.480E-001	3.847E-001	1.804E-004	9.862E-002

Y.LI INTAKE FROM WHOLE BODY

INTAKE EVALUATION

****************************** RADIONUCLIDE ******************************

P-32
PHYSICAL HALF-LIFE = 1.428E+001 DAYS

************ RESPIRATORY AND GI TRACT INPUT - DOSIMETRY INPUT ************

ACUTE INGESTION INTAKE

STANDARD ICRP 30 RESPIRATORY TRACT AND GI TRACT MODELS USED

WITH FRACTIONAL UPTAKE FROM GI TRACT (F1) = 8.000E-001
STOCHASTIC (INGESTION) ALI = 6.000E+002 uCi

********************* PARAMETERS FOR SYSTEMIC MODEL *********************

COMPARTMENT	COEFFICIENT	BIOLOGICAL HALF-LIFE (DAYS)
1	1.500E-001	5.000E-001
2	1.500E-001	2.000E+000
3	4.000E-001	1.900E+001
4	3.000E-001	1.500E+003

***************************** INTAKE ESTIMATE *****************************

INTAKE ESTIMATED FROM WHOLE-BODY BIOASSAY
ESTIMATE OF INTAKE FROM ITERATIVE
WEIGHTED FIT OF DATA = 5.789E+002 uCi
EXPERIMENTAL ERROR IN INTAKE ESTIMATE = 4.414E+000 uCi

**************************** DOSIMETRY RESULTS ****************************

FRACTION OF STOCHASTIC ALI = 9.6E-001
COMMITTED EFFECTIVE DOSE EQUIVALENT = 4.824E+000 rem

Y.LI INTAKE FROM WHOLE BODY

INTAKE ESTIMATED FROM STATISTICAL EVALUATION OF
P-32 WHOLE-BODY BIOASSAY

TIME POST INTAKE (DAYS)	BIOASSAY MEASUREMENT (uCi)	ERROR MEASUREMENT (uCi)	RETENTION FRACTION	ITERATIVE WEIGHTED-FIT EXPECTATION MEASUREMENT (uCi)
5.00	2.670E+002	1.634E+001	4.204E-001	2.433E+002
7.00	2.040E+002	1.428E+001	3.571E-001	2.067E+002
8.00	1.940E+002	1.393E+001	3.315E-001	1.919E+002
9.00	1.780E+002	1.334E+001	3.085E-001	1.786E+002
10.00	1.650E+002	1.285E+001	2.876E-001	1.665E+002
11.00	1.570E+002	1.253E+001	2.684E-001	1.554E+002
14.00	1.290E+002	1.136E+001	2.196E-001	1.271E+002
15.00	1.220E+002	1.105E+001	2.056E-001	1.190E+002
16.00	1.090E+002	1.044E+001	1.926E-001	1.115E+002
17.00	1.030E+002	1.015E+001	1.806E-001	1.045E+002
18.00	9.900E+001	9.950E+000	1.693E-001	9.802E+001
22.00	7.600E+001	8.718E+000	1.314E-001	7.608E+001
23.00	6.900E+001	8.307E+000	1.235E-001	7.147E+001
24.00	6.500E+001	8.062E+000	1.160E-001	6.715E+001
25.00	6.600E+001	8.124E+000	1.090E-001	6.312E+001
28.00	5.000E+001	7.071E+000	9.072E-002	5.252E+001
29.00	4.900E+001	7.000E+000	8.538E-002	4.943E+001
30.00	4.500E+001	6.708E+000	8.037E-002	4.653E+001
31.00	4.400E+001	6.633E+000	7.568E-002	4.381E+001
32.00	4.100E+001	6.403E+000	7.128E-002	4.126E+001
35.00	3.400E+001	5.831E+000	5.966E-002	3.454E+001
36.00	2.830E+001	5.320E+000	5.625E-002	3.256E+001
37.00	2.850E+001	5.339E+000	5.305E-002	3.071E+001
38.00	2.780E+001	5.273E+000	5.005E-002	2.897E+001
39.00	2.580E+001	5.079E+000	4.722E-002	2.734E+001
42.00	2.230E+001	4.722E+000	3.973E-002	2.300E+001
43.00	1.980E+001	4.450E+000	3.752E-002	2.172E+001
44.00	1.980E+001	4.450E+000	3.545E-002	2.052E+001
45.00	1.840E+001	4.290E+000	3.350E-002	1.939E+001
46.00	1.650E+001	4.062E+000	3.166E-002	1.833E+001
49.00	1.450E+001	3.808E+000	2.676E-002	1.549E+001
50.00	1.350E+001	3.674E+000	2.531E-002	1.465E+001

Y.LI ITERATIVE INTAKE (NOON)

INTAKE EVALUATION

******************************* RADIONUCLIDE *******************************

P-32
PHYSICAL HALF-LIFE = 1.428E+001 DAYS

************ RESPIRATORY AND GI TRACT INPUT - DOSIMETRY INPUT ************

ACUTE INGESTION INTAKE

STANDARD ICRP 30 RESPIRATORY TRACT AND GI TRACT MODELS USED

WITH FRACTIONAL UPTAKE FROM GI TRACT (F1) = 8.000E-001
STOCHASTIC (INGESTION) ALI = 6.000E+002 uCi

*************************** SYSTEMIC EXCRETION *************************

FRACTION OF SYSTEMIC EXCRETION THROUGH URINE = 0.90

********************* PARAMETERS FOR SYSTEMIC MODEL *********************

COMPARTMENT	COEFFICIENT	BIOLOGICAL HALF-LIFE (DAYS)
1	1.500E-001	5.000E-001
2	1.500E-001	2.000E+000
3	4.000E-001	1.900E+001
4	3.000E-001	1.500E+003

***************************** INTAKE ESTIMATE *****************************

INTAKE ESTIMATED FROM INCREMENTAL URINE DATA
ESTIMATE OF INTAKE FROM ITERATIVE
WEIGHTED FIT OF DATA = 5.584E+002 uCi
EXPERIMENTAL ERROR IN INTAKE ESTIMATE = 1.880E+001 uCi

*************************** DOSIMETRY RESULTS ***************************

FRACTION OF STOCHASTIC ALI = 9.3E-001
COMMITTED EFFECTIVE DOSE EQUIVALENT = 4.653E+000 rem

Y.LI ITERATIVE INTAKE (NOON)

INTAKE ESTIMATED FROM STATISTICAL EVALUATION OF P-32 INCREMENTAL URINE DATA

TIME POST INTAKE (DAYS)	URINE COLLECTION PERIOD (DAYS)	BIOASSAY MEASUREMENT (uCi)	ERROR MEASUREMENT (uCi)	RETENTION FRACTION	ITERATIVE WEIGHTED-FIT EXPECTATION MEASUREMENT (uCi)
11.00	1.00	2.568E+000	1.602E+000	4.865E-003	2.716E+000
12.00	1.00	1.460E+000	1.208E+000	4.324E-003	2.415E+000
13.00	1.00	1.610E+000	1.269E+000	3.876E-003	2.164E+000
14.00	1.00	2.027E+000	1.424E+000	3.495E-003	1.952E+000
15.00	1.00	2.069E+000	1.438E+000	3.168E-003	1.769E+000
16.00	1.00	1.556E+000	1.248E+000	2.881E-003	1.609E+000
17.00	1.00	1.460E+000	1.209E+000	[illegible]	1.467E+000
18.00	1.00	1.501E+000	1.225E+000	[illegible]	1.341E+000
19.00	1.00	1.315E+000	1.147E+000	2.198E-003	1.227E+000
20.00	1.00	9.710E-001	9.854E-001	2.014E-003	1.124E+000
21.00	1.00	1.224E+000	1.107E+000	1.847E-003	1.031E+000
22.00	1.00	9.769E-001	9.884E-001	1.695E-003	9.462E-001
23.00	1.00	8.927E-001	9.448E-001	1.556E-003	8.687E-001
24.00	1.00	6.945E-001	8.334E-001	1.429E-003	7.978E-001
25.00	1.00	7.346E-001	8.571E-001	1.313E-003	7.329E-001
26.00	1.00	5.886E-001	7.672E-001	1.206E-003	6.733E-001
27.00	1.00	7.820E-001	8.843E-001	1.108E-003	6.188E-001
28.00	1.00	7.020E-001	8.379E-001	1.019E-003	5.687E-001
29.00	1.00	6.720E-001	8.198E-001	9.362E-004	5.227E-001
30.00	1.00	5.633E-001	7.505E-001	8.606E-004	4.805E-001
31.00	1.00	5.200E-001	7.211E-001	7.911E-004	4.417E-001
32.00	1.00	4.162E-001	6.451E-001	7.273E-004	4.061E-001
33.00	1.00	3.767E-001	6.138E-001	6.687E-004	3.734E-001
34.00	1.00	3.389E-001	5.822E-001	6.148E-004	3.433E-001
35.00	1.00	3.122E-001	5.587E-001	5.653E-004	3.157E-001
36.00	1.00	3.310E-001	5.753E-001	5.199E-004	2.903E-001
37.00	1.00	3.810E-001	6.173E-001	4.781E-004	2.669E-001
38.00	1.00	3.534E-001	5.945E-001	4.396E-004	2.455E-001
39.00	1.00	2.963E-001	5.443E-001	4.043E-004	2.258E-001
40.00	1.00	2.883E-001	5.369E-001	3.719E-004	2.076E-001
41.00	1.00	2.410E-001	4.909E-001	3.420E-004	1.910E-001
42.00	1.00	2.389E-001	4.888E-001	3.146E-004	1.757E-001
43.00	1.00	2.052E-001	4.530E-001	2.894E-004	1.616E-001

Y.LI WEIGHTED INTAKE (NOON)

INTAKE EVALUATION

******************************** RADIONUCLIDE ********************************

P-32
PHYSICAL HALF-LIFE = 1.428E+001 DAYS

************* RESPIRATORY AND GI TRACT INPUT - DOSIMETRY INPUT ************

ACUTE INGESTION INTAKE

STANDARD ICRP 30 RESPIRATORY TRACT AND GI TRACT MODELS USED

WITH FRACTIONAL UPTAKE FROM GI TRACT (F1) = 8.000E-001
STOCHASTIC (INGESTION) ALI = 6.000E+002 uCi

***************************** SYSTEMIC EXCRETION *****************************

FRACTION OF SYSTEMIC EXCRETION THROUGH URINE = 0.90

********************** PARAMETERS FOR SYSTEMIC MODEL **********************

COMPARTMENT	COEFFICIENT	BIOLOGICAL HALF-LIFE (DAYS)
1	1.500E-001	5.000E-001
2	1.500E-001	2.000E+000
3	4.000E-001	1.900E+001
4	3.000E-001	1.500E+003

****************************** INTAKE ESTIMATE ******************************

INTAKE ESTIMATED FROM INCREMENTAL URINE DATA
ESTIMATE OF INTAKE FROM WEIGHTED FIT OF DATA = 5.352E+002 uCi
EXPERIMENTAL ERROR IN INTAKE ESTIMATE = 1.970E+001 uCi

**************************** DOSIMETRY RESULTS ****************************

FRACTION OF STOCHASTIC ALI = 8.9E-001
COMMITTED EFFECTIVE DOSE EQUIVALENT = 4.460E+000 rem

Y.LI WEIGHTED INTAKE (NOON)

INTAKE ESTIMATED FROM STATISTICAL EVALUATION OF
P-32 INCREMENTAL URINE DATA

TIME POST INTAKE (DAYS)	URINE COLLECTION PERIOD (DAYS)	BIOASSAY MEASUREMENT (uCi)	ERROR MEASUREMENT (uCi)	RETENTION FRACTION	WEIGHTED-FIT EXPECTATION MEASUREMENT (uCi)
11.00	1.00	2.568E+000	1.602E+000	4.865E-003	2.603E+000
12.00	1.00	1.460E+000	1.208E+000	4.324E-003	2.314E+000
13.00	1.00	1.610E+000	1.269E+000	3.876E-003	2.074E+000
14.00	1.00	2.027E+000	1.424E+000	3.495E-003	1.871E+000
15.00	1.00	2.069E+000	1.438E+000	3.168E-003	1.695E+000
16.00	1.00	1.556E+000	1.248E+000	2.881E-003	1.542E+000
17.00	1.00	1.460E+000	1.209E+000	2.628E-003	1.406E+000
18.00	1.00	1.501E+000	1.225E+000	2.401E-003	1.285E+000
19.00	1.00	1.315E+000	1.147E+000	2.198E-003	1.176E+000
20.00	1.00	9.710E-001	9.854E-001	2.014E-003	1.078E+000
21.00	1.00	1.224E+000	1.107E+000	1.847E-003	9.883E-001
22.00	1.00	9.769E-001	9.884E-001	1.695E-003	9.069E-001
23.00	1.00	8.927E-001	9.448E-001	1.556E-003	8.326E-001
24.00	1.00	6.945E-001	8.334E-001	1.429E-003	7.646E-001
25.00	1.00	7.346E-001	8.571E-001	1.313E-003	7.024E-001
26.00	1.00	5.886E-001	7.672E-001	1.206E-003	6.454E-001
27.00	1.00	7.820E-001	8.843E-001	1.108E-003	5.931E-001
28.00	1.00	7.020E-001	8.379E-001	1.019E-003	5.451E-001
29.00	1.00	6.720E-001	8.198E-001	9.362E-004	5.010E-001
30.00	1.00	5.633E-001	7.505E-001	8.606E-004	4.605E-001
31.00	1.00	5.200E-001	7.211E-001	7.911E-004	4.234E-001
32.00	1.00	4.162E-001	6.451E-001	7.273E-004	3.892E-001
33.00	1.00	3.767E-001	6.138E-001	6.687E-004	3.579E-001
34.00	1.00	3.389E-001	5.822E-001	6.148E-004	3.290E-001
35.00	1.00	3.122E-001	5.587E-001	5.653E-004	3.025E-001
36.00	1.00	3.310E-001	5.753E-001	5.199E-004	2.782E-001
37.00	1.00	3.810E-001	6.173E-001	4.781E-004	2.558E-001
38.00	1.00	3.534E-001	5.945E-001	4.396E-004	2.353E-001
39.00	1.00	2.963E-001	5.443E-001	4.043E-004	2.164E-001
40.00	1.00	2.883E-001	5.369E-001	3.719E-004	1.990E-001
41.00	1.00	2.410E-001	4.909E-001	3.420E-004	1.830E-001
42.00	1.00	2.389E-001	4.888E-001	3.146E-004	1.684E-001
43.00	1.00	2.052E-001	4.530E-001	2.894E-004	1.549E-001

Y.LI UNWEIGHTED INTAKE (NOON)

INTAKE EVALUATION

******************************** RADIONUCLIDE ********************************

P-32
PHYSICAL HALF-LIFE = 1.428E+001 DAYS

************ RESPIRATORY AND GI TRACT INPUT - DOSIMETRY INPUT ************

ACUTE INGESTION INTAKE

STANDARD ICRP 30 RESPIRATORY TRACT AND GI TRACT MODELS USED

WITH FRACTIONAL UPTAKE FROM GI TRACT (F1) = 8.000E-001
STOCHASTIC (INGESTION) ALI = 6.000E+002 uCi

*************************** SYSTEMIC EXCRETION ***************************

FRACTION OF SYSTEMIC EXCRETION THROUGH URINE = 0.90

********************* PARAMETERS FOR SYSTEMIC MODEL *********************

COMPARTMENT	COEFFICIENT	BIOLOGICAL HALF-LIFE (DAYS)
1	1.500E-001	5.000E-001
2	1.500E-001	2.000E+000
3	4.000E-001	1.900E+001
4	3.000E-001	1.500E+003

***************************** INTAKE ESTIMATE *****************************

INTAKE ESTIMATED FROM INCREMENTAL URINE DATA
ESTIMATE OF INTAKE FROM UNWEIGHTED FIT OF DATA = 5.228E+002 uCi
EXPERIMENTAL ERROR IN INTAKE ESTIMATE = 1.837E+001 uCi

**************************** DOSIMETRY RESULTS ****************************

FRACTION OF STOCHASTIC ALI = 8.7E-001
COMMITTED EFFECTIVE DOSE EQUIVALENT = 4.357E+000 rem

Y.LI UNWEIGHTED INTAKE (NOON)

INTAKE ESTIMATED FROM STATISTICAL EVALUATION OF
P-32 INCREMENTAL URINE DATA

TIME POST INTAKE (DAYS)	URINE COLLECTION PERIOD (DAYS)	BIOASSAY MEASUREMENT (uCi)	ERROR MEASUREMENT (uCi)	RETENTION FRACTION	UNWEIGHTED-FIT EXPECTATION MEASUREMENT (uCi)
11.00	1.00	2.568E+000	1.602E+000	4.865E-003	2.543E+000
12.00	1.00	1.460E+000	1.208E+000	4.324E-003	2.261E+000
13.00	1.00	1.610E+000	1.269E+000	3.876E-003	2.026E+000
14.00	1.00	2.027E+000	1.424E+000	3.495E-003	1.827E+000
15.00	1.00	2.069E+000	1.438E+000	3.168E-003	1.656E+000
16.00	1.00	1.556E+000	1.248E+000	2.881E-003	1.506E+000
17.00	1.00	1.460E+000	1.209E+000	2.628E-003	1.374E+000
18.00	1.00	1.501E+000	1.225E+000	2.401E-003	1.255E+000
19.00	1.00	1.315E+000	1.147E+000	2.198E-003	1.149E+000
20.00	1.00	9.710E-001	9.854E-001	2.014E-003	1.053E+000
21.00	1.00	1.224E+000	1.107E+000	1.847E-003	9.655E-001
22.00	1.00	9.769E-001	9.884E-001	1.695E-003	8.859E-001
23.00	1.00	8.927E-001	9.448E-001	1.556E-003	8.133E-001
24.00	1.00	6.945E-001	8.334E-001	1.429E-003	7.470E-001
25.00	1.00	7.346E-001	8.571E-001	1.313E-003	6.862E-001
26.00	1.00	5.886E-001	7.672E-001	1.206E-003	6.305E-001
27.00	1.00	7.820E-001	8.843E-001	1.108E-003	5.794E-001
28.00	1.00	7.020E-001	8.379E-001	1.019E-003	5.325E-001
29.00	1.00	6.720E-001	8.198E-001	9.362E-004	4.894E-001
30.00	1.00	5.633E-001	7.505E-001	8.606E-004	4.499E-001
31.00	1.00	5.200E-001	7.211E-001	7.911E-004	4.136E-001
32.00	1.00	4.162E-001	6.451E-001	7.273E-004	3.802E-001
33.00	1.00	3.767E-001	6.138E-001	6.687E-004	3.496E-001
34.00	1.00	3.389E-001	5.822E-001	6.148E-004	3.214E-001
35.00	1.00	3.122E-001	5.587E-001	5.653E-004	2.956E-001
36.00	1.00	3.310E-001	5.753E-001	5.199E-004	2.718E-001
37.00	1.00	3.810E-001	6.173E-001	4.781E-004	2.499E-001
38.00	1.00	3.534E-001	5.945E-001	4.396E-004	2.298E-001
39.00	1.00	2.963E-001	5.443E-001	4.043E-004	2.114E-001
40.00	1.00	2.883E-001	5.369E-001	3.719E-004	1.944E-001
41.00	1.00	2.410E-001	4.909E-001	3.420E-004	1.788E-001
42.00	1.00	2.389E-001	4.888E-001	3.146E-004	1.645E-001
43.00	1.00	2.052E-001	4.530E-001	2.894E-004	1.513E-001

Y.LI ITERATIVE INTAKE (8PM)

INTAKE EVALUATION

******************************** RADIONUCLIDE ********************************

P-32
PHYSICAL HALF-LIFE = 1.428E+001 DAYS

************ RESPIRATORY AND GI TRACT INPUT - DOSIMETRY INPUT ************

ACUTE INGESTION INTAKE

STANDARD ICRP 30 RESPIRATORY TRACT AND GI TRACT MODELS USED

WITH FRACTIONAL UPTAKE FROM GI TRACT (F1) = 8.000E-001
STOCHASTIC (INGESTION) ALI = 6.000E+002 uCi

**************************** SYSTEMIC EXCRETION ****************************

FRACTION OF SYSTEMIC EXCRETION THROUGH URINE = 0.90

********************** PARAMETERS FOR SYSTEMIC MODEL **********************

COMPARTMENT	COEFFICIENT	BIOLOGICAL HALF-LIFE (DAYS)
1	1.500E-001	5.000E-001
2	1.500E-001	2.000E+000
3	4.000E-001	1.900E+001
4	3.000E-001	1.500E+003

****************************** INTAKE ESTIMATE ******************************

INTAKE ESTIMATED FROM INCREMENTAL URINE DATA
ESTIMATE OF INTAKE FROM ITERATIVE
WEIGHTED FIT OF DATA = 5.410E+002 uCi
EXPERIMENTAL ERROR IN INTAKE ESTIMATE = 1.845E+001 uCi

**************************** DOSIMETRY RESULTS ****************************

FRACTION OF STOCHASTIC ALI = 9.0E-001
COMMITTED EFFECTIVE DOSE EQUIVALENT = 4.508E+000 rem

Y.LI ITERATIVE INTAKE (8PM)

INTAKE ESTIMATED FROM STATISTICAL EVALUATION OF
P-32 INCREMENTAL URINE DATA

TIME POST INTAKE (DAYS)	URINE COLLECTION PERIOD (DAYS)	BIOASSAY MEASUREMENT (uCi)	ERROR MEASUREMENT (uCi)	RETENTION FRACTION	ITERATIVE WEIGHTED-FIT EXPECTATION MEASUREMENT (uCi)
10.67	1.00	2.568E+000	1.602E+000	5.068E-003	2.742E+000
11.67	1.00	1.460E+000	1.208E+000	4.491E-003	2.430E+000
12.67	1.00	1.610E+000	1.269E+000	4.015E-003	2.172E+000
13.67	1.00	2.027E+000	1.424E+000	3.614E-003	1.955E+000
14.67	1.00	2.069E+000	1.438E+000	3.271E-003	1.769E+000
15.67	1.00	1.556E+000	1.248E+000	2.972E-003	1.608E+000
16.67	1.00	1.460E+000	1.209E+000	2.708E-003	1.465E+000
17.67	1.00	1.501E+000	1.225E+000	2.473E-003	1.338E+000
18.67	1.00	1.315E+000	1.147E+000	2.263E-003	1.224E+000
19.67	1.00	9.710E-001	9.854E-001	2.073E-003	1.121E+000
20.67	1.00	1.224E+000	1.107E+000	1.900E-003	1.028E+000
21.67	1.00	9.769E-001	9.884E-001	1.743E-003	9.431E-001
22.67	1.00	8.927E-001	9.448E-001	1.600E-003	8.657E-001
23.67	1.00	6.945E-001	8.334E-001	1.469E-003	7.949E-001
24.67	1.00	7.346E-001	8.571E-001	1.350E-003	7.302E-001
25.67	1.00	5.886E-001	7.672E-001	1.240E-003	6.708E-001
26.67	1.00	7.820E-001	8.843E-001	1.140E-003	6.164E-001
27.67	1.00	7.020E-001	8.379E-001	1.047E-003	5.665E-001
28.67	1.00	6.720E-001	8.198E-001	9.626E-004	5.207E-001
29.67	1.00	5.633E-001	7.505E-001	8.848E-004	4.786E-001
30.67	1.00	5.200E-001	7.211E-001	8.134E-004	4.400E-001
31.67	1.00	4.162E-001	6.451E-001	7.478E-004	4.045E-001
32.67	1.00	3.767E-001	6.138E-001	6.875E-004	3.719E-001
33.67	1.00	3.389E-001	5.822E-001	6.321E-004	3.419E-001
34.67	1.00	3.122E-001	5.587E-001	5.812E-004	3.144E-001
35.67	1.00	3.310E-001	5.753E-001	5.344E-004	2.891E-001
36.67	1.00	3.810E-001	6.173E-001	4.915E-004	2.659E-001
37.67	1.00	3.534E-001	5.945E-001	4.520E-004	2.445E-001
38.67	1.00	2.963E-001	5.443E-001	4.156E-004	2.248E-001
39.67	1.00	2.883E-001	5.369E-001	3.823E-004	2.068E-001
40.67	1.00	2.410E-001	4.909E-001	3.516E-004	1.902E-001
41.67	1.00	2.389E-001	4.888E-001	3.234E-004	1.749E-001
42.67	1.00	2.052E-001	4.530E-001	2.975E-004	1.609E-001

Y.LI WEIGHTED INTAKE (8PM)

INTAKE EVALUATION

********************************* RADIONUCLIDE *********************************

P-32
PHYSICAL HALF-LIFE = 1.428E+001 DAYS

************ RESPIRATORY AND GI TRACT INPUT - DOSIMETRY INPUT ************

ACUTE INGESTION INTAKE

STANDARD ICRP 30 RESPIRATORY TRACT AND GI TRACT MODELS USED

WITH FRACTIONAL UPTAKE FROM GI TRACT (F1) = 8.000E-001
STOCHASTIC (INGESTION) ALI = 6.000E+002 uCi

**************************** SYSTEMIC EXCRETION ****************************

FRACTION OF SYSTEMIC EXCRETION THROUGH URINE = 0.90

********************** PARAMETERS FOR SYSTEMIC MODEL **********************

COMPARTMENT	COEFFICIENT	BIOLOGICAL HALF-LIFE (DAYS)
1	1.500E-001	5.000E-001
2	1.500E-001	2.000E+000
3	4.000E-001	1.900E+001
4	3.000E-001	1.500E+003

****************************** INTAKE ESTIMATE ******************************

INTAKE ESTIMATED FROM INCREMENTAL URINE DATA
ESTIMATE OF INTAKE FROM WEIGHTED FIT OF DATA = 5.179E+002 uCi
EXPERIMENTAL ERROR IN INTAKE ESTIMATE = 1.933E+001 uCi

**************************** DOSIMETRY RESULTS ****************************

FRACTION OF STOCHASTIC ALI = 8.6E-001
COMMITTED EFFECTIVE DOSE EQUIVALENT = 4.316E+000 rem

Y.LI WEIGHTED INTAKE (8PM)

INTAKE ESTIMATED FROM STATISTICAL EVALUATION OF
P-32 INCREMENTAL URINE DATA

TIME POST INTAKE (DAYS)	URINE COLLECTION PERIOD (DAYS)	BIOASSAY MEASUREMENT (uCi)	ERROR MEASUREMENT (uCi)	RETENTION FRACTION	WEIGHTED-FIT EXPECTATION MEASUREMENT (uCi)
10.67	1.00	2.568E+000	1.602E+000	5.068E-003	2.625E+000
11.67	1.00	1.460E+000	1.208E+000	4.491E-003	2.326E+000
12.67	1.00	1.610E+000	1.269E+000	4.015E-003	2.079E+000
13.67	1.00	2.027E+000	1.424E+000	3.614E-003	1.872E+000
14.67	1.00	2.069E+000	1.438E+000	3.271E-003	1.694E+000
15.67	1.00	1.556E+000	1.248E+000	2.972E-003	1.539E+000
16.67	1.00	1.460E+000	1.209E+000	2.708E-003	1.402E+000
17.67	1.00	1.501E+000	1.225E+000	2.473E-003	1.281E+000
18.67	1.00	1.315E+000	1.147E+000	2.263E-003	1.172E+000
19.67	1.00	9.710E-001	9.854E-001	2.073E-003	1.073E+000
20.67	1.00	1.224E+000	1.107E+000	1.900E-003	9.840E-001
21.67	1.00	9.769E-001	9.884E-001	1.743E-003	9.028E-001
22.67	1.00	8.927E-001	9.448E-001	1.600E-003	8.287E-001
23.67	1.00	6.945E-001	8.334E-001	1.469E-003	7.610E-001
24.67	1.00	7.346E-001	8.571E-001	1.350E-003	6.990E-001
25.67	1.00	5.886E-001	7.672E-001	1.240E-003	6.422E-001
26.67	1.00	7.820E-001	8.843E-001	1.140E-003	5.901E-001
27.67	1.00	7.020E-001	8.379E-001	1.047E-003	5.423E-001
28.67	1.00	6.720E-001	8.198E-001	9.626E-004	4.985E-001
29.67	1.00	5.633E-001	7.505E-001	8.848E-004	4.582E-001
30.67	1.00	5.200E-001	7.211E-001	8.134E-004	4.212E-001
31.67	1.00	4.162E-001	6.451E-001	7.478E-004	3.872E-001
32.67	1.00	3.767E-001	6.138E-001	6.875E-004	3.560E-001
33.67	1.00	3.389E-001	5.822E-001	6.321E-004	3.274E-001
34.67	1.00	3.122E-001	5.587E-001	5.812E-004	3.010E-001
35.67	1.00	3.310E-001	5.753E-001	5.344E-004	2.768E-001
36.67	1.00	3.810E-001	6.173E-001	4.915E-004	2.545E-001
37.67	1.00	3.534E-001	5.945E-001	4.520E-004	2.341E-001
38.67	1.00	2.963E-001	5.443E-001	4.156E-004	2.153E-001
39.67	1.00	2.883E-001	5.369E-001	3.823E-004	1.980E-001
40.67	1.00	2.410E-001	4.909E-001	3.516E-004	1.821E-001
41.67	1.00	2.389E-001	4.888E-001	3.234E-004	1.675E-001
42.67	1.00	2.052E-001	4.530E-001	2.975E-004	1.541E-001

Y.LI UNWEIGHTED INTAKE (8PM)

INTAKE EVALUATION

******************************** RADIONUCLIDE ********************************

P-32
PHYSICAL HALF-LIFE = 1.428E+001 DAYS

************ RESPIRATORY AND GI TRACT INPUT - DOSIMETRY INPUT ************

ACUTE INGESTION INTAKE

STANDARD ICRP 30 RESPIRATORY TRACT AND GI TRACT MODELS USED

WITH FRACTIONAL UPTAKE FROM GI TRACT (F1) = 8.000E-001
STOCHASTIC (INGESTION) ALI = 6.000E+002 uCi

*************************** SYSTEMIC EXCRETION ***************************

FRACTION OF SYSTEMIC EXCRETION THROUGH URINE = 0.90

******************** PARAMETERS FOR SYSTEMIC MODEL ********************

COMPARTMENT	COEFFICIENT	BIOLOGICAL HALF-LIFE (DAYS)
1	1.500E-001	5.000E-001
2	1.500E-001	2.000E+000
3	4.000E-001	1.900E+001
4	3.000E-001	1.500E+003

**************************** INTAKE ESTIMATE ****************************

INTAKE ESTIMATED FROM INCREMENTAL URINE DATA
ESTIMATE OF INTAKE FROM UNWEIGHTED FIT OF DATA = 5.051E+002 uCi
EXPERIMENTAL ERROR IN INTAKE ESTIMATE = 1.797E+001 uCi

*************************** DOSIMETRY RESULTS ***************************

FRACTION OF STOCHASTIC ALI = 8.4E-001
COMMITTED EFFECTIVE DOSE EQUIVALENT = 4.209E+000 rem

Y.LI UNWEIGHTED INTAKE (8PM)

INTAKE ESTIMATED FROM STATISTICAL EVALUATION OF
P-32 INCREMENTAL URINE DATA

TIME POST INTAKE (DAYS)	URINE COLLECTION PERIOD (DAYS)	BIOASSAY MEASUREMENT (uCi)	ERROR MEASUREMENT (uCi)	RETENTION FRACTION	UNWEIGHTED-FIT EXPECTATION MEASUREMENT (uCi)
10.67	1.00	2.568E+000	1.602E+000	5.068E-003	2.560E+000
11.67	1.00	1.460E+000	1.208E+000	4.491E-003	2.269E+000
12.67	1.00	1.610E+000	1.269E+000	4.015E-003	2.028E+000
13.67	1.00	2.027E+000	1.424E+000	3.614E-003	1.826E+000
14.67	1.00	2.069E+000	1.438E+000	3.271E-003	1.652E+000
15.67	1.00	1.556E+000	1.248E+000	2.972E-003	1.501E+000
16.67	1.00	1.460E+000	1.209E+000	2.708E-003	1.368E+000
17.67	1.00	1.501E+000	1.225E+000	2.473E-003	1.249E+000
18.67	1.00	1.315E+000	1.147E+000	2.263E-003	1.143E+000
19.67	1.00	9.710E-001	9.854E-001	2.073E-003	1.047E+000
20.67	1.00	1.224E+000	1.107E+000	1.900E-003	9.598E-001
21.67	1.00	9.769E-001	9.884E-001	1.743E-003	8.806E-001
22.67	1.00	8.927E-001	9.448E-001	1.600E-003	8.083E-001
23.67	1.00	6.945E-001	8.334E-001	1.469E-003	7.423E-001
24.67	1.00	7.346E-001	8.571E-001	1.350E-003	6.818E-001
25.67	1.00	5.886E-001	7.672E-001	1.240E-003	6.264E-001
26.67	1.00	7.820E-001	8.843E-001	1.140E-003	5.756E-001
27.67	1.00	7.020E-001	8.379E-001	1.047E-003	5.290E-001
28.67	1.00	6.720E-001	8.198E-001	9.626E-004	4.862E-001
29.67	1.00	5.633E-001	7.505E-001	8.848E-004	4.469E-001
30.67	1.00	5.200E-001	7.211E-001	8.134E-004	4.109E-001
31.67	1.00	4.162E-001	6.451E-001	7.478E-004	3.777E-001
32.67	1.00	3.767E-001	6.138E-001	6.875E-004	3.473E-001
33.67	1.00	3.389E-001	5.822E-001	6.321E-004	3.193E-001
34.67	1.00	3.122E-001	5.587E-001	5.812E-004	2.936E-001
35.67	1.00	3.310E-001	5.753E-001	5.344E-004	2.700E-001
36.67	1.00	3.810E-001	6.173E-001	4.915E-004	2.482E-001
37.67	1.00	3.534E-001	5.945E-001	4.520E-004	2.283E-001
38.67	1.00	2.963E-001	5.443E-001	4.156E-004	2.100E-001
39.67	1.00	2.883E-001	5.369E-001	3.823E-004	1.931E-001
40.67	1.00	2.410E-001	4.909E-001	3.516E-004	1.776E-001
41.67	1.00	2.389E-001	4.888E-001	3.234E-004	1.634E-001
42.67	1.00	2.052E-001	4.530E-001	2.975E-004	1.503E-001

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Interpretation of Bioassay Measurements

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PREFACE

The purpose of this report is to provide a practical and consistent method for estimating intakes from bioassay measurements, and to provide guidance in order to establish an effective internal radiation protection program. Our procedure for estimating intakes provides a way to rapidly assess the significance of an e posure. Users of this document will be able to demonstrate compliance with the provisions of 10CFR Part 20, and be able to assure adequate interpretation of bioassay measurements. Additionally this report may be useful in order to (1) establish derived investigation levels in the body or in excreta of exposed persons, (2) determine the frequency of monitoring individuals, and (3) determine the appropriate method of monitoring. Users of this document will be able to adjust their estimate of intake for particle sizes between 0.2 and 10 micrometers, and be able to interpret measurements associated with single, multiple or continuous intakes. Use of this report may also lead to further refinement of models which are used to interpret bioassay measurements.

INTERPRETATION OF BIOASSAY MEASUREMENTS

1. INTRODUCTION

1.1 Problems Associated with Internal Dose Assessment

The estimation of internal radiation doses from radionuclides taken into the body, either by workers or by members of the public, often depends on the proper interpretation of bioassay measurements. Measurements of radioactivity in body organs or in the whole body (in vivo), or measurements in samples of excretion (in vitro), must be interpreted first in terms of the quantity of radioactive material taken into the body by using dynamic mathematical models that describe the translocation, distribution and elimination of specific radionuclides in specified physical and chemical forms. Although area air sampling results can provide estimates of intake for demonstrating compliance with regulatory limits, they are unreliable and inaccurate if exposure to concentrations vary in space and in time. In such cases, personnel monitoring procedures such as breathing zone air sampling and bioassay should be used for the estimation of intakes by workers (Ca 72). After known or suspected exposures have occurred or when the potential for such exposures is sufficiently great, bioassay has been required as a final quality control procedure under the provisions of 10CFR Part 20 (FR86) in order to assure adequate functioning of the air monitoring program and other elements of the internal radiation protection program.

Dose conversion factors have been calculated from ICRP Publication 30 and other models by various authors, and these factors are available to convert estimated or assumed intakes into 50 year committed doses to various body organs or into the so called committed effective dose equivalent to the whole body. However, the models of ICRP Publication 30 used in these calculations do not provide for excretion compartments. Thus, they do not provide a direct way to calculate intakes from excreta bioassay measurements. Intake calculations from bioassay measurements were found to be in demand after the Three Mile Island accident as well as after other significant cases of human intake of radioactive material by workers. Such calculations are made not only to determine compliance with applicable regulations on intake of radioactive material but also to provide continued refinement of estimates of internal dose. Such dose estimates may be needed for both early emergency medical decisions and long-term medical follow up of significantly exposed workers.

To date, the interpretations of bioassay data in terms of intakes have been made using various empirical models that have often produced inconsistent estimates, particularly in the early emergency phases after an accidental intake. The guide we have developed provides a consistent approach to calculating intakes of all important radionuclides from bioassay measurements. In this guide we describe these calculations and present tables of values for intake retention functions, thus providing a practical and consistent way of computing intakes from both in vivo and in vitro bioassay measurements.

For each radionuclide included in Appendix B, intake retention fractions (IRFs) for the inhalation of ICRP Publication 30 Classes D, W, and Y materials are provided. Similar IRF values are given for ingestion intakes. The

tabulated values in Appendix B include the decay factor. The IRF values are applicable to whole-body and lung measurement results as well as the results from urine and fecal analyses. A table of IRF values for the thyroid is provided for converting the results of thyroid measurements into estimates of intake of iodine isotopes. Methods for extending the use of the tables to include conditions of multiple and continuous intakes and for aerosols having a particle size distribution other than 1 micrometer Activity Median Aerodynamic Diameter (AMAD), as used in ICRP Publication 30, are given.

1.2 Criteria for Selecting this Approach, Literature Reviewed, Validation and Verification Methods

The computational method used here was selected because it was recently documented and illustrated in publications by Skrable (Sk80, Sk81, Sk83). Methods for solving for quantities associated with compartmental models, using microcomputers and algorithms, have also been described by Birchall (Bi86), and he indicates a specific algorithm, using BASIC, which executes in seconds. Skrable (Sk81), on the other hand, has written programs using Hewlett Packard language on the HP41CV for solving the retention and excretion of inhaled or ingested materials. The serial-transformation kinetics equation used by both these authors requires that all pathways leading to a compartment of interest be defined. Thus, many applications of the equation are needed to follow a nuclide through the body. Without computers these computations would be tedious. In addition, recent compilations have become available (ICRP74, ICRP77, ICRP83), which are specific for radiation protection, for standard radiological and physiological parameters that describe a radionuclide's fate in the body of a reference adult male. Thus, the computational approach for IRFs was selected based on the availability of current models and parameters, plus the availability of computers.

The ease of computing intakes, on the other hand, can be improved from the availability of tabulated values of the IRFs for both in vivo and in vitro bioassay compartments. The data in these tables are obtained by repetitive application of algorithms similar to those supplied by Birchall and Skrable. In addition, tabular data giving the intake retention fractions, expected to be present in various bioassay compartments are helpful in choosing a bioassay procedure.

In ICRP Publication 30 (ICRP79), the whole-body systemic uptake retention functions in many instances are expressed as a sum of exponential terms. Because of this and because this suited our approach, the criteria used to select an excretion or systemic uptake retention expression was that it be expressed as an exponential or sum of exponentials. Exponential functions are suitable for models which incorporate feedback and recycling of an element such as those for iodine and those used in this manual for the alkaline earth elements. In this study, we use a pseudo-retention function for plutonium based upon an excretion function recently reported by Jones (Jo85). Exponential models were fitted to the alkaline earth metabolism described in ICRP Publication 20 (ICRP72) based upon a model reported by Johnson and Myers (in Sk83), and we used these fitted functions for Ca, Sr, Ba and Ra. These models duplicate the ICRP Task Group's retention function (ICRP72) over the period 0.1 day to 20,000 days post intake but they are used here since they are appropriate functions for the computational method developed by Skrable (Sk83). For all other elements the whole-body systemic uptake retention functions in

ELEMENT DATA SHEET

ELEMENT: PHOSPHORUS

PARTICLE SIZE: 1.0E+00 MICRONS

LUNG DEPOSITION:	NASAL PASSAGES	TRACHEA AND BRONCHIAL TREE	PULMONARY PARENCHYMA
	3.10E-01	8.00E-02	2.49E-01

SYSTEMIC RETENTION:	COEFFICIENT	RATE CONSTANT, 1/DAYS
	1.50E-01	1.39E+00
	1.50E-01	3.47E-01
	4.00E-01	3.65E-02
	3.00E-01	4.62E-04

FRACTION FROM GI TRACT TO BLOOD (f_1): 8.00E-01 INGESTION

8.00E-01 CLASS D 8.00E-01 CLASS W 0.00E+00 CLASS Y

FRACTION OF SYSTEMIC UPTAKE EXCRETED THROUGH URINE (f_u): 9.00E-01

FRACTION OF SYSTEMIC UPTAKE EXCRETED THROUGH FECES (f_f): 1.00E-01

THE COMMON ISOTOPES OF PHOSPHORUS:	MASS NUMBER	HALFLIFE, DAYS
	31	STABLE
	32	1.43E+01
	33	2.54E+01

INGESTION f_1= 8.00E-01 HALFLIFE= 1.43E+01 DAYS PHOSPHORUS 32

TIME AFTER SINGLE INTAKE	FRACTION OF INITIAL INTAKE IN:			
DAYS	24-HOUR URINE	ACCUMULATED URINE	24-HOUR FECES	ACCUMULATED FECES
1.00E-01		7.08E-03		1.19E-03
2.00E-01		2.29E-02		5.45E-03
3.00E-01		3.86E-02		1.20E-02
4.00E-01		5.29E-02		2.02E-02
5.00E-01		6.55E-02		2.94E-02
6.00E-01		7.69E-02		3.93E-02
7.00E-01		8.70E-02		4.93E-02
8.00E-01		9.61E-02		5.94E-02
9.00E-01		1.04E-01		6.93E-02
1.00E+00	1.12E-01	1.12E-01	7.89E-02	7.89E-02
2.00E+00	5.04E-02	1.57E-01	7.21E-02	1.47E-01
3.00E+00	2.73E-02	1.77E-01	3.29E-02	1.73E-01
4.00E+00	1.83E-02	1.87E-01	1.35E-02	1.78E-01
5.00E+00	1.37E-02	1.92E-01	5.69E-03	1.76E-01
6.00E+00	1.09E-02	1.93E-01	2.69E-03	1.70E-01
7.00E+00	8.90E-03	1.93E-01	1.51E-03	1.64E-01
8.00E+00	7.45E-03	1.91E-01	1.01E-03	1.57E-01
9.00E+00	6.37E-03	1.89E-01	7.72E-04	1.50E-01
1.00E+01	5.53E-03	1.85E-01	6.37E-04	1.44E-01
2.00E+01	2.02E-03	1.39E-01	2.24E-04	9.12E-02
3.00E+01	8.61E-04	9.57E-02	9.57E-05	5.73E-02
4.00E+01	3.72E-04	6.33E-02	4.14E-05	3.58E-02
5.00E+01	1.62E-04	4.09E-02	1.80E-05	2.22E-02
6.00E+01	7.08E-05	2.60E-02	7.86E-06	1.38E-02
7.00E+01	3.12E-05	1.64E-02	3.47E-06	8.52E-03
8.00E+01	1.40E-05	1.02E-02	1.55E-06	5.27E-03
9.00E+01	6.33E-06	6.38E-03	7.04E-07	3.25E-03
1.00E+02	2.93E-06	3.96E-03	3.26E-07	2.00E-03

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RADIATION PROTECTION OFFICE

To : Radiation Protection Committee
From : Donald Haes, Assistant Radiation Protection Officer
Subject : Y. Li P-32 Ingestion Assessment
Date : September 11, 1995

The assessment procedure I was asked to use for this incident is outlined in the published proceedings of ICRP-30 (see attachment A). The proceedings outlined the urine concentration investigation level for various radionuclides which would correspond to 20% of the Annual Limit of Intake (ALI) for that particular radionuclide.

The formula I used is the following:

$$[Urine(\mu Ci)][\frac{ALI(\mu Ci)}{Table2(\mu Ci/\ell)X(1.4\ell)}]$$

Where: 20% the ALI **was 27 μCi.**
the Table 2 values lists activity (μCi) in urine **per liter.**
the factor (1.4) normalizes to the 1.4 liter "standard man" urine excretion volume.

In addition, the activity values from Table 2 are only listed for 3, 7, 30, and 60 days past incident. Thus, it was necessary to extrapolate between points. I used a Hewlett Packard model 42S calculator to extrapolate between the points for day 7 through 30 (see attachment B).

The results are listed and plotted on the attached pages (see attachment C).

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Attachment A

INVESTIGATION LEVELS OF RADIOISOTOPES IN THE BODY AND IN URINE. CONSEQUENCES OF THE RECENT RECOMMENDATIONS ON THE ANNUAL LIMITS OF INTAKE

Y. Shamai, M. Tirkel and T. Schlesinger

The recommendations of Committee 2 of the International Commission on Radiological Protection (ICRP) concerning annual limits of intake (ALI) for workers (1) have recently been published. These limits differ in many cases from the maximum permissible annual intake (MPAI) recommended previously by the same committee (2,3). The new recommendations directly influence the derived health physics parameters, such as the acceptable total body burden and concentrations of radioisotopes in the urine.

Radioactivity in the body can be monitored routinely either by whole body counting or indirectly by urine analysis. Thus the monitoring laboratories have to know the relation between the activity in the urine or the body and the committed dose for calculating the latter from their measurements.

The activity of a radioelement in the body at any time t after intake of a unit of activity is given by its retention R(t):

$$R(t) = F_1 \exp(-\lambda t) \sum_i A_i \sum_j B_{ij} \exp(-\lambda_{ij} t)$$

where F_1 is the coefficient expressing the fraction of the intake transferred to the transfer compartment; A_i are coefficients expressing the fractions transferred from the transfer compartment to the i-th organ; B_{ij} are the coefficients of the linear combination of exponentials with decay constants λ_{ij} representing the retention in the i-th organ (1,4) and λ is the physical decay constant.

The amount of activity U(t) excreted in the urine at any time t after the intake of a unit of activity, is given by the first derivative of the biological retention function, multiplied by F_u the fraction of the excretion that is excreted through the urine (3,5):

$$U(t) = F_1 F_u \exp(-\lambda t) \sum_i A_i \sum_j \lambda_{ij} B_{ij} \exp(-\lambda_{ij} t)$$

When the decay constants λ are expressed in days^{-1} then U(t) is the daily excretion. The average daily urine volume is 1.4 liters (5); thus division by 1.4 yields the concentration of the radioelement per liter.

The investigation level at any time t after intake was defined as the concentration of activity in the urine arising from an intake of 1/20 of an ALI (3). An analogous definition is used here for the total body investigation level. A computer code was written which

receives as input the various coefficients $F_1, F_u, A_i, B_{ij}, \lambda_{ij}, \lambda$ and the ALI (1,4) and calculates the investigation levels. Tables 1 and 2 list the investigation levels in the body and the urine of a few commonly used radioisotopes, as a function of time after ingestion. Different tables should be used for the case of inhalation.

TABLE 1. Total body investigation levels as a function of time after ingestion.

Isotope	Organ	Chemical form	Investigation level (µCi) days after ingestion 3	7	30	60
^{22}Na	T.B.*		14	12	4.0	0.97
^{42}K	T.B.		0.51	$2.2 \cdot 10^{-3}$	-	-
^{51}Cr	T.B.	Trivalent	9.1	6.5	2.0	0.73
	T.B.	Hexavalent	91	65	20	7.3
^{57}Co	T.B.	Inorganic	8.4	6.5	3.3	2.5
	T.B.	Organic	26	20	10	7.9
^{60}Co	T.B.	Inorganic	0.52	0.41	0.22	0.18
	T.B.	Organic	1.2	0.92	0.50	0.40
^{59}Fe	T.B.		3.9	3.6	2.5	1.6
^{65}Zn	T.B.		8.5	8.1	6.5	5.3
^{67}Ga	T.B.		0.17	0.056	$0.19 \cdot 10^{-3}$	-
^{75}Se	T.B.	Elemental	5.4	4.2	2.1	1.1
	T.B.	Inorganic	30	23	11	6.2
^{99}Mo	T.B.	Sulfide	1.1	0.39	$0.96 \cdot 10^{-3}$	-
	T.B.	Other	27	9.4	0.023	$9.0 \cdot 10^{-6}$
^{99m}Tc	T.B.		0.66	$3.5 \cdot 10^{-6}$	-	-
^{125}I	Thyroid		0.39	0.36	0.25	0.16
^{131}I	Thyroid		0.31	0.21	0.026	$1.7 \cdot 10^{-3}$
^{137}Cs	T.B.		5.0	4.7	4.0	3.3
^{144}Ce	L.L.I.*		$3.2 \cdot 10^{-3}$	$3.2 \cdot 10^{-3}$	$3.0 \cdot 10^{-3}$	$2.8 \cdot 10^{-3}$
^{226}Ra	B.S.*		$4.8 \cdot 10^{-3}$	$2.9 \cdot 10^{-3}$	$1.5 \cdot 10^{-3}$	$1.2 \cdot 10^{-3}$
^{232}Th	B.S.		$7.3 \cdot 10^{-6}$	$7.3 \cdot 10^{-6}$	$7.2 \cdot 10^{-6}$	$7.2 \cdot 10^{-6}$
^{238}U	B.S.	Hexavalent	$13 \cdot 10^{-3}$	$9.6 \cdot 10^{-3}$	$3.4 \cdot 10^{-3}$	$1.6 \cdot 10^{-3}$
	T.B.	Tetravalent	$7.2 \cdot 10^{-3}$	$5.4 \cdot 10^{-3}$	$1.9 \cdot 10^{-3}$	$0.9 \cdot 10^{-3}$
^{239}Pu	B.S.		$24 \cdot 10^{-6}$	$24 \cdot 10^{-6}$	$24 \cdot 10^{-6}$	$24 \cdot 10^{-6}$
^{241}Am	B.S.		$30 \cdot 10^{-6}$	$30 \cdot 10^{-6}$	$30 \cdot 10^{-6}$	$30 \cdot 10^{-6}$

* T.B. = total body; B.S. = bone surface; L.L.I. = lower large intestine

The following assumptions are inherent in the calculations:

a) The activity build-up time in the organs is assumed to be negligible compared to the decay time. Since the exponential approximation is in any case too crude to use for calculations for the first day no attempt was made to insert the build-up effect in the calculations. Therefore, this calculation should not be used for the first day.

b) The urinary excretion fraction F_u is taken as one constant for all organs and at any time. It will be possible to insert better approximations into the computer code when more biological information is available.

The computer code and Tables 1 and 2 give the levels in the urine and the body arising from an intake that corresponds to a particular committed dose. In the future we shall use the same tables and routines to reverse the procedure and calculate the committed dose from a measured activity.

TABLE 2. Investigation level in urine as a function of time after ingestion.

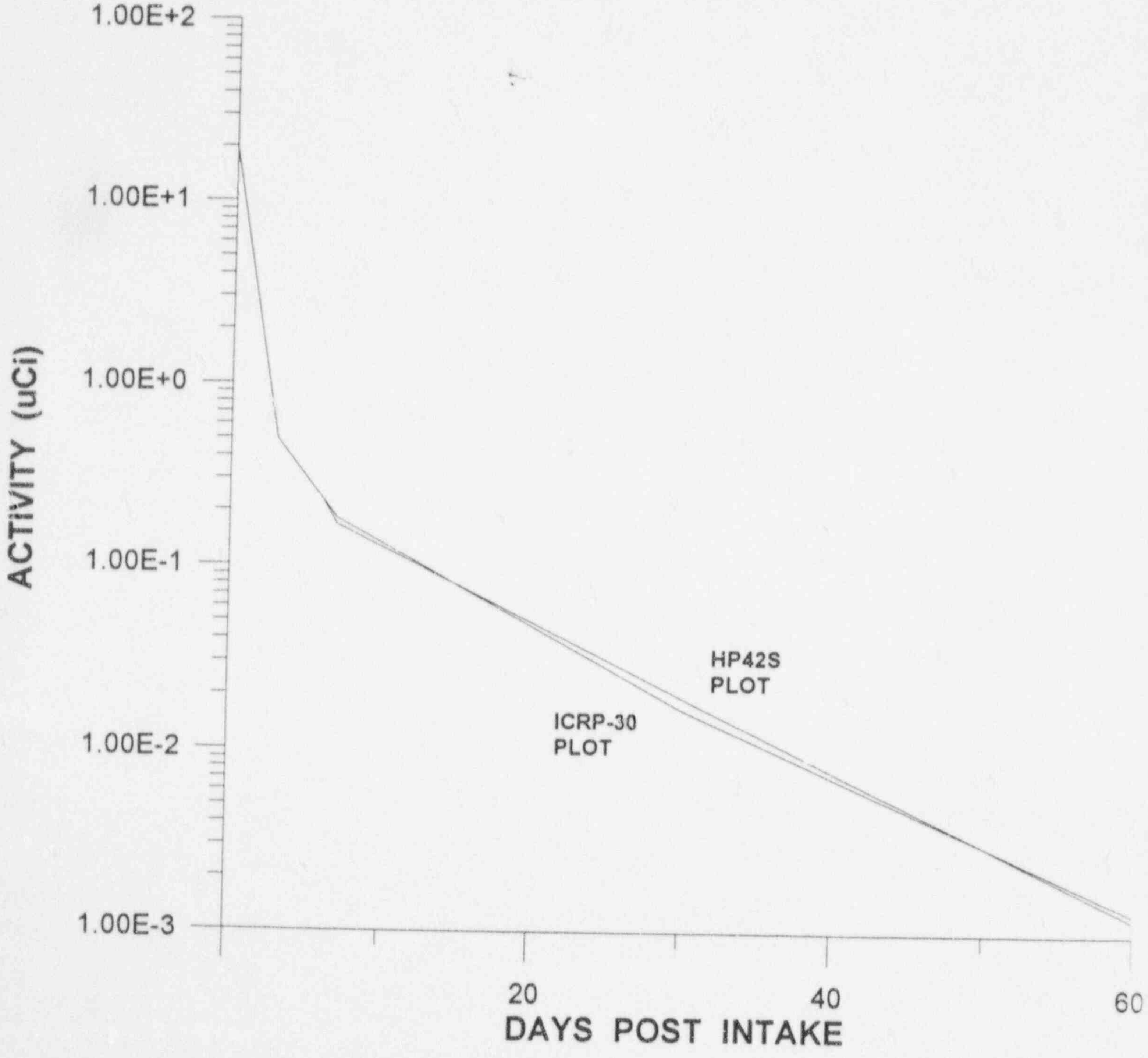
Isotope	Organ	Chemical form	Investigation level (μCi) days after ingestion 3	7	30	60
^{3}H	T.B.	Water	81	62	12	1.6
^{22}Na	T.B.		0.46	0.39	0.13	0.032
^{32}P	T.B.		0.49	0.18	0.017	$1.3\cdot10^{-3}$
^{35}S	L.L.I.	Elemental	0.37	0.068	0.025	$7.2\cdot10^{-3}$
	T.B.	Other	9.3	1.7	0.63	0.18
^{36}Cl	T.B.		3.3	2.5	0.50	0.063
^{42}K	T.B.		$7.1\cdot10^{-3}$	$31\cdot10^{-6}$	-	-
^{45}Ca	T.B.		0.32	0.12	0.024	$8.1\cdot10^{-3}$
^{51}Cr	T.B.	Trivalent	0.21	0.11	$8.2\cdot10^{-3}$	$1.7\cdot10^{-3}$
	T.B.	Hexavalent	2.1	1.1	0.082	0.017
^{57}Co	T.B.	Inorganic	0.37	0.17	0.019	$6.0\cdot10^{-3}$
	T.B.	Organic	1.1	0.52	0.058	0.019
^{60}Co	T.B.	Inorganic	0.023	0.01	$1.2\cdot10^{-3}$	$0.42\cdot10^{-3}$
	T.B.	Organic	0.052	0.024	$2.8\cdot10^{-3}$	$0.96\cdot10^{-3}$
^{65}Zn	T.B.		0.014	0.012	$6.0\cdot10^{-3}$	$2.9\cdot10^{-3}$
^{67}Ga	T.B.		$2.2\cdot10^{-3}$	$0.6\cdot10^{-3}$	$0.8\cdot10^{-6}$	-
^{75}Se	T.B.	Elemental	0.12	0.039	$9.3\cdot10^{-3}$	$3.2\cdot10^{-3}$
	T.B.	Inorganic	0.67	0.21	0.05	0.017
^{85}Sr	T.B.	Titanate	0.021	$5.6\cdot10^{-3}$	$0.32\cdot10^{-3}$	$0.11\cdot10^{-3}$
	T.B.	Other	0.42	0.11	$6.4\cdot10^{-3}$	$2.2\cdot10^{-3}$
^{90}Sr	T.B.	Titanate	$2.7\cdot10^{-3}$	$0.76\cdot10^{-3}$	$55\cdot10^{-6}$	$27\cdot10^{-6}$
	B.S.	Other	$4.8\cdot10^{-3}$	$1.3\cdot10^{-3}$	$0.1\cdot10^{-3}$	$47\cdot10^{-6}$
^{99}Mo	T.B.	Sulfide	0.010	$2.1\cdot10^{-3}$	$5.0\cdot10^{-6}$	-
	T.B.	Other	0.24	0.051	$0.12\cdot10^{-3}$	-
^{99m}Tc	T.B.		0.074	-	-	-
^{125}I	Thyroid		$3.2\cdot10^{-3}$	$0.8\cdot10^{-3}$	$0.54\cdot10^{-3}$	$0.34\cdot10^{-3}$
^{131}I	Thyroid		$2.6\cdot10^{-3}$	$0.46\cdot10^{-3}$	$57\cdot10^{-6}$	$3.7\cdot10^{-6}$
^{137}Cs	T.B.		0.055	0.026	0.014	0.012
^{204}Tl	T.B.		0.87	0.58	0.059	$3.0\cdot10^{-3}$
^{226}Ra	B.S.		$32\cdot10^{-6}$	$8.6\cdot10^{-6}$	$0.6\cdot10^{-6}$	$0.3\cdot10^{-6}$
^{238}U	B.S.	Hexavalent	$0.18\cdot10^{-3}$	$86\cdot10^{-6}$	$16\cdot10^{-6}$	$4.3\cdot10^{-6}$
	T.B.	Tetravalent	$0.1\cdot10^{-3}$	$48\cdot10^{-6}$	$8.9\cdot10^{-6}$	$2.4\cdot10^{-6}$

REFERENCES

1. Annals of the ICRP, ICRP Publ. 30 (1979).
2. ICRP Publ. 6 (1962).
3. ICRP Publ. 10 (1968).
4. Adams, N., Hunt, B.W. and Reissland, J.A. (1978):NRPB-R 82, Harwell.
5. ICRP Publ. 23 (1974).

Attachment B

COMPARISON OF INTERPOLATIONS FROM HP42S CALCULATOR WITH PROCEEDINGS OF ICRP-30



Attachment C

$$[6.39\mu Ci]\left[\frac{27}{(0.2970)(1.4)}\right]=415\,\mu Ci$$

Day 5

$$[5.99\mu Ci]\left[\frac{27}{(0.2315)(1.4)}\right]=499\mu Ci$$

Day 6

$$[3.35\mu Ci]\left[\frac{27}{(0.1800)(1.4)}\right]=359\mu Ci$$

Day 7

$$[3.44\mu Ci]\left[\frac{27}{(0.1520)(1.4)}\right]=436\mu Ci$$

Day 8

$$[2.45\mu Ci]\left[\frac{27}{(0.1385)(1.4)}\right]=341\mu Ci$$

Day 9

$$[2.72\mu Ci]\left[\frac{27}{(0.1262)(1.4)}\right]=416\mu Ci$$

Day 10

$$[1.57\mu Ci]\left[\frac{27}{(0.1150)(1.4)}\right]=263\mu Ci$$

Day 11

$$[1.74\mu Ci]\left[\frac{27}{(0.1048)(1.4)}\right]=321\mu Ci$$

Day 12

$$[2.17\mu Ci]\left[\frac{27}{(0.0955)(1.4)}\right]=438\mu Ci$$

Day 13

$$[2.21\mu Ci]\left[\frac{27}{(0.0870)(1.4)}\right]=490\mu Ci$$

Day 14

$$[1.66\mu Ci]\left[\frac{27}{(0.0793)(1.4)}\right]=404\mu Ci$$

Day 15

$$[1.56\mu Ci]\left[\frac{27}{(0.0723)(1.4)}\right]=416\mu Ci$$

Day 16

$$[1.60\mu Ci]\left[\frac{27}{(0.0659)(1.4)}\right]=468\mu Ci$$

Day 17

$$[1.43\mu Ci]\left[\frac{27}{(0.0600)(1.4)}\right]=460\mu Ci$$

Day 18

$$[1.08\mu Ci]\left[\frac{27}{(0.0547)(1.4)}\right]=381\mu Ci$$

Day 19

$$[1.33\mu Ci]\left[\frac{27}{(0.0498)(1.4)}\right]=515\mu Ci$$

Day 20

$$[1.06\,\mu Ci]\left[\frac{27}{(0.0454)(1.4)}\right] = 450\,\mu Ci$$

Day 21

$$[0.97\,\mu Ci]\left[\frac{27}{(0.0414)(1.4)}\right] = 452\,\mu Ci$$

Day 22

$$[0.88\,\mu Ci]\left[\frac{27}{(0.0377)(1.4)}\right] = 450\,\mu Ci$$

Day 23

$$[0.77\,\mu Ci]\left[\frac{27}{(0.0344)(1.4)}\right] = 432\,\mu Ci$$

Day 24

$$[0.75\,\mu Ci]\left[\frac{27}{(0.0313)(1.4)}\right] = 462\,\mu Ci$$

Day 25

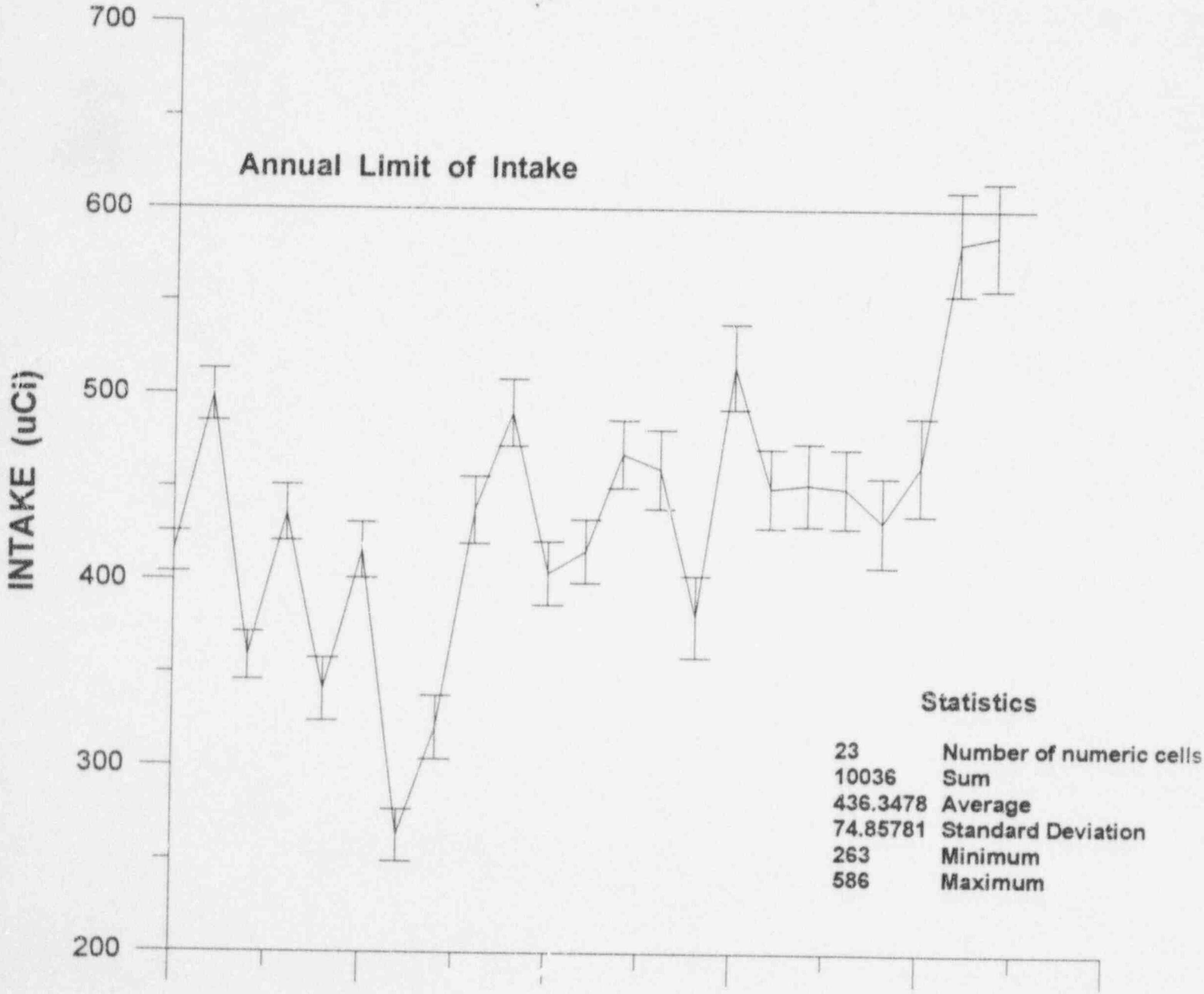
$$[0.86\,\mu Ci]\left[\frac{27}{(0.0285)(1.4)}\right] = 582\,\mu Ci$$

Day 26

$$[0.79\,\mu Ci]\left[\frac{27}{(0.0260)(1.4)}\right] = 586\,\mu Ci$$

Day 27

PROCEEDINGS OF ICRP-30
RESULTS OF Y. Li P-32 INTAKE
CORRECTED TO 8/14/95



Joseph P. Ring
Radiation Protection Services
P. O. Box 391
Groton, MA 01472-0391

October 15, 1995

Frank Masse´
Massachusetts Institute of Technology
20-C-207
77 Massachusetts Ave
Cambridge, MA 02139

Dear Frank:

I calculate Dr. Yoling Li's intake of ^{32}P as 571 μCi based on the data provided by both Mitchell Galanek and by Dr. Li using the International Commission on Radiation Protection (ICRP) models reported in ICRP 30[1] and ICRP 54[2]. I used the whole body counting data, the bioassays from August 19 to 22 as urinary concentration measurements and those from August 23 to September 26 as 24 hr collections. Since the measurements taken at a longer time since exposure are often more significant dosimetrically than those early on which may have fluctuations due to early clearance properties and because the 24-hour urinary collections are a better indicator than the urinary concentrations, the 24-hr data set is exceptionally strong.

Dr. Li and I worked extensively together to review both sets of data and input them into INDOS[3]. In my initial work I assumed a fraction excreted to the urine (F_u) of 0.75 which is an average of the ICRP 30 and ICRP 54 values. However, since the Nuclear Regulatory Commission (NRC) has adopted a F_u of 0.90 in its report NUREG CR-4884, 'Interpretation of Bioassay Measurements', I feel it is appropriate to use 0.90.

Data Location

The bioassay data I used are from the MIT RPO and are not included in this report. However, the decay corrected values are listed in the INDOS printouts attached as Appendix A. The intake values I report are presented in Table 1 with a one standard deviation error estimate.

The data Dr. Li provided is included as Appendix C and the INDOS printouts are in Appendix D.

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1 ICRP Publication 30 , "Limitas for Intakes of Radionuclides by Workers", (New York: Pergamon Press), 1978.

2 ICRP Publication 54, "Individual Monitoring for Inatkes of Radionucides by Workers: Design and Interpretation", (New York: Pergamon Press), 1988.

3 INDOS - Internal Dosimetry Computer Programs, Skrable Enterprises Chelmsford, MA.

The reported intake values determined from Dr. Li's data are summarized as Table 2. The INDOS printouts for my review of the MIT RPO data files are included in Appendix B with the data summarized in Table 3.

Assumptions

As Mr. Galenick and Dr. Li report, the exposure was most probably on August 14, 1995. Since I did not have a better defined time of intake, I assumed it was at noon. I should note that the MIT Radiation Protection Office (RPO) assumed the intake occurred at 8:00PM. This time difference will change the reported number somewhat due to the rapid removal rates in the model. I did not reproduce the measurements reported by either Dr. Li or the MIT RPO since reported radioactivities were in agreement and Dr. Li agreed there was no need.

Prior to entering the data points into INDOS, I corrected the reported concentration to the end of collection and adjusted for background. For the whole body counting system, the data was provided at the end of collection. All the inputs assumed the intake was on August 14 at noon, so with the accumulated 24 hr urine voids ending at 12:00 noon, the INDOS days-since-exposure entry were an integer date. I did not have the time of the whole body count so I assumed an integer number of days-since-exposure. One notable assumption is that the total daily urine volume for Dr. Li is substantially different from ICRP's Reference Man, so I made an adjustment based on the average daily volume from August 22 to September 14 of 2.687 liters per day from the base of 1.4 liters/day. Without this volume correction, the urinary concentration data would not be representative of Dr. Li's intake.

Results

The large number of data points for the 24-hr voids make the accumulated urine samples a very significant data source and the results are in complete agreement with the whole body counting data. These 24-hr void data points may also be more reliable since the longer time-since-exposure places the measurements in the longer clearance rates and should better represent the internal uptake. Since the earlier days are reported by urinary concentration data points and have substantial variation, these data should be considered less reliable. Some of this unreliability can be reduced, for the purposes of comparison to the 24 hr voids, by using an iterative weighted fit. The iterative weighted fit produces a more reliable estimate since it iterates the fitting to achieve the best match between the expected amount and the measured value. Because of this I recommend using the iterative weighted fit (IWF) value as the most representative value.

To determine the intake, I used the data from August 23 to September 28 as 24 hr incremental urine samples, the samples collected from August 19-22 were used as urinary concentrations,

Comparison to Other Data Sources

Dr. Li's data and that of the MIT RPO report an intake that is within 0.5 standard deviations (10 μCi) of my value. With such close agreement for all data sources, using the only internationally

accepted method (ICRP 30 and 54) to determine the intake, I find it difficult to believe the number is substantially different from 570 μCi.

Dr. Li and I entered the data into INDOS for his replicate samples of the 24 hr urine voids and his numbers for the MIT whole body counter, listed in Table 2. The iterative weighted fit for these data reported 582 μCi for the 24 hr urine set and 639 μCi for the whole body counting data. I note that Dr. Li did not believe the whole body data was corrected for background. Subsequent conversations with M. Galanek confirmed that the background was not subtracted.

To validate the intake reported by the MIT RPO, since they were using an older version of INDOS, I reran their INDOS data files, results listed in Table 3. This data reports an intake of 564 μCi assuming the exposure was at noon on August 14, 1995, 548 μCi with the assumption of 8:00 PM intake, and 581 μCi (my number was different than the MIT INDOS-reported value of 579 μCi) for the whole body count bioassay.

Summary

I am very surprised with the exceptionally close agreement between the different types of bioassays and measurements and analysises done by Dr. li and MIT. The IWF value for the 24 hr voids (568 μCi) is remarkably close to the value reported for the urinary concentrations (512 μCi) taken in the first days after intake, especially when one considers the large fluctuations in the urinary concentration data. The intake estimate from the whole body data report an intake of 574 μCi. Since these measurements are all within one standard deviation of each other, I assumed that the full set of 24 hr voids and the whole body measurement results should be averaged to report an intake of 571 μCi.

Sincerely,

Joseph P. Ring, Ph.D., CHP

Table 1
Bioassay Results for Y. Li
MIT Data Source Prepared by J. Ring
August '95 Data
Reported: September 29, 1995
F_u=0.90

Sample Media	Un-weighted Fit	Weighted Fit	Iterative Weighted Fit
24 hr Incrimental Urine (8/22 to 9/14)	511±25	517±26	549±25
Urinary Concentration	484±162	327±146	512±174
Whole Body Data	588±5	569±10	574±8
Full Data Set of 24 hr voids (8/22-9/28)	524±20	542±21	568±20

Table 2
Bioassay Results for Y. Li
Li Data Source **Prepared by Y. Li**
August '95 Data
Reported: September 29, 1995
F_u=0.90

Sample Media	Un-weighted Fit	Weighted Fit	Iterative Weighted Fit
Whole Body Data *Note: This data does not have background subtracted*	613±8	631±12	639±13
Full Data Set of 24 hr voids (8/25-9/28)	537±19	636±17	582±20

Table 3 Bioassay Results for Y. Li MIT Data Source **Prepared by MIT RPO** August '95 Data Reported:October 15, 1995 **F_u=0.90**			
Sample Media	Un-weighted Fit	Weighted Fit	Iterative Weighted Fit
24 hr urine voids, assuming 12:00 Noon Intake	523±17	539±19	564±18
24 hr urine voids assuming 8:00 PM Intake	506±17	522±19	547±18
Whole Body Data	590±5	580±5	581±5

Appendix A

INDOS Printouts for:

MIT Provided data
reviewed and corrected to an assumed intake on August 14, 1995 at Noon
by J. Ring

15-OCT-95

JOSEPH RING

INTAKE EVALUATION - for Urine concentration data to 8-21

****************************** RADIONUCLIDE ******************************

P-32
PHYSICAL HALF-LIFE = 1.428E+001 DAYS

************ RESPIRATORY AND GI TRACT INPUT - DOSIMETRY INPUT ************

ACUTE INGESTION INTAKE

STANDARD ICRP 30 RESPIRATORY TRACT AND GI TRACT MODELS USED

WITH FRACTIONAL UPTAKE FROM GI TRACT (F1) = 8.000E-001
MPC (WATER) = 1.000E+000 uCi/mL
STOCHASTIC (INGESTION) ALI = 6.000E+002 uCi

*************************** SYSTEMIC EXCRETION ***************************

FRACTION OF SYSTEMIC EXCRETION THROUGH URINE = 0.90

VOLUME OF URINE EXCRETED PER DAY = 2.7 LITERS

******************** PARAMETERS FOR SYSTEMIC MODEL ********************

COMPARTMENT	COEFFICIENT	BIOLOGICAL HALF-LIFE (DAYS)
1	1.500E-001	5.000E-001
2	1.500E-001	2.000E+000
3	4.000E-001	1.900E+001
4	3.000E-001	1.500E+003

**************************** INTAKE ESTIMATE ****************************

INTAKE ESTIMATED FROM URINE CONCENTRATION DATA
ESTIMATE OF INTAKE FROM ITERATIVE
WEIGHTED FIT OF DATA = 5.121E+002 uCi
EXPERIMENTAL ERROR IN INTAKE ESTIMATE = 1.735E+002 uCi

*************************** DOSIMETRY RESULTS ***************************

FRACTION OF STOCHASTIC ALI = 8.5E-001
COMMITTED EFFECTIVE DOSE EQUIVALENT = 4.267E+000 rem
NUMBER OF MPC-HRS = 3.724E+000

PAGE 2

INTAKE ESTIMATED FROM STATISTICAL EVALUATION OF
P-32 URINE CONCENTRATION MEASUREMENTS

TIME POST INTAKE (DAYS)	BIOASSAY MEASUREMENT (uCi/L)	ERROR MEASUREMENT (uCi/L)	ITERATIVE WEIGHTED-FIT RETENTION FRACTION (1/L)	EXPECTATION MEASUREMENT (uCi/L)
5.17	3.120E+000	1.619E+000	4.447E-003	2.277E+000
5.42	6.870E+000	2.621E+000	4.208E-003	2.155E+000
5.53	2.370E-001	4.868E-001	4.109E-003	2.104E+000
5.58	7.540E-001	1.058E+000	4.066E-003	2.082E+000
5.62	2.910E-002	1.453E+000	4.031E-003	2.064E+000
5.68	9.096E-001	1.257E+000	3.981E-003	2.039E+000
5.71	4.258E-001	1.221E+000	3.956E-003	2.026E+000
5.85	3.360E-001	1.237E+000	3.844E-003	1.968E+000
5.86	1.797E+000	1.166E+000	3.840E-003	1.966E+000
5.87	1.540E+000	1.010E+000	3.828E-003	1.960E+000
6.77	1.761E+000	1.127E+000	3.221E-003	1.649E+000
6.92	5.637E-001	1.005E+000	3.135E-003	1.606E+000
7.76	1.736E+000	9.592E-001	2.720E-003	1.393E+000
8.07	6.535E+000	9.110E-001	2.589E-003	1.326E+000

15-OCT-95

JOSEPH RING

INTAKE EVALUATION- for all the 24 hr voiding data

****************************** RADIONUCLIDE ******************************

P-32
PHYSICAL HALF-LIFE = 1.428E+001 DAYS

************ RESPIRATORY AND GI TRACT INPUT - DOSIMETRY INPUT ************

ACUTE INGESTION INTAKE

STANDARD ICRP 30 RESPIRATORY TRACT AND GI TRACT MODELS USED

WITH FRACTIONAL UPTAKE FROM GI TRACT (F1) = 8.000E-001
MPC (WATER) = 1.000E+000 uCi/mL
STOCHASTIC (INGESTION) ALI = 6.000E+002 uCi

*************************** SYSTEMIC EXCRETION ***************************

FRACTION OF SYSTEMIC EXCRETION THROUGH URINE = 0.90

********************* PARAMETERS FOR SYSTEMIC MODEL *********************

COMPARTMENT	COEFFICIENT	BIOLOGICAL HALF-LIFE (DAYS)
1	1.500E-001	5.000E-001
2	1.500E-001	2.000E+000
3	4.000E-001	1.900E+001
4	3.000E-001	1.500E+003

****************************** INTAKE ESTIMATE ******************************

INTAKE ESTIMATED FROM INCREMENTAL URINE DATA
ESTIMATE OF INTAKE FROM ITERATIVE
WEIGHTED FIT OF DATA = 5.681E+002 uCi
EXPERIMENTAL ERROR IN INTAKE ESTIMATE = 1.977E+001 uCi

**************************** DOSIMETRY RESULTS ****************************

FRACTION OF STOCHASTIC ALI = 9.5E-001
COMMITTED EFFECTIVE DOSE EQUIVALENT = 4.734E+000 rem
NUMBER OF MPC-HRS = 4.132E+000

PAGE 2

INTAKE ESTIMATED FROM STATISTICAL EVALUATION OF
P-32 INCREMENTAL URINE DATA

TIME POST INTAKE MEASUREMENT (DAYS)	URINE COLLECTION PERIOD (DAYS)	BIOASSAY MEASUREMENT (uCi)	ERROR MEASUREMENT (uCi)	ITERATIVE WEIGHTED-FIT RETENTION FRACTION	EXPECTATION (uCi)
12.00	1.00	1.465E+000	1.210E+000	4.324E-003	2.457E+000
13.00	1.00	1.616E+000	1.271E+000	3.876E-003	2.202E+000
14.00	1.00	2.029E+000	1.424E+000	3.495E-003	1.986E+000
15.00	1.00	2.070E+000	1.439E+000	3.168E-003	1.800E+000
16.00	1.00	1.558E+000	1.453E+000	2.881E-003	1.637E+000
17.00	1.00	1.461E+000	1.209E+000	2.628E-003	1.493E+000
18.00	1.00	1.503E+000	1.226E+000	2.401E-003	1.364E+000
19.00	1.00	1.324E+000	1.15[illegible]E+000	2.198E-003	1.249E+000
20.00	1.00	9.830E-001	9.915E-001	2.014E-003	1.144E+000
21.00	1.00	1.230E+000	1.109E+000	1.847E-003	1.049E+000
22.00	1.00	9.800E-001	9.899E-001	1.695E-003	9.628E-001
23.00	1.00	8.940E-001	9.455E-001	1.556E-003	8.839E-001
24.00	1.00	7.980E-001	8.933E-001	1.429E-003	8.117E-001
25.00	1.00	6.970E-001	8.349E-001	1.313E-003	7.457E-001
26.00	1.00	5.970E-001	7.727E-001	1.206E-003	6.851E-001
27.00	1.00	7.900E-001	8.888E-001	1.108E-003	6.296E-001
28.00	1.00	7.070E-001	8.408E-001	1.019E-003	5.787E-001
29.00	1.00	6.740E-001	8.210E-001	9.362E-004	5.319E-001
30.00	1.00	5.660E-001	7.523E-001	8.606E-004	4.889E-001
31.00	1.00	5.220E-001	7.225E-001	7.911E-004	4.495E-001
32.00	1.00	4.270E-001	6.535E-001	7.273E-004	4.132E-001
33.00	1.00	3.850E-001	6.205E-001	6.687E-004	3.799E-001
34.00	1.00	3.440E-001	5.865E-001	6.148E-004	3.493E-001
35.00	1.00	3.150E-001	5.612E-001	5.653E-004	3.212E-001
36.00	1.00	3.330E-001	5.771E-001	5.199E-004	2.953E-001
37.00	1.00	3.830E-001	6.189E-001	4.781E-004	2.716E-001
38.00	1.00	3.570E-001	5.975E-001	4.396E-004	2.498E-001
39.00	1.00	2.980E-001	5.459E-001	4.043E-004	2.297E-001
40.00	1.00	2.960E-001	5.441E-001	3.719E-004	2.113E-001
41.00	1.00	2.470E-001	4.970E-001	3.420E-004	1.943E-001
42.00	1.00	2.430E-001	4.930E-001	3.146E-004	1.787E-001
43.00	1.00	2.070E-001	4.550E-001	2.894E-004	1.644E-001
44.00	1.00	1.860E-001	4.313E-001	2.662E-004	1.512E-001
45.00	1.00	2.120E-001	4.604E-001	2.449E-004	1.391E-001

15-OCT-95

JOSEPH RING
INTAKE EVALUATION - for 24 hr voids from 8/22 to 9/14

****************************** RADIONUCLIDE ******************************

P-32
PHYSICAL HALF-LIFE = 1.428E+001 DAYS

************ RESPIRATORY AND GI TRACT INPUT - DOSIMETRY INPUT ************

ACUTE INGESTION INTAKE

STANDARD ICRP 30 RESPIRATORY TRACT AND GI TRACT MODELS USED

WITH FRACTIONAL UPTAKE FROM GI TRACT (F1) = 8.000E-001
MPC (WATER) = 1.000E+000 uCi/mL
STOCHASTIC (INGESTION) ALI = 6.000E+002 uCi

**************************** SYSTEMIC EXCRETION ****************************

FRACTION OF SYSTEMIC EXCRETION THROUGH URINE = 0.90

********************* PARAMETERS FOR SYSTEMIC MODEL *********************

COMPARTMENT	COEFFICIENT	BIOLOGICAL HALF-LIFE (DAYS)
1	1.500E-001	5.000E-001
2	1.500E-001	2.000E+000
3	4.000E-001	1.900E+001
4	3.000E-001	1.500E+003

***************************** INTAKE ESTIMATE *****************************

INTAKE ESTIMATED FROM INCREMENTAL URINE DATA
ESTIMATE OF INTAKE FROM ITERATIVE
WEIGHTED FIT OF DATA = 5.490E+002 uCi
EXPERIMENTAL ERROR IN INTAKE ESTIMATE = 2.477E+001 uCi

**************************** DOSIMETRY RESULTS ****************************

FRACTION OF STOCHASTIC ALI = 9.2E-001
COMMITTED EFFECTIVE DOSE EQUIVALENT = 4.575E+000 rem
NUMBER OF MPC-HRS = 3.993E+000

PAGE 2

INTAKE ESTIMATED FROM STATISTICAL EVALUATION OF
P-32 INCREMENTAL URINE DATA

TIME POST INTAKE MEASUREMENT (DAYS)	URINE COLLECTION PERIOD (DAYS)	BIOASSAY MEASUREMENT (uCi)	ERROR MEASUREMENT (uCi)	RETENTION FRACTION	ITERATIVE WEIGHTED-FIT EXPECTATION (uCi)
10.95	1.00	2.620E+000	1.619E+000	4.895E-003	2.687E+000
12.00	1.00	1.500E+000	1.225E+000	4.324E-003	2.374E+000
13.00	1.00	1.670E+000	1.292E+000	3.876E-003	2.128E+000
14.00	1.00	1.120E+000	1.058E+000	3.495E-003	1.919E+000
15.00	1.00	2.110E+000	1.453E+000	3.168E-003	1.739E+000
16.00	1.00	1.580E+000	1.257E+000	2.881E-003	1.582E+000
17.00	1.00	1.490E+000	1.221E+000	2.628E-003	1.443E+000
18.00	1.00	1.530E+000	1.237E+000	2.401E-003	1.318E+000
19.00	1.00	1.360E+000	1.166E+000	2.198E-003	1.207E+000
20.00	1.00	1.020E+000	1.010E+000	2.014E-003	1.106E+000
21.00	1.00	1.270E+000	1.127E+000	1.847E-003	1.014E+000
22.00	1.00	1.010E+000	1.005E+000	1.695E-003	9.304E-001
23.00	1.00	9.200E-001	9.592E-001	1.556E-003	8.541E-001
24.00	1.00	8.300E-001	9.110E-001	1.429E-003	7.844E-001
25.00	1.00	7.400E-001	8.602E-001	1.313E-003	7.206E-001
26.00	1.00	6.300E-001	7.937E-001	1.206E-003	6.621E-001
27.00	1.00	8.200E-001	9.055E-001	1.108E-003	6.084E-001
28.00	1.00	7.400E-001	8.602E-001	1.019E-003	5.592E-001
29.00	1.00	7.100E-001	8.426E-001	9.362E-004	5.140E-001
30.00	1.00	6.100E-001	7.810E-001	8.606E-004	4.725E-001
31.00	1.00	5.600E-001	7.483E-001	7.911E-004	4.343E-001
32.00	1.00	4.700E-001	6.856E-001	7.273E-004	3.993E-001
33.00	1.00	4.200E-001	6.481E-001	6.687E-004	3.671E-001
34.00	1.00	3.900E-001	6.245E-001	6.148E-004	3.375E-001
35.00	1.00	3.500E-001	5.916E-001	5.653E-004	3.104E-001

15-OCT-95

JOSEPH RING

INTAKE EVALUATION - for WB data

****************************** RADIONUCLIDE ******************************

P-32
PHYSICAL HALF-LIFE = 1.428E+001 DAYS

************ RESPIRATORY AND GI TRACT INPUT - DOSIMETRY INPUT ***********

ACUTE INGESTION INTAKE

STANDARD ICRP 30 RESPIRATORY TRACT AND GI TRACT MODELS USED

WITH FRACTIONAL UPTAKE FROM GI TRACT (F1) = 8.000E-001
MPC (WATER) = 1.000E+000 uCi/mL
STOCHASTIC (INGESTION) ALI = 6.000E+002 uCi

********************* PARAMETERS FOR SYSTEMIC MODEL *********************

COMPARTMENT	COEFFICIENT	BIOLOGICAL HALF-LIFE (DAYS)
1	1.500E-001	5.000E-001
2	1.500E-001	2.000E+000
3	4.000E-001	1.900E+001
4	3.000E-001	1.500E+003

***************************** INTAKE ESTIMATE *****************************

INTAKE ESTIMATED FROM WHOLE-BODY BIOASSAY
ESTIMATE OF INTAKE FROM ITERATIVE
WEIGHTED FIT OF DATA = 5.743E+002 uCi
EXPERIMENTAL ERROR IN INTAKE ESTIMATE = 8.017E+000 uCi

*************************** DOSIMETRY RESULTS ***************************

FRACTION OF STOCHASTIC ALI = 9.6E-001
COMMITTED EFFECTIVE DOSE EQUIVALENT = 4.786E+000 rem
NUMBER OF MPC-HRS = 4.177E+000

PAGE 2

INTAKE ESTIMATED FROM STATISTICAL EVALUATION OF
P-32 WHOLE-BODY BIOASSAY

TIME POST INTAKE (DAYS)	BIOASSAY MEASUREMENT (uCi)	ERROR MEASUREMENT (uCi)	ITERATIVE WEIGHTED-FIT RETENTION FRACTION	EXPECTATION MEASUREMENT (uCi)
5.00	2.630E+002	1.622E+001	4.173E-001	2.396E+002
7.00	2.040E+002	1.428E+001	3.553E-001	2.041E+002
8.00	1.940E+002	1.393E+001	3.300E-001	1.895E+002
9.00	1.780E+002	1.342E+001	3.073E-001	1.765E+002
10.00	1.650E+002	1.285E+001	2.865E-001	1.646E+002
11.00	1.570E+002	1.253E+001	2.675E-001	1.536E+002
14.00	1.290E+002	1.136E+001	2.189E-001	1.257E+002
15.00	1.220E+002	1.105E+001	2.050E-001	1.178E+002
16.00	1.090E+002	1.044E+001	1.921E-001	1.103E+002
17.00	1.030E+002	1.015E+001	1.801E-001	1.034E+002
18.00	9.900E+001	9.950E+000	1.689E-001	9.700E+001
22.00	7.600E+001	8.718E+000	1.311E-001	7.530E+001
23.00	6.900E+001	8.307E+000	1.232E-001	7.074E+001
24.00	6.500E+001	8.062E+000	1.158E-001	6.648E+001
25.00	6.600E+001	8.124E+000	1.088E-001	6.249E+001
28.00	5.000E+001	7.071E+000	9.054E-002	5.200E+001
29.00	4.900E+001	7.000E+000	8.521E-002	4.894E+001
30.00	4.500E+001	6.708E+000	8.022E-002	4.607E+001
31.00	4.400E+001	6.633E+000	7.554E-002	4.338E+001
32.00	4.100E+001	6.403E+000	7.115E-002	4.086E+001
35.00	3.400E+001	5.831E+000	5.956E-002	3.420E+001
36.00	2.830E+001	5.320E+000	5.616E-002	3.225E+001
37.00	2.850E+001	5.339E+000	5.297E-002	3.042E+001
38.00	2.780E+001	5.273E+000	4.997E-002	2.870E+001
39.00	2.580E+001	5.079E+000	4.715E-002	2.708E+001
42.00	2.230E+001	4.722E+000	3.968E-002	2.278E+001
43.00	1.980E+001	4.450E+000	3.747E-002	2.152E+001
44.00	1.280E+001	3.578E+000	3.540E-002	2.033E+001
45.00	1.200E+001	3.464E+000	3.345E-002	1.921E+001
46.00	1.070E+001	3.271E+000	3.162E-002	1.816E+001
49.00	9.400E+000	3.066E+000	2.673E-002	1.535E+001
50.00	1.350E+001	3.674E+000	2.528E-002	1.452E+001

Appendix B

INDOS Printouts for:

MIT RPO INDOS Datafiles
rerun on INDOS
by J. Ring

15-OCT-95

JOSEPH RING

INTAKE EVALUATION - MIT Provided file assuming Noon intake

****************************** RADIONUCLIDE ******************************

P-32
PHYSICAL HALF-LIFE = 1.428E+001 DAYS

************ RESPIRATORY AND GI TRACT INPUT - DOSIMETRY INPUT
****

ACUTE INGESTION INTAKE

STANDARD ICRP 30 RESPIRATORY TRACT AND GI TRACT MODELS USED

WITH FRACTIONAL UPTAKE FROM GI TRACT (F1) = 8.000E-001
MPC (WATER) = 1.000E+000 uCi/mL
STOCHASTIC (INGESTION) ALI = 6.000E+002 uCi

************************** SYSTEMIC EXCRETION **************************

FRACTION OF SYSTEMIC EXCRETION THROUGH URINE = 0.90

******************** PARAMETERS FOR SYSTEMIC MODEL
****

COMPARTMENT	COEFFICIENT	BIOLOGICAL HALF-LIFE (DAYS)
1	1.500E-001	5.000E-001
2	1.500E-001	2.000E+000
3	4.000E-001	1.900E+001
4	3.000E-001	1.500E+003

*************************** INTAKE ESTIMATE ***************************

INTAKE ESTIMATED FROM INCREMENTAL URINE DATA
ESTIMATE OF INTAKE FROM ITERATIVE
WEIGHTED FIT OF DATA = 5.642E+002 uCi
EXPERIMENTAL ERROR IN INTAKE ESTIMATE = 1.846E+001 uCi

************************** DOSIMETRY RESULTS **************************

FRACTION OF STOCHASTIC ALI = 9.4E-001
COMMITTED EFFECTIVE DOSE EQUIVALENT = 4.702E+000 rem
NUMBER OF MPC-HRS = 4.103E+000

PAGE 2

INTAKE ESTIMATED FROM STATISTICAL EVALUATION OF
P-32 INCREMENTAL URINE DATA

TIME POST INTAKE (DAYS)	URINE COLLECTION PERIOD (DAYS)	BIOASSAY MEASUREMENT (uCi)	ERROR MEASUREMENT (uCi)	ITERATIVE WEIGHTED-FIT RETENTION FRACTION	EXPECTATION MEASUREMENT (uCi)
11.00	1.00	2.568E+000	1.602E+000	4.865E-003	2.745E+000
12.00	1.00	1.460E+000	1.208E+000	4.324E-003	2.440E+000
13.00	1.00	1.610E+000	1.269E+000	3.876E-003	2.187E+000
14.00	1.00	2.027E+000	1.424E+000	3.495E-003	1.972E+000
15.00	1.00	2.069E+000	1.438E+000	3.168E-003	1.787E+000
16.00	1.00	1.556E+000	1.248E+000	2.881E-003	1.626E+000
17.00	1.00	1.460E+000	1.209E+000	2.628E-003	1.483E+000
18.00	1.00	1.501E+000	1.225E+000	2.401E-003	1.355E+000
19.00	1.00	1.315E+000	1.147E+000	2.198E-003	1.240E+000
20.00	1.00	9.710E-001	9.854E-001	2.014E-003	1.136E+000
21.00	1.00	1.224E+000	1.107E+000	1.847E-003	1.042E+000
22.00	1.00	9.769E-001	9.884E-001	1.695E-003	9.561E-001
23.00	1.00	8.927E-001	9.448E-001	1.556E-003	8.778E-001
24.00	1.00	6.945E-001	8.334E-001	1.429E-003	8.061E-001
25.00	1.00	7.346E-001	8.571E-001	1.313E-003	7.405E-001
26.00	1.00	5.886E-001	7.672E-001	1.206E-003	6.804E-001
27.00	1.00	7.820E-001	8.843E-001	1.108E-003	6.253E-001
28.00	1.00	7.020E-001	8.379E-001	1.019E-003	5.747E-001
29.00	1.00	6.720E-001	8.198E-001	9.362E-004	5.282E-001
30.00	1.00	5.633E-001	7.505E-001	8.606E-004	4.855E-001
31.00	1.00	5.200E-001	7.211E-001	7.911E-004	4.464E-001
32.00	1.00	4.162E-001	6.451E-001	7.273E-004	4.104E-001
33.00	1.00	3.767E-001	6.138E-001	6.687E-004	3.773E-001
34.00	1.00	3.389E-001	5.822E-001	6.148E-004	3.469E-001
35.00	1.00	3.122E-001	5.587E-001	5.653E-004	3.190E-001
36.00	1.00	3.310E-001	5.753E-001	5.199E-004	2.933E-001
37.00	1.00	3.810E-001	6.173E-001	4.781E-004	2.697E-001
38.00	1.00	3.534E-001	5.945E-001	4.396E-004	2.480E-001
39.00	1.00	2.963E-001	5.443E-001	4.043E-004	2.281E-001
40.00	1.00	2.883E-001	5.369E-001	3.719E-004	2.098E-001
41.00	1.00	2.410E-001	4.909E-001	3.420E-004	1.930E-001
42.00	1.00	2.389E-001	4.888E-001	3.146E-004	1.775E-001
43.00	1.00	2.052E-001	4.530E-001	2.894E-004	1.633E-001
44.00	1.00	1.327E-001	3.643E-001	2.662E-004	1.502E-001
45.00	1.00	2.110E-001	4.593E-001	2.449E-004	1.382E-001
46.00	1.00	1.970E-001	4.438E-001	2.253E-004	1.271E-001
47.00	1.00	1.944E-001	4.409E-001	2.073E-004	1.170E-001
48.00	1.00	1.567E-001	3.959E-001	1.907E-004	1.076E-001
49.00	1.00	1.480E-001	3.847E-001	1.755E-004	9.902E-002

15-OCT-95

JOSEPH RING

INTAKE EVALUATION - MIT Provided file assuming 8PM intake

******************************* RADIONUCLIDE *******************************

P-32
PHYSICAL HALF-LIFE = 1.428E+001 DAYS

************ RESPIRATORY AND GI TRACT INPUT - DOSIMETRY INPUT ************

ACUTE INGESTION INTAKE

STANDARD ICRP 30 RESPIRATORY TRACT AND GI TRACT MODELS USED

WITH FRACTIONAL UPTAKE FROM GI TRACT (F1) = 8.000E-001
MPC (WATER) = 1.000E+000 uCi/mL
STOCHASTIC (INGESTION) ALI = 6.000E+002 uCi

*************************** SYSTEMIC EXCRETION ***************************

FRACTION OF SYSTEMIC EXCRETION THROUGH URINE = 0.90

********************* PARAMETERS FOR SYSTEMIC MODEL *********************

COMPARTMENT	COEFFICIENT	BIOLOGICAL HALF-LIFE (DAYS)
1	1.500E-001	5.000E-001
2	1.500E-001	2.000E+000
3	4.000E-001	1.900E+001
4	3.000E-001	1.500E+003

***************************** INTAKE ESTIMATE *****************************

INTAKE ESTIMATED FROM INCREMENTAL URINE DATA
ESTIMATE OF INTAKE FROM ITERATIVE
WEIGHTED FIT OF DATA = 5.467E+002 uCi
EXPERIMENTAL ERROR IN INTAKE ESTIMATE = 1.811E+001 uCi

*************************** DOSIMETRY RESULTS ***************************

FRACTION OF STOCHASTIC ALI = 9.1E-001
COMMITTED EFFECTIVE DOSE EQUIVALENT = 4.556E+000 rem
NUMBER OF MPC-HRS = 3.976E+000

PAGE 2

INTAKE ESTIMATED FROM STATISTICAL EVALUATION OF
P-32 INCREMENTAL URINE DATA

TIME POST INTAKE (DAYS)	URINE COLLECTION PERIOD (DAYS)	BIOASSAY MEASUREMENT (uCi)	ITERATIVE WEIGHTED-FIT ERROR MEASUREMENT (uCi)	RETENTION FRACTION	EXPECTATION MEASUREMENT (uCi)
10.67	1.00	2.568E+000	1.602E+000	5.068E-003	2.771E+000
11.67	1.00	1.460E+000	1.208E+000	4.491E-003	2.455E+000
12.67	1.00	1.610E+000	1.269E+000	4.015E-003	2.195E+000
13.67	1.00	2.027E+000	1.424E+000	3.614E-003	1.976E+000
14.67	1.00	2.069E+000	1.438E+000	3.271E-003	1.788E+000
15.67	1.00	1.556E+000	1.248E+000	2.972E-003	1.625E+000
16.67	1.00	1.460E+000	1.209E+000	2.708E-003	1.480E+000
17.67	1.00	1.501E+000	1.225E+000	2.473E-003	1.352E+000
18.67	1.00	1.315E+000	1.147E+000	2.263E-003	1.237E+000
19.67	1.00	9.710E-001	9.854E-001	2.073E-003	1.133E+000
20.67	1.00	1.224E+000	1.107E+000	1.900E-003	1.039E+000
21.67	1.00	9.769E-001	9.884E-001	1.743E-003	9.531E-001
22.67	1.00	8.927E-001	9.448E-001	1.600E-003	8.748E-001
23.67	1.00	6.945E-001	8.334E-001	1.469E-003	8.033E-001
24.67	1.00	7.346E-001	8.571E-001	1.350E-003	7.379E-001
25.67	1.00	5.886E-001	7.672E-001	1.240E-003	6.780E-001
26.67	1.00	7.820E-001	8.843E-001	1.140E-003	6.230E-001
27.67	1.00	7.020E-001	8.379E-001	1.047E-003	5.725E-001
28.67	1.00	6.720E-001	8.198E-001	9.626E-004	5.262E-001
29.67	1.00	5.633E-001	7.505E-001	8.848E-004	4.837E-001
30.67	1.00	5.200E-001	7.211E-001	8.134E-004	4.447E-001
31.67	1.00	4.162E-001	6.451E-001	7.478E-004	4.088E-001
32.67	1.00	3.767E-001	6.138E-001	6.875E-004	3.758E-001
33.67	1.00	3.389E-001	5.822E-001	6.321E-004	3.456E-001
34.67	1.00	3.122E-001	5.587E-001	5.812E-004	3.177E-001
35.67	1.00	3.310E-001	5.753E-001	5.344E-004	2.922E-001
36.67	1.00	3.810E-001	6.173E-001	4.915E-004	2.687E-001
37.67	1.00	3.534E-001	5.945E-001	4.520E-004	2.471E-001
38.67	1.00	2.963E-001	5.443E-001	4.156E-004	2.272E-001
39.67	1.00	2.883E-001	5.369E-001	3.823E-004	2.090E-001
40.67	1.00	2.410E-001	4.909E-001	3.516E-004	1.922E-001
41.67	1.00	2.389E-001	4.888E-001	3.234E-004	1.768E-001
42.67	1.00	2.052E-001	4.530E-001	2.975E-004	1.626E-001
43.67	1.00	1.327E-001	3.643E-001	2.736E-004	1.496E-001
44.67	1.00	2.110E-001	4.593E-001	2.517E-004	1.376E-001
45.67	1.00	1.970E-001	4.438E-001	2.316E-004	1.266E-001
46.67	1.00	1.944E-001	4.409E-001	2.131E-004	1.165E-001
47.67	1.00	1.567E-001	3.959E-001	1.960E-004	1.072E-001
48.67	1.00	1.480E-001	3.847E-001	1.804E-004	9.862E-002

15-OCT-95

JOSEPH RING
INTAKE EVALUATION - MIT provided file for Whole Body Count

****************************** RADIONUCLIDE ******************************

P-32
PHYSICAL HALF-LIFE = 1.428E+001 DAYS

************ RESPIRATORY AND GI TRACT INPUT - DOSIMETRY INPUT ************

ACUTE INGESTION INTAKE

STANDARD ICRP 30 RESPIRATORY TRACT AND GI TRACT MODELS USED

WITH FRACTIONAL UPTAKE FROM GI TRACT (F1) = 8.000E-001
MPC (WATER) = 1.000E+000 uCi/mL
STOCHASTIC (INGESTION) ALI = 6.000E+002 uCi

********************* PARAMETERS FOR SYSTEMIC MODEL *********************

COMPARTMENT	COEFFICIENT	BIOLOGICAL HALF-LIFE (DAYS)
1	1.500E-001	5.000E-001
2	1.500E-001	2.000E+000
3	4.000E-001	1.900E+001
4	3.000E-001	1.500E+003

***************************** INTAKE ESTIMATE *****************************

INTAKE ESTIMATED FROM WHOLE-BODY BIOASSAY
ESTIMATE OF INTAKE FROM ITERATIVE
WEIGHTED FIT OF DATA = 5.809E+002 uCi
EXPERIMENTAL ERROR IN INTAKE ESTIMATE = 4.565E+000 uCi

**************************** DOSIMETRY RESULTS ****************************

FRACTION OF STOCHASTIC ALI = 9.7E-001
COMMITTED EFFECTIVE DOSE EQUIVALENT = 4.840E+000 rem
NUMBER OF MPC-HRS = 4.224E+000

PAGE 2

INTAKE ESTIMATED FROM STATISTICAL EVALUATION OF
P-32 WHOLE-BODY BIOASSAY

TIME POST INTAKE (DAYS)	BIOASSAY MEASUREMENT (uCi)	ERROR MEASUREMENT (uCi)	ITERATIVE WEIGHTED-FIT RETENTION FRACTION	EXPECTATION MEASUREMENT (uCi)
5.00	2.670E+002	1.634E+001	4.173E-001	2.424E+002
7.00	2.040E+002	1.428E+001	3.553E-001	2.064E+002
8.00	1.940E+002	1.393E+001	3.300E-001	1.917E+002
9.00	1.780E+002	1.334E+001	3.073E-001	1.785E+002
10.00	1.650E+002	1.285E+001	2.865E-001	1.664E+002
11.00	1.570E+002	1.253E+001	2.675E-001	1.554E+002
14.00	1.290E+002	1.136E+001	2.189E-001	1.272E+002
15.00	1.220E+002	1.105E+001	2.050E-001	1.191E+002
16.00	1.090E+002	1.044E+001	1.921E-001	1.116E+002
17.00	1.030E+002	1.015E+001	1.801E-001	1.046E+002
18.00	9.900E+001	9.950E+000	1.689E-001	9.811E+001
22.00	7.600E+001	8.718E+000	1.311E-001	7.616E+001
23.00	6.900E+001	8.307E+000	1.232E-001	7.155E+001
24.00	6.500E+001	8.062E+000	1.158E-001	6.724E+001
25.00	6.600E+001	8.124E+000	1.088E-001	6.320E+001
28.00	5.000E+001	7.071E+000	9.054E-002	5.259E+001
29.00	4.900E+001	7.000E+000	8.521E-002	4.950E+001
30.00	4.500E+001	6.708E+000	8.022E-002	4.660E+001
31.00	4.400E+001	6.633E+000	7.554E-002	4.388E+001
32.00	4.100E+001	6.403E+000	7.115E-002	4.133E+001
35.00	3.400E+001	5.831E+000	5.956E-002	3.459E+001
36.00	2.830E+001	5.320E+000	5.616E-002	3.262E+001
37.00	2.850E+001	5.339E+000	5.297E-002	3.077E+001
38.00	2.780E+001	5.273E+000	4.997E-002	2.902E+001
39.00	2.580E+001	5.079E+000	4.715E-002	2.739E+001
42.00	2.230E+001	4.722E+000	3.968E-002	2.305E+001
43.00	1.980E+001	4.450E+000	3.747E-002	2.177E+001
44.00	1.980E+001	4.450E+000	3.540E-002	2.056E+001
45.00	1.840E+001	4.290E+000	3.345E-002	1.943E+001
46.00	1.650E+001	4.062E+000	3.162E-002	1.837E+001
49.00	1.450E+001	3.808E+000	2.673E-002	1.552E+001
50.00	1.350E+001	3.674E+000	2.528E-002	1.468E+001

Appendix C

Data provided by
Y. Li
on September 29, 1995

Whole Body Counts 09/28/95

	date/time of measurment	days post-ingestion	counts	adjusted counts	radioactivity (uCi)	IRF	radioactivity day 0 (uCi)
1	8/19 20:49	5	119,329	121,493	264.00	4.17E-1	633
2	8/21 17:05	7	94,012	94,966	206.36	3.55E-1	581
3	8/22 14:43	8	89,460	89,949	195.46	3.30E-1	592
4	8/23 15:13	9	82,868	83,408	181.24	3.07E-1	590
5	8/24 16:41	10	77,219	77,955	169.39	2.87E-1	590
6	8/25 16:25	11	73,921	74,546	161.99		
7	8/28 16:46	14	61,561	62,157	135.06		
8	8/29 13:25	15	58,839	59,008	128.22		
9	8/30 14:52	16	53,326	53,636	116.55		
10	8/31 13:48	17	50,691	50,876	110.55		
11	9/01 14:48	18	48,652	48,928	106.32		
12	9/05 15:38	22	38,763	39,048	84.85		
13	9/06 14:29	23	36,139	36,322	78.93		
14	9/07 14:34	24	34,069	34,246	74.42		
15	9/08 13:47	25	34,721	34,846	75.72		
16	9/11 14:36	28	27,988	28,135	61.14		
17	9/12 12:51	29	27,138	27,185	59.07		
18	9/13 14:19	30	25,813	25,934	56.35	8.03E-2	702
19	9/14 13:44	31	25,120	25,208	54.78		
20	9/15 14:07	32	23,696	23,798	51.71		
21	9/18 14:48	35	20,919	21,038	45.71		
22	9/19 13:43	36	18,458	18,522	40.25		
23	9/20 15:15	37	18,522	18,644	40.51		
24	9/21 15:43	38	18,257	18,395	39.97		
25	9/22 10:51	39	17,388	17,348	37.70		
26	9/25 13:31	42	15,861	15,910	34.57		
27	9/26 13:33	43	14,803	14,849	32.27		
28	9/27 13:09	44	14,790	14,824	32.21		
29	9/28 13:39	45	14,202	14,249	30.96		
30	9/29	46					
31	9/30	47					
32	10/01						

DATE	DAY	VOL ml	cpm	cpm-backg	adj. DPM	total activity (MIT)	total activity LI (uCi)	NOTE
9/11 12:00- 9/12 12:00	29	2520	583 610	554 581	597	0.677 uCi	0.742	
9/12 12:00- 9/13 12:00	30	2870	439 452	410 423	438	0.566 uCi	0.572	
9/13 12:00- 9/14 12:00	31	2150	562 559	533 530	540	0.523	0.561	
9/14 12:00- 9/15 12:00	32	3140	257 283	228 254	293	0.414	0.439	
9/15 12:00- 9/16 12:00	33	2420	340 319	311 290	348	0.397	0.407	
9/16 12:00- 9/17 12:00	34	3240	244 233	215 204	231	0.337	0.354	
9/17 12:00- 9/18 12:00	35	2220	336 312	307 283	310	0.310	0.315	
9/18 12:00- 9/19 12:00	36						0.344	
9/19 12:00- 9/20 12:00	37	2500	373 325	344 296	336	0.379	0.306	
9/20 12:00- 9/21 12:00	38	2960	283 274	254 245	262	0.350	0.341	
9/21 12:00- 9/22 12:00	39	2120	337 338	308 309	314	0.300	0.311	
9/22 12:00- 9/23 12:00	40	2860	229 215	200 186	224	0.289	0.268	
9/23 12:00- 9/24 12:00	41	3250	173 184	144 155	165	0.242	0.257	
9/24 12:00- 9/25 12:00	42	3080	188 199	159 170	173	0.241	0.263	
9/25 12:00- 9/26 12:00	43	2660	206 184	177 155	169	0.202	0.210	
9/26 12:00- 9/27 12:00	44	2250	195 197	166 168	181	0.183	0.219	
9/27 12:00- 9/28 12:00	45	3230	176 163	147 134	143	0.208	0.211	602±244 665±271
9/28 12:00- 9/29 12:00	46							

Appendix D

INDOS Printouts for:

Dr. Yoling Li provided data

	DATE	DAY	VOL ml	cpm	cpm-backg	adj. DPM	total acti-vity (MIT)	total activi-ty LI (uCi)	NOTE
18	8/24 12:00- 8/25 12:00	11	3000	1933 1873	1904 1844	1908	2.578	2.562	
19	8/25 12:00- 8/26 12:00	12	2670	1087 1139	1058 1110	1214	1.460	1.517	
20	8/26 12:00- 8/27 12:00	13	3780	877 950	848 921	944	1.607 uCi	1.593	
21	8/27 12:00- 8/28 12:00	14	3420	1368 1292	1339 1263	1322	2.037 uCi	2.064	
22	8/28 12:00- 8/29 12:00	15	2880	1571 1651	1542 1622	1601	2.077 uCi	2.055	
23	8/29 12:00- 8/30 12:00	16	2760	1249 1294	1220 1265	1265	1.573 uCi	1.664	
24	8/30 12:00- 8/31 12:00	17	2180	1446 1552	1417 1523	1489	1.462 uCi	1.529	
25	8/31 12:00- 9/01 12:00	18	2270	1417 1547	1388 1518	1479	1.513 uCi	1.573	
26	9/01 12:00- 9/02 12:00	19	2940	825 920	796 891	994	1.316 uCi	1.360	
27	9/02 12:00- 9/03 12:00	20	3680	542 561	513 532	587	0.972 uCi	0.985	
28	9/03 12:00- 9/04 12:00	21	3250	805 829	776 800	843	1.234 uCi	1.315	
29	9/04 12:00- 9/05 12:00	22	2500	883 885	854 856	871	0.981 uCi	1.044	
29	9/05 12:00- 9/06 12:00	23	2720	771 722	742 693	729	0.893 uCi	1.009	10-15% missing
30	9/06 12:00- 9/07 12:00	24	2205	771 811	742 782	794	0.789 uCi	0.885	
31	9/07 12:00- 9/08 12:00	25	2750	574 584	545 555	565	0.700 uCi	0.742	
32	9/08 12:00- 9/09 12:00	26	2610	439 449	410 420	504	0.593 uCi	0.706	
33	9/09 12:00- 9/10 12:00	27	2490	632 632	603 603	698	0.783 uCi	0.807	
34	9/10 12:00- 9/11 12:00	28	2540	574 598	545 569	615	0.703 uCi	0.773	

15-OCT-95

JOSEPH RING

INTAKE EVALUATION for Y. Li provided 24 hr void Data on 9-29-95

****************************** RADIONUCLIDE ******************************

P-32
PHYSICAL HALF-LIFE = 1.428E+001 DAYS

************ RESPIRATORY AND GI TRACT INPUT - DOSIMETRY INPUT ************

ACUTE INGESTION INTAKE

STANDARD ICRP 30 RESPIRATORY TRACT AND GI TRACT MODELS USED

WITH FRACTIONAL UPTAKE FROM GI TRACT (F1) = 8.000E-001
MPC (WATER) = 1.000E+000 uCi/mL
STOCHASTIC (INGESTION) ALI = 6.000E+002 uCi

*************************** SYSTEMIC EXCRETION ***************************

FRACTION OF SYSTEMIC EXCRETION THROUGH URINE = 0.90

********************* PARAMETERS FOR SYSTEMIC MODEL *********************

COMPARTMENT	COEFFICIENT	BIOLOGICAL HALF-LIFE (DAYS)
1	1.500E-001	5.000E-001
2	1.500E-001	2.000E+000
3	4.000E-001	1.900E+001
4	3.000E-001	1.500E+003

***************************** INTAKE ESTIMATE *****************************

INTAKE ESTIMATED FROM INCREMENTAL URINE DATA
ESTIMATE OF INTAKE FROM ITERATIVE
WEIGHTED FIT OF DATA = 5.824E+002 uCi
EXPERIMENTAL ERROR IN INTAKE ESTIMATE = 2.013E+001 uCi

*************************** DOSIMETRY RESULTS ***************************

FRACTION OF STOCHASTIC ALI = 9.7E-001
COMMITTED EFFECTIVE DOSE EQUIVALENT = 4.853E+000 rem
NUMBER OF MPC-HRS = 4.236E+000

PAGE 2

INTAKE ESTIMATED FROM STATISTICAL EVALUATION OF
P-32 INCREMENTAL URINE DATA

TIME POST INTAKE (DAYS)	URINE COLLECTION PERIOD (DAYS)	BIOASSAY MEASUREMENT (uCi)	ERROR MEASUREMENT (uCi)	ITERATIVE WEIGHTED-FIT RETENTION FRACTION	EXPECTATION MEASUREMENT (uCi)
11.00	1.00	2.562E+000	1.601E+000	4.865E-003	2.833E+000
12.00	1.00	1.517E+000	1.232E+000	4.324E-003	2.518E+000
13.00	1.00	1.593E+000	1.262E+000	3.876E-003	2.257E+000
14.00	1.00	2.064E+000	1.437E+000	3.495E-003	2.036E+000
15.00	1.00	2.055E+000	1.434E+000	3.168E-003	1.845E+000
16.00	1.00	1.664E+000	1.290E+000	2.881E-003	1.678E+000
17.00	1.00	1.529E+000	1.237E+000	2.628E-003	1.530E+000
18.00	1.00	1.573E+000	1.254E+000	2.401E-003	1.398E+000
19.00	1.00	1.360E+000	1.166E+000	2.198E-003	1.280E+000
20.00	1.00	9.850E-001	9.925E-001	2.014E-003	1.173E+000
21.00	1.00	1.315E+000	1.147E+000	1.847E-003	1.076E+000
22.00	1.00	1.044E+000	1.022E+000	1.695E-003	9.869E-001
24.00	1.00	8.850E-001	9.407E-001	1.429E-003	8.321E-001
25.00	1.00	7.420E-001	8.614E-001	1.313E-003	7.644E-001
26.00	1.00	7.060E-001	8.402E-001	1.206E-003	7.023E-001
27.00	1.00	8.070E-001	8.983E-001	1.108E-003	6.454E-001
28.00	1.00	7.730E-001	8.792E-001	1.019E-003	5.932E-001
29.00	1.00	7.420E-001	8.614E-001	9.362E-004	5.452E-001
30.00	1.00	5.720E-001	7.563E-001	8.606E-004	5.012E-001
31.00	1.00	5.610E-001	7.490E-001	7.911E-004	4.607E-001
32.00	1.00	4.390E-001	6.626E-001	7.273E-004	4.236E-001
33.00	1.00	4.070E-001	6.380E-001	6.687E-004	3.894E-001
34.00	1.00	3.540E-001	5.950E-001	6.148E-004	3.581E-001
35.00	1.00	3.150E-001	5.612E-001	5.653E-004	3.292E-001
36.00	1.00	3.440E-001	5.865E-001	5.199E-004	3.028E-001
37.00	1.00	3.060E-001	5.532E-001	4.781E-004	2.784E-001
38.00	1.00	3.410E-001	5.840E-001	4.396E-004	2.560E-001
39.00	1.00	3.110E-001	5.577E-001	4.043E-004	2.355E-001
40.00	1.00	2.680E-001	5.177E-001	3.719E-004	2.166E-001
41.00	1.00	2.570E-001	5.070E-001	3.420E-004	1.992E-001
42.00	1.00	2.630E-001	5.128E-001	3.146E-004	1.832E-001
43.00	1.00	2.100E-001	4.583E-001	2.894E-004	1.685E-001
44.00	1.00	2.190E-001	4.680E-001	2.662E-004	1.550E-001
45.00	1.00	2.110E-001	4.593E-001	2.449E-004	1.426E-001

JOSEPH RING

time adjusted WB data MIT-Li

INTAKE ESTIMATED FROM STATISTICAL EVALUATION OF
P-32 WHOLE-BODY BIOASSAY

TIME POST INTAKE (DAYS)	BIOASSAY MEASUREMENT (uCi)	ERROR MEASUREMENT (uCi)	RETENTION FRACTION	ITERATIVE WEIGHTED-FIT EXPECTATION MEASUREMENT (uCi)
5.00	2.640E+002	1.625E+001	4.204E-001	2.685E+002
7.00	2.064E+002	1.437E+001	3.571E-001	2.281E+002
8.00	1.955E+002	1.123E+001	3.315E-001	2.117E+002
9.00	1.812E+002	1.346E+001	3.085E-001	1.970E+002
10.00	1.694E+002	1.302E+001	2.876E-001	1.837E+002
11.00	1.620E+002	1.273E+001	2.684E-001	1.715E+002
14.00	1.351E+002	1.162E+001	2.196E-001	1.403E+002
15.00	1.282E+002	1.132E+001	2.056E-001	1.313E+002
16.00	1.166E+002	1.080E+001	1.926E-001	1.231E+002
17.00	1.106E+002	1.052E+001	1.806E-001	1.153E+002
18.00	1.063E+002	1.031E+001	1.693E-001	1.082E+002
22.00	8.490E+001	9.214E+000	1.314E-001	8.395E+001
23.00	7.890E+001	8.883E+000	1.235E-001	7.886E+001
24.00	7.440E+001	8.626E+000	1.160E-001	7.410E+001
25.00	7.570E+001	8.701E+000	1.090E-001	6.966E+001
28.00	6.110E+001	7.817E+000	9.072E-002	5.795E+001
29.00	5.910E+001	7.688E+000	8.538E-002	5.454E+001
30.00	5.640E+001	7.510E+000	8.037E-002	5.134E+001
31.00	5.480E+001	7.403E+000	7.568E-002	4.834E+001
32.00	5.170E+001	7.190E+000	7.128E-002	4.553E+001
35.00	4.570E+001	6.760E+000	5.966E-002	3.811E+001
36.00	4.030E+001	6.348E+000	5.625E-002	3.593E+001
37.00	4.050E+001	6.364E+000	5.305E-002	3.389E+001
38.00	4.000E+001	6.325E+000	5.005E-002	3.197E+001
39.00	3.770E+001	6.140E+000	4.722E-002	3.017E+001
42.00	3.460E+001	5.882E+000	3.973E-002	2.533E+001
43.00	3.230E+001	5.683E+000	3.752E-002	2.397E+001
44.00	3.220E+001	5.675E+000	3.545E-002	2.264E+001
45.00	3.096E+001	5.564E+000	3.350E-002	2.140E+001

29-SEP-95

JOSEPH RING

time adjusted WB data MIT-Li

INTAKE EVALUATION

****************************** RADIONUCLIDE ******************************

P-32
PHYSICAL HALF-LIFE = 1.428E+001 DAYS

************ RESPIRATORY AND GI TRACT INPUT - DOSIMETRY INPUT ************

ACUTE INGESTION INTAKE

STANDARD ICRP 30 RESPIRATORY TRACT AND GI TRACT MODELS USED

WITH FRACTIONAL UPTAKE FROM GI TRACT (F1) = 8.000E-001
MPC (WATER) = 1.000E+000 uCi/mL
STOCHASTIC (INGESTION) ALI = 6.000E+002 uCi

******************** PARAMETERS FOR SYSTEMIC MODEL ********************

COMPARTMENT	COEFFICIENT	BIOLOGICAL HALF-LIFE (DAYS)
1	1.500E-001	5.000E-001
2	1.500E-001	2.000E+000
3	4.000E-001	1.900E+001
4	3.000E-001	1.500E+003

***************************** INTAKE ESTIMATE *****************************

INTAKE ESTIMATED FROM WHOLE-BODY BIOASSAY
ESTIMATE OF INTAKE FROM ITERATIVE
WEIGHTED FIT OF DATA = 6.388E+002 uCi
EXPERIMENTAL ERROR IN INTAKE ESTIMATE = 1.317E+001 uCi

**************************** DOSIMETRY RESULTS ****************************

FRACTION OF STOCHASTIC ALI = 1.1E+000
COMMITTED EFFECTIVE DOSE EQUIVALENT = 5.323E+000 rem
NUMBER OF MPC-HRS = 4.646E+000