APPENDIX E - DERIVED INTERVENTION LEVELS FOR OTHER RADIONUCLIDES IN THE INVENTORY OF THE CORE OF AN OPERATING NUCLEAR REACTOR

After a reactor accident, radionuclides other than the principal radionuclides may also be detected in the food supply, usually at much lower concentrations (See Appendix C). However, in the event other radionuclides are present in significant concentrations, this Appendix presents Derived Intervention Levels (DILs) for a number of other radionuclides commonly found in a reactor core inventory.

The DILs for fifteen other radionuclides were determined by the same procedure used in Appendix D. The Protective Action Guides were also the same, i.e. 5 mSv[20] committed effective dose equivalent, or 50 mSv committed dose equivalent to individual tissues and organs.

Age groups and their related food intakes for one year were given previously in Table D-3, Appendix D. Dietary intakes for seven of the fifteen other radionuclides that have half-lives much less than one year were computed for the periods of time (i.e. in nearest whole number of days) required for the radionuclides to decay to less than 1% of the initial activities. Table E-1 and Table E-2 give the relevant data for these seven radionuclides.

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[20] The International System of Units is used throughout the document. See Appendix A, Glossary, for equivalence to units used in previous FDA guidance.

Dose coefficients for seven of the fifteen other radionuclides included in this Appendix are provided in ICRP Publication 56 (ICRP 1989) for all six age groups. For the remaining eight radionuclides, DCs are available in NRPB Publication GS7 (NRPB 1987), but for only three age groups, i.e. 1-year, 10-year and adult. The more limited data in NRPB publication GS7 are supplemented as indicated in the next section.

Fractions of food intake assumed to be contaminated (f) are:

0.3 for all radionuclides except Te-132, I-133 and Np-239 in infant diets (i.e., the 3-month and 1-year age groups);

1.0 for Te-132, I-133 and Np-239 in infant diets.

SELECTION OF DERIVED INTERVENTION LEVELS

The dose coefficients in ICRP Publication 56 and NRPB Publication GS7 are for individual tissues and the effective dose equivalent, as formulated in ICRP Publication 26. ICRP has also developed dose coefficients for individual tissues and the effective dose, as formulated in ICRP publication 60. These latter dose coefficients were published in ICRP Publication 67 (ICRP 1993) and ICRP 72 Publication (ICRP 1996) for all six age groups. Review of all these DCs demonstrated that the trend for relative values of DCs with age for any given radionuclide or for radionuclides with common biokinetic characteristics and half lives is similar. Therefore, DCs for the missing 3-month, 5-year, and 15-year age groups were derived for the eight

radionuclides in NRPB Publication GS7, based on the trends observed in the three sets of ICRP tables. Table E-3 presents the derived DCs for these three age groups and the data from ICRP Publication 67 or 72 used in the derivations. Table E-4 gives the DCs used in computing the DILs for all fifteen radionuclides presented in Table E-5. DILs have been rounded to two significant figures (except one significant figure for Np-237 and Cm-244).

In the same manner as for the principal radionuclides in Appendix D, the most limiting Derived Intervention Level for a radionuclide for either PAG is given in Table E-6 for each age group. Then, the most limiting DIL for a radionuclide for each age group is presented in Table E-7.

During the immediate period after a nuclear reactor accident, decisions on protective actions for food may be required and may need to be based on the general status of the facility or the overall prognosis for worsening conditions. Once food monitoring data is available, the recommended DILs or criterion for the principal radionuclides I-131, Cs-134 + Cs-137, and Ru-103 + Ru-106 recommended in Table 2 of the main text should be used.

The more complex radiochemical or gamma-ray spectrometric analyses for the fifteen other radionuclides listed in this Appendix would not be generally available. If other radionuclides are subsequently detected in food, there will be adequate time to

review the data on the concentrations of the other radionuclides to evaluate whether their contributions to radiation dose via ingestion are unexpectedly high, and to determine whether additional radionuclides should be controlled by their respective DILs in Table E-7. The evaluation takes place with knowledge of the radiation dose represented by the concentrations of the principal radionuclides, which may already exceed one or more of their DILs.

Table E-1

NEAREST WHOLE NUMBER OF DAYS FOR SHORT-LIVED RADIONUCLIDES TO HAVE DECAYED TO LESS THAN 1% OF INITIAL ACTIVITY (A_0)

Radionuclide	Half-life		Nearest Whole Number Of Days to Decay to Less Than 1% of A_0
I-133	20.8	h	6
Np-239	2.36	d	16
Te-132	3.26	d	22
Ba-140	12.7	d	85
Ce-141	32.5	d	217
Nb-95[a]	35.2	d	236
Sr-89	50.5	d	336

(a) Applies to Nb-95 existing in core inventory of an operating reactor at the time of release. Nb-95 produced as a result of decay of released parent Zr-95 is accounted for in the treatment of Zr-95.

TABLE E-2

DIETARY INTAKES[a,b] (kg)

ICRP AGE GROUP	ANNUAL INTAKE	Sr-89 336-DAY INTAKE	Nb-95 236-DAY INTAKE	Ce-141 217-DAY INTAKE	Ba-140 85-DAY INTAKE	Te-132 22-DAY INTAKE	Np-239 16-DAY INTAKE	I-133 6-DAY INTAKE
3 months	418	385	270	249	97	25	18	6.9
1 year	506	466	327	301	118	31	22	8.3
5 years	660	608	427	392	154	40	29	11
10 years	779	717	503	463	181	47	34	13
15 years	869	799	562	517	202	52	38	14
Adult	943	868	610	561	220	57	41	16

(a) The annual intakes (from Table D-3) are for radionuclides which do not decay to less than 1% of initial activity within a year.

(b) Time periods for intakes are for specified radionuclides (from Table E-1) which decay to less than 1% of the initial activity within a year.

Table E-3

DOSE COEFFICIENTS(mSv/Bq) DERIVED FOR THE 3-MONTH, 5-YEAR AND 15-YEAR AGE GROUPS[a] NOT AVAILABLE IN NRPB PUBLICATION GS7, USING DATA IN ICRP PUBLICATIONS[b]

RADIONUCLIDES[c]		REFERENCES USED	DOSE COEFFICIENTS BY AGE GROUP 3 months	1 year	5 years	10 years	15 years	Adult
Sr-89	H_E	NRPB GS7	**3.0E-05**	1.5E-05	**7.7E-06**	5.2E-06	**3.5E-06**	2.2E-06
Sr-89	E	ICRP 72	3.6E-05	1.8E-05	8.9E-06	5.8E-06	4.0E-06	2.6E-06
Y-91	LLI	NRPB GS7	**3.3E-04**	2.1E-04	**1.1E-04**	7.1E-05	**3.8E-05**	3.0E-05
Y-91	E	ICRP 72	2.8E-05	1.8E-05	8.8E-06	5.2E-06	2.9E-06	2.4E-06
Te-132	THY	NRPB GS7	**4.6E-04**	2.2E-04	**1.3E-04**	6.0E-05	**3.5E-05**	1.9E-05
Te-132	THY	ICRP 67	6.2E-04	3.0E-04	1.6E-04	7.1E-05	4.6E-05	2.9E-05
I-133	THY	NRPB GS7	**9.6E-04**	8.6E-04	**5.0E-04**	2.3E-04	**1.5E-04**	8.3E-05
I-133	E	ICRP 72	4.9E-05	4.4E-05	2.3E-05	1.0E-05	6.8E-06	4.3E-06
Ba-140	LLI	NRPB GS7	**2.1E-04**	1.8E-04	**9.7E-05**	6.0E-05	**3.1E-05**	2.6E-05
Ba-140	LLI	ICRP 67	2.2E-04	1.9E-04	9.9E-05	5.7E-05	3.1E-05	2.9E-05
Ce-141	LLI	NRPB GS7	**9.3E-05**	6.0E-05	**3.3E-05**	2.0E-05	**1.2E-05**	8.7E-06
Ce-141	LLI	ICRP 67	9.8E-05	6.3E-05	3.2E-05	1.9E-05	1.1E-05	8.7E-06
Cm-242	BS	NRPB GS7	**2.1E-02**	2.6E-03	**1.4E-03**	8.9E-04	**5.6E-04**	4.5E-04
Cm-242	E	ICRP 72	5.9E-04	7.5E-05	3.9E-05	2.4E-05	1.5E-05	1.2E-05
Cm-244	BS	NRPB GS7	**2.5E-01**	2.5E-02	**1.6E-02**	1.2E-02	**9.9E-03**	9.8E-03
Cm-244	E	ICRP 72	2.9E-03	2.9E-04	1.9E-04	1.4E-04	1.2E-04	1.2E-04

(a) The dose coefficients (DCs) derived for age groups not available in NRPB Publication GS7 are indicated in bold font.

(b) The derived DCs were obtained by multiplying the DC for the NRPB age group contiguous to the missing NRPB age group by the following: the ratio of the DC for the desired age group to the DC of the contiguous age group, from the supporting ICRP data. When there were two contiguous age groups (i.e. for the 5-year and 15-year age groups), the two resulting DCs for the missing NRPB age groups were averaged.

c) The dose quantity used is noted for each radionuclide. LLI is lower large intestine, THY is thyroid, BS is bone surface, H_E is effective dose equivalent, and E is effective dose.

Table E-4

DOSE COEFFICIENTS (mSv/Bq) [a]

Radionuclides		AGE GROUP 3 months	1 year	5 years	10 years	15 years	Adult
Sr-89	lower large intestine	2.8E-05	1.4E-04	7.1E-05	4.8E-05	2.3E-05	2.1E-05
Sr-89		3.0E-05	1.5E-05	7.7E-06	5.2E-06	3.5E-06	2.2E-06
Y-91	lower large intestine	3.3E-04	2.1E-04	1.1E-04	7.1E-05	3.8E-05	3.0E-05
Y-91		2.8E-05	1.7E-05	8.8E-06	5.7E-06	3.1E-06	2.4E-06
Zr-95		1.0E-05	6.6E-06	3.6E-06	2.2E-06	1.4E-06	1.1E-06
Nb-95		5.2E-06	3.7E-06	2.1E-06	1.3E-06	8.6E-07	6.8E-07
Te-132	thyroid	4.6E-04	2.2E-04	1.3E-04	6.0E-05	3.5E-05	1.9E-05
Te-132		3.0E-05	1.9E-05	1.1E-05	6.4E-06	3.4E-06	2.0E-06
I-129	thyroid	3.7E-03	4.3E-03	3.5E-03	3.8E-03	2.8E-03	2.1E-03
I-129		1.1E-04	1.3E-04	1.0E-04	1.1E-04	8.4E-05	6.4E-05
I-133	thyroid	9.6E-04	8.6E-04	5.0E-04	2.3E-04	1.5E-04	8.3E-05
I-133		2.9E-05	2.6E-05	1.8E-05	7.0E-06	4.3E-06	2.5E-06
Ba-140	lower large intestine	2.1E-04	1.8E-04	9.7E-05	6.0E-05	3.1E-05	2.6E-05
Ba-140		2.5E-05	1.4E-05	7.6E-06	5.1E-06	3.7E-06	2.3E-06
Ce-141	lower large intestine	9.3E-05	6.0E-05	3.3E-05	2.0E-05	1.1E-05	8.7E-06
Ce-141		7.8E-06	4.9E-06	2.5E-06	1.6E-06	9.0E-07	7.0E-07
Ce-144	lower large intestine	7.6E-04	4.9E-04	2.4E-04	1.5E-04	8.2E-05	6.6E-05
Ce-144		8.0E-05	4.3E-05	2.1E-05	1.3E-05	7.2E-06	5.8E-06
Np-237	bone surface	1.0E-01	8.9E-03	9.3E-03	9.9E-03	1.2E-02	1.2E-02
Np-237		5.5E-03	4.9E-04	4.3E-04	4.0E-04	4.7E-04	4.5E-04
Np-239	lower large intestine	9.8E-05	6.4E-05	3.2E-05	1.9E-05	1.1E-05	8.8E-06
Np-239		9.6E-06	6.3E-06	3.2E-06	1.9E-06	1.1E-06	8.7E-07
Pu-241	bone surface	3.3E-03	3.4E-04	3.5E-04	3.9E-04	3.9E-04	3.7E-04
Pu-241		2.2E-04	2.2E-05	2.1E-05	2.0E-05	2.0E-05	1.9E-05
Cm-242	bone surface	2.1E-02	2.6E-03	1.4E-03	8.9E-04	5.6E-04	4.5E-04
Cm-242		1.4E-03	1.8E-04	9.8E-05	6.4E-05	3.8E-05	3.0E-05
Cm-244	bone surface	2.5E-01	2.5E-02	1.6E-02	1.2E-02	9.9E-03	9.8E-03
Cm-244		1.4E-02	1.4E-03	9.2E-04	6.7E-04	5.9E-04	5.4E-04

(a) When dose coefficients were available from ICRP Publication 56 (ICRP 1989), they were given for all six age groups. When dose coefficients were available only from NRPB GS7 (NRPB 1987), they were given for only three age groups (i.e. 1 year, 10 years, and adult),and derived for the other three age groups (see Table E-3). The committed effective dose equivalents or committed dose equivalents are computed to age 70 years.

TABLE E-5

PAG AND DERIVED INTERVENTION LEVELS
(individual radionuclides, all age groups)[a]

Radionuclide		PAG (mSv)	Derived Intervention Levels (Bq/kg) 3 months	1 year	5 years	10 years	15 years	Adult
Sr-89	lower large intestine	50	1600	2600	3900	4800	9100	9100
Sr-89		5	1400	2400	3600	4500	5800	8700
Y-91	lower large intestine	50	1200	1600	2300	3000	5300	5900
Y-91		5	1500	1900	2900	3800	6200	7400
Zr-95		5	4000	5000	7000	9700	14000	16000
Nb-95		5	12000	14000	19000	26000	35000	40000
Te-132	thyroid	50	4400	7300	35000	59000	89000	150000
Te-132		5	6700	8500	38000	55000	94000	150000
I-129	thyroid	50	110	76	72	56	69	84
I-129		5	360	250	250	200	230	280
I-133	thyroid	50	7600	7000	30000	56000	79000	130000
I-133		5	25000	23000	84000	180000	280000	420000
Ba-140	lower large intestine	50	8200	7900	11000	15000	27000	29000
Ba-140		5	6900	10000	14000	18000	22000	33000
Ce-141	lower large intestine	50	7200	9200	13000	18000	27000	34000
Ce-141		5	8600	11000	17000	23000	36000	43000
Ce-144	lower large intestine	50	530	670	1100	1400	2300	2700
Ce-144		5	500	770	1200	1700	2700	3100
Np-237	bone surface	50	4	37	27	22	16	15
Np-237		5	7	67	59	54	41	39
Np-239	lower large intestine	50	28000	36000	180000	260000	400000	460000
Np-239		5	29000	36000	180000	260000	400000	470000
Pu-241	bone surface	50	120	970	720	550	490	480
Pu-241		5	180	1500	1200	1100	960	930
Cm-242	bone surface	50	19	130	180	240	340	390
Cm-242		5	29	180	260	330	510	590
Cm-244	bone surface	50	2	13	16	18	19	18
Cm-244		5	3	24	27	32	33	33

(a) Derived Intervention Levels were computed using dose coefficients from Table E-4, dietary intakes from Table E-2 and "f" as given below:

0.3 (except for I-133, Te-132 and Np-239 in infant diets, i.e., the 3-month and 1-year age groups)
1.0 for I-133, Te-132 and Np-239 in infant diets

TABLE E-6

DERIVED INTERVENTION LEVELS (Bq/kg)

Most limiting of Derived Intervention Levels for 5 mSv H_E or 50 mSv H_T (individual radionuclides, by age group)

Radionuclide	3 months	1 year	5 years	10 years	15 years	Adult
Sr-89	1400	2400	3600	4500	5800	8700
Y-91	1200	1600	2300	3000	5300	5900
Zr-95	4000	5000	7000	9700	14000	16000
Nb-95	12000	14000	19000	26000	35000	40000
Te-132	4400	7300	35000	55000	89000	150000
I-129	110	76	72	56	68	84
I-133	7600	7000	30000	56000	79000	130000
Ba-140	6900	7900	11000	15000	27000	29000
Ce-141	7200	9200	12000	18000	29000	34000
Ce-144	500	670	1100	1400	2300	2700
Np-237	4	37	27	22	16	15
Np-239	28000	36000	180000	260000	400000	460000
Pu 241	120	970	720	550	490	480
Cm-242	19	130	180	240	340	390
Cm-244	2	13	16	18	19	18

TABLE E-7

DERIVED INTERVENTION LEVELS (Bq/kg)

(radionuclide groups, most limiting of all diets)

Radionuclide Group	Derived Intervention Level	
Sr-89	1400	(3 months)
Y-91	1200	(3 months)
Zr-95	4000	(3 months)
Nb-95	12000	(3 months)
Te-132	4400	(3 months)
I-129	56	(10 years)
I-133	7000	(1 year)
Ba-140	6900	(3 months)
Ce-141	7200	(3 months)
Ce-144	500	(3 months)
Np-237	4	(3 months)
Np-239	28000	(3 months)
Pu-241	120	(3 months)
Cm-242	19	(3 months)
Cm-244	2	(3 months)

APPENDIX F - DERIVED INTERVENTION LEVELS ADOPTED BY THE COMMISSION OF THE EUROPEAN COMMUNITIES AND THE CODEX ALIMENTARIUS COMMISSION FOR INTERNATIONAL TRADE

Foods exported from the U.S. are subject to the criteria used by the importing country, such as the recommendations of the CODEX Alimentarius Commission (CODEX) or the regulations of the Commission of the European Communities (CEC). CODEX is operated by the Joint Food Standards Programme of the Food and Agriculture Organization of the United Nations (FAO) and World Health Organization (WHO). CODEX develops and recommends standards and other guidance which are widely used in international trade. CEC regulations govern trade within the European Economic Community (EEC) and between the EEC and other countries. U.S. food exporters need to be familiar with the guidance from these organizations.

A discussion of CEC and CODEX Derived Intervention Levels (DILs)[21] is given below to provide insight into their differences.

(a) Commission of The European Communities: DILs for Future Accidents

[21] The International System of Units is used throughout the document. See Appendix A, Glossary, for equivalence to units used in previous FDA guidance.

The CEC adopted regulations in 1987 and 1989, establishing DILs for human food and animal feeds following a nuclear accident or any other case of radiological emergency (CEC 1987, 1989a, 1989b). These were established for use following any future accident and do not apply to residual contamination from the accident at Chernobyl. DILs addressing radioactive contamination from the Chernobyl accident were adopted by the CEC in 1986 (CEC 1986b).

The DILs for foods contaminated by future accidents are presented in Table F-1. DILs were given for four radionuclide groups and four food categories. The radionuclide groups include: isotopes of strontium, notably Sr-90; isotopes of iodine, notably I-131; alpha-emitting isotopes of plutonium and transplutonium elements, notably Pu-239 and Am-241; and all other radionuclides of half-life greater than 10 days, notably Cs-134 and Cs-137. For each group, CEC specified DILs for four food categories: baby foods, dairy produce, other food except minor food, and liquid foods.

Baby foods were defined as "foodstuffs intended for the feeding of infants during the first four to six months of life, ... and are put up for sale in packages which are clearly identified and labeled food preparation for infants". Dairy produce, liquid food, and minor foods were defined by reference to specific CEC regulations and nomenclature.

Liquid foods included tap water and the CEC stated the "same values should be applied to drinking water supplies at the discretion of competent authorities of member states". Dried products referred to the products as prepared for consumption. Dilution factors were not specified and the CEC permitted member states to specify the dilution conditions.

DILs for minor foods such as spices were established, in a separate regulation, at ten times the DILs specified for "other foods" (CEC 1989a). Each DIL is to be applied independently. However, for each radionuclide group, the concentrations within the group are to be added when more than one radionuclide is present. The DILs are to be reviewed within three months following an accident to determine if they should be continued.

(b) CODEX Alimentarius Commission: DILS for Use in International Trade

CODEX adopted guidance in 1989 establishing DILs for food contaminated with radionuclides. The CODEX DILs were issued as guideline levels following an accidental nuclear contamination event (CODEX 1989). The guidance was developed from earlier publications of FAO (FAO 1987, Lupien and Randall 1988) and WHO (Waight 1988, WHO 1988). The DILs are presented in Table F-2. They were given for several

radionuclide groups categorized by the magnitude of their dose coefficients and two food groups.

The food groups are milk and infant foods and foods destined for general consumption. CODEX defined infant food as a food prepared specifically for consumption by infants in the first year of life and stated that such foods are packaged and identified as being for this purpose (CODEX 1989). The radionuclides were grouped according to the magnitude of their dose coefficients (DCs). The specific groupings differed for the two food groups. CODEX listed representative radionuclides for each DC group. CODEX guidelines were not restricted to these radionuclides; any radionuclide can be placed into the appropriate DC group.

CODEX DILs apply for one year following a nuclear accident. They are intended to be applied to food prepared for consumption. Each DIL is to be applied independently. However, for each, the concentrations within the group are to be added. No guidance is provided for foods which are consumed in small quantities, although CODEX stated that application of the DILs to products of this type may be unnecessarily restrictive (CODEX 1989).

Table F-1

DILs ADOPTED BY CEC FOR FUTURE ACCIDENTS[a] (CEC 1989b)

Radionuclide Group	Derived Intervention Levels (Bq/kg) Baby Foods	Dairy Produce	Other Foods except minor foods	Liquid Foods
Isotopes of strontium, notably Sr-90	75	125	750	125
Isotopes of iodine, notably I-131	150	500	2000	500
Alpha-emitting isotopes of Pu and transplutonium elements, notably Pu-239, Am-241	1	20	80	20
All other radionuclides of half-life greater than 10 days, notably Cs-134, Cs-137	400	1000	1250	1000

[a] Do not apply to residual contamination from the accident at Chernobyl.

Table F-2

DIL VALUES RECOMMENDED BY CODEX (CODEX 1989)

FOODS DESTINED FOR GENERAL CONSUMPTION

Approximate Dose Coefficient (Sv/Bq)	Representative Radionuclides	DIL (Bq/kg)
10^{-6}	Am-241, Pu-239	10
10^{-7}	Sr-90	100
10^{-8}	I-131, Cs-134, Cs-137	1000

MILK AND INFANT FOODS

Approximate Dose Coefficient (Sv/Bq)	Representative Radionuclides	DIL (Bq/kg)
10^{-5}	Am-241, Pu-239	1
10^{-7}	I-131, Sr-90	100
10^{-8}	Cs-134, Cs-137	1000

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