APPENDIX A - GLOSSARY

absorbed dose -

the quotient of the mean energy imparted by ionizing radiation, $d\epsilon$, to matter of mass dm. unit: Gy (ICRU 1993)

averted dose -

the radiation dose saved by implementing a protective action. It may be expressed in any of the relevant dose quantities. (ICRP 1991b)

becquerel (Bq) -

the unit of radionuclide activity or expectation value of the number of spontaneous nuclear transitions per unit of time. Bq = 1 transition per second. Unit: 1/s (ICRU 1980) The unit of radionuclide activity used in the previous FDA guidance was the curie (Ci)[12]. 1 Bq = 27×10^{-12} Ci = 27 picocuries (pCi).

committed dose equivalent (H_T) -

the dose equivalent accruing in an organ or tissue up to a specified number of years after the intake of a radionuclide into the body. In this document, committed dose equivalent is always computed to age 70 years. Unit: Sv (ICRP 1984a)

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12 The International System of Units is used throughout the document. In this Glossary, the units that were used in previous FDA guidance are given as reference points for the reader in the definitions of the units "becquerel" and "sievert".

committed effective dose equivalent (H_E) -

committed dose equivalents to individual organs or tissues, multiplied by weighting factors, then summed. In this document, committed effective dose equivalent is always computed to age 70 years. Unit: Sv (ICRP 1984a)

contamination -

radionuclides on or in food or animal feed as a result of an accidental release.

concentration -

radionuclide activity concentration. Unit: Bq/kg; 1 Bq/kg = 27 pCi/kg.

Derived Intervention Level (DIL) -

concentration derived from the intervention level of dose at which introduction of protective measures should be considered. Unit: Bq/kg (IAEA 1985)

dose coefficient (DC) -

the conversion coefficient for committed dose equivalent or committed effective dose equivalent per unit intake of radionuclide activity. Unit: Sv/Bq (ICRP 1989) dose equivalent[13] (H_T) -

the product of the absorbed dose in an organ or tissue and the quality factor. Unit: Sv (ICRU 1993)

effective dose equivalent[12] (H_E) -

sum of weighted dose equivalents for irradiated tissues or organs.

$$H_E = \sum w_T H_T$$

where w_T is a weighting factor representing the proportionate stochastic risk for tissue T, and H_T is the mean dose equivalent received by tissue T. A list of tissues and their weighting factors is given by ICRP (ICRP 1984a). Unit: Sv

gray (Gy) -

unit of absorbed dose. 1 Gy = 1 J/kg; 1 milligray (mGy) = 10^{-3} Gy. (ICRU 1993) The unit of absorbed dose in previous FDA publications was the rad. 1 Gy = 100 rad; 1 mGy = 0.1 rad.

intervention level of dose -

reference level of dose equivalent to an individual at which introduction of protective actions should be considered. Unit: Sv (ICRP 1977, ICRP 1984b)

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[13] In this document, dose equivalent and committed dose equivalent are synonymous, and effective dose equivalent and committed effective dose equivalent are synonymous, because they always refer to the general public, to radionuclides deposited in the body, and to values computed to age 70 years.

Level of Concern (LOC) -

concentration in an imported food, set by FDA after the Chernobyl accident, below which unrestricted distribution in U.S. commerce is permitted.

precautionary action -

action taken, prior to confirmation of contamination, to avoid or reduce the potential for contamination of food and animal feed.

protective action -

action taken to limit the radiation dose from ingestion by avoiding or reducing the contamination in or on human food and animal feeds.

Protective Action Guide (PAG) -

committed effective dose equivalent or committed dose equivalent to an individual organ or tissue that warrants protective action following a release of radionuclides.

quality factor -

modifying factor that weights the absorbed dose for the biological effectiveness of the charged particles producing the absorbed dose. (ICRU 1993) sievert (Sv) -

unit of dose equivalent. 1 Sv = 1 J/kg; 1 millisievert (mSv) = 10^{-3} Sv. (ICRU 1993) The unit of dose equivalent used in previous FDA guidance was the rem. 1 Sv = 100 rem; 1 mSv = 0.1 rem.

APPENDIX B - INTERNATIONAL CONSENSUS ON INTERVENTION LEVELS OF DOSE

In 1984, the International Commission on Radiological Protection (ICRP) recommended basic principles for planning intervention in the event of major radiation accidents and provided general guidance on radiation dose levels for the implementation of countermeasures (ICRP 1984b). The term "intervention level of dose" is used by ICRP for these dose levels. The ICRP guidance indicated that for any countermeasure there is a lower level of radiation dose below which the introduction of the countermeasure is unlikely to be warranted, an upper level of radiation dose above which the countermeasure should almost certainly be implemented, and when between these levels, the specifics of the situation determine which actions (if any) would be taken. For the control of food, ICRP indicated lower and upper levels of 5 mSv[14] and 50 mSv, respectively, for committed effective dose equivalent and 50 mSv and 500 mSv, respectively, for committed dose equivalent to an individual organ or tissue (ICRP 1984b, ICRP 1977).

Since 1984, a number of international organizations have provided guidance dealing with the ingestion of radionuclides that was consistent with the ICRP guidance. These organizations included

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

the Commission of the European Communities (CEC), the Codex Alimentarius Commission (CODEX), the Food and Agricultural Organization of the United Nations (FAO), the International Atomic Energy Agency (IAEA), the Nuclear Energy Agency of the Organization for Economic Cooperation and Development (NEA), and the World Health Organization (WHO). All have adopted 5 mSv committed effective dose equivalent as the radiation dose level above which intervention was recommended (CODEX 1989, FAO 1987, IAEA 1986, Luykx 1989, NEA 1989, Waight 1988, WHO 1988). All except CODEX also adopted 50 mSv committed dose equivalent to an individual tissue or organ when that value is more limiting.

The ICRP has updated its general concepts on intervention in its Publication 60 (ICRP 1991a). Additional advice for intervention for protection of the public was provided in its Publication 63 (ICRP 1991b). The additional advice included an intervention level of averted dose (10 mSv effective dose[15] in a year) for restriction of a single foodstuff. ICRP considered this level appropriate for almost all cases, excepting when alternative food supplies are not available or population groups might suffer serious disruption of their food supply.

The ICRP approach recommended that in application of this intervention level of averted dose, the net benefit of

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[15] Effective dose is the ICRP's revised formulation of effective dose equivalent, as described in its 1990 recommendations (ICRP 1991a).

withdrawing a particular foodstuff be made optimum, based on knowledge of the local situation and other assumptions about the monetary value assigned to the effective dose. The ICRP provided an example of how to evaluate the optimum. Such a procedure requires information that would not be available during the early phases of an accident.

The FDA uses the principles in the general guidance provided by ICRP in 1984 for the immediate response to a major radiation accident, recognizing that at later stages, after the local situation is stabilized and more clearly defined, the longer-term intervention for food can be modified based on more detailed evaluation of local conditions by local authorities. Therefore, the PAGs for the ingestion pathway at the onset of an accident are 5 mSv committed effective dose equivalent or 50 mSv committed dose equivalent to an individual tissue or organ, whichever is more limiting.

APPENDIX C - RADIONUCLIDES DETECTED IN FOOD FOLLOWING THE CHERNOBYL NUCLEAR POWER PLANT ACCIDENT OF APRIL 1986

(a) Analyses of Imported Food by the United States and Canada

(1) I-131 and Cs-134 + Cs-137

Shortly after the accident at Chernobyl on April 26, 1986, the FDA and FSIS of the USDA began sampling imported food for analysis to determine radionuclide activity concentrations. Regulatory actions were based on FDA Levels of Concern (LOCs) and the FSIS Screening Levels which were developed in 1986 and applied to I-131 and Cs-134 + Cs-137.

The regulatory results of FDA and FSIS import monitoring and analyses are summarized in Table C-1[16]. The radionuclide activity concentrations (concentrations) exceeded the FDA LOCs (Cunningham et al 1992) in 23 out of 2600 (0.9%) food samples, and exceeded the FSIS Screening Values (equal to the LOCs)(Engel et al 1989, Randecker 1990) in 107 out of 6295 (1.7%) meat and poultry samples. In general, Cs-134 and Cs-137 were the principal radionuclides detected by FDA and FSIS in the imported foods analyzed. I-131 was significant for only about two months. Cs-134 and Cs-137 were also the

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

dominant radionuclides in imported foods analyzed by Canada (NHW 1987). The European countries of the Nuclear Energy Agency (NEA) also found that I-131 and Cs-134 + Cs-137 contributed most of the radiation dose from radionuclides ingested with food contaminated by the Chernobyl accident (NEA 1987, NEA 1989).

(2) Radionuclides Other Than I-131 and Cs-134 + Cs-137

In addition to the radionuclides used for regulatory actions (I-131, Cs-134 + Cs-137), a number of other radionuclides were detected in imported food entering the U. S. and Canada. Of these, the most commonly detected radionuclides were Ru-103, Ru-106, Ba-140, Sr-90, Ce-144 and Zr-95. The results of FDA and Canadian import sampling for the latter radionuclides are summarized in Table C-2. The data supported the prediction that I-131 and Cs-134 + Cs-137 were the most significant radionuclides for screening of imported foods, and that the other radionuclides were of significantly less importance.

During 1986, of about 500 imported samples monitored by FDA, Ru-103 and Ru-106 were above the detection levels for 18 samples and Ba-140 was above the detection levels in 9 samples (Cunningham et al 1992). These radionuclides were not detected after 1986. Only selected samples were analyzed for Sr-90. Two samples, containing relatively high amounts of Cs-134 + Cs-137 were analyzed for Sr-90 in 1986. In the following years, a total of 40 samples (those having Cs-134 + Cs-137 in excess of 110 Bq/kg) were analyzed for Sr-90. The Sr-90 was above the detection levels in all 42 samples.

For Canadian imported foods, Ru-103 was above detection levels in 46 of 840 samples analyzed during 1986 and 1987, and below detection levels in all samples analyzed later. Ru-106 was above detection levels in 130 of 936 samples analyzed from 1986 through 1989 (Marshall 1992). Samples were analyzed for Ce-144 and Zr-95 from 1987 through 1989. Out of 486 samples, Ce-144 was above detection levels in 88 samples and Zr-95 was above detection levels in 3 samples.

Concentrations in FDA and Canadian imported samples were generally below 10% of the respective Derived Intervention Levels (DILs) given in Appendices D and E. The main exceptions were for Ru-106 in Canadian samples which ranged up to 42% of the DIL.

The results of analysis for imported samples collected by the U.S. and Canada are representative of collections distant from the accident site. Therefore, not only was the food variety relatively limited, but time delays between accident and sample collection, processing effects, and selective screening that exporters may have applied could have influenced the findings. Consequently, findings from samples collected at countries close to Chernobyl are most useful for U.S.

decision-makers responding to a domestic release because these findings are more representative of a local contamination event.

(b) Analyses of Foods Collected Locally at Central and Eastern European Countries

In 1986, FDA received a variety of foods collected locally by United States Embassy staff in Central and Eastern European countries. A total of 48 samples from Bulgaria, Czechoslovakia, Finland, Hungary, Poland, Romania, Russia, and Yugoslavia, were analyzed. Results for Ru-103, Ru-106, and Ba-140 are summarized in Table C-3. The number of samples above detection levels for each radionuclide is given with the ranges of associated percentages relative to the DILs. I-131 and Cs-134 + Cs-137 (not shown) were also detected in most of the samples. I-131 concentrations exceeded the DIL for 27 samples; while Cs-134 + Cs-137 exceeded the DIL for 2 samples.

Most of the 48 embassy samples were fresh vegetables. The edible portions were leafy for 28 samples and roots, bulbs, shoots, or seedlings for 12 samples. Ru-103 was above detection levels in all vegetables, exceeding its DIL for 6 samples. Ru-106 was above detection levels in all vegetables, exceeding its DIL for 14 samples. Ba-140 was above detection levels in 19, but did not exceed its DIL in any vegetables (maximum, 6.3% of DIL).

Other samples included 3 fresh fruit and 5 processed foods (cheese, yogurt, ice cream, and 2 milk samples). Ru-106 was above detection levels in all fruit (maximum, 14% of DIL) and in 2 processed foods (maximum, 29% of DIL). Ru-103 and Ba-140 were above detection levels but did not exceed 2% of their DILs in the fruit or processed food samples.

In September 1986, 28 samples of spices from Turkey and Greece (not offered for import) were provided by the American Spice Trade Association (ASTA) for testing by FDA. This set of samples represented deposition at a distance comparable to many of the Eastern European embassy samples but were analyzed at a later time after the accident. FDA analyzed spices for gamma-ray emitting radionuclides and Sr-90. Findings are included in Table C-3. Following the advice of CEC (CEC 1989a) and CODEX (CODEX 1989) for minor foods, a dilution factor of ten was applied to the concentrations for herbs, spices and flavorings, because they will be consumed in very small quantities.

Cs-134 + Cs-137 (not shown in Table C-3), Ru-103, Ru-106, and Sr-90 were above detection levels in all samples. I-131 and Ba-140 were below detection levels having undergone ten or more half-lives of radioactive decay.

Ru-103, having decayed for over four half-lives, ranged to a maximum of only 4.5% of its DIL while Sr-90, though having decayed very little, reached 10% of the DIL in only 8 samples (maximum, 30% of DIL). Ru-106 exceeded its DIL in 2 samples, was 50% to 100% in 5, and 10% to 50% in another 17.

(c) Conclusions

The results support the expectation that concentrations of I-131 and Cs-134 + Cs-137 would serve as the main indicators of the need for protective actions for imported and local food. However, concentrations of Ru-106 were consistently in excess or at a significant fraction of the DIL, which suggests that Ru-106 should also serve as an indicator, i.e. be included as a principal radionuclide for nuclear reactor incidents.

Also, for local samples of fresh vegetables harvested during the first week of the incident, half of the samples had Ru-103 concentrations a significant fraction of the DIL and another quarter of the samples had Ru-103 concentrations in excess of the DIL. Consequently, it would be prudent to consider Ru-103 as a principal radionuclide for local deposition, particularly in the early phase of a nuclear reactor incident.

Sr-90 did not exceed 11% of the DIL in imported food (Table C-2). For the series of 28 local (ASTA) spice samples (Table

C-3), Sr-90 was less than 30% of its DIL (generally a lower percent of the DIL than found for Ru-106 or Cs-134 + Cs-137). Also, the analytical method for determination of Sr-90 in food is lengthy compared to analysis for the gamma-ray emitting radionuclides, such that protective actions based on the concentration of Sr-90 could not be taken in a timely manner. Therefore, Sr-90 would not be an effective indicator of the need for protective actions in the early phase of a nuclear reactor incident.

During the first year after an accident, concentrations in local or imported food other than for I-131, Cs-134, Cs-137, Ru-103 and Ru-106 are expected to be significant only when one or more of these principal radionuclides has exceeded its DIL. Therefore, the food would already have been subject to protective action.

Table C-1

SUMMARY OF U.S. REGULATORY FINDINGS FOR IMPORTED FOOD FOLLOWING THE CHERNOBYL ACCIDENT

Agency	Number of Samples Analyzed	Sampling Period	Number of Samples Contaminated Above Regulatory Limits[c] I-131	Cs-134 + Cs-137
FDA[a]	2600	5/86-9/92	2	21
FSIS[b]	6295	5/86-10/88	-	107
Regulatory Limits[c]			300 Bq/kg	370 Bq/kg

[a] Food and Drug Administration

[b] Food Safety and Inspection Service of the U.S. Department of Agriculture

[c] FDA: Levels of Concern FSIS: Screening Levels

Table C-2

Ru-103, Ru-106, Ba-140, Sr-90, Ce-144, AND Zr-95
IN IMPORTED FOOD SAMPLES[a] (UNITED STATES AND CANADA)

Year	Number of Samples Analyzed[b]		Ru-103[c]	Ru-106[c]	Ba-140	Sr-90	Ce-144	Zr-95
			Number of Samples with Measurable Concentration (Maximum Percent of Derived Intervention Level)					
United States (FDA)								
1986	500[d]	Herbs	2 (0.02)	2 (9)	9 (1.9)	2[e] (8)		
		Others	16 (1.3)	16 (6)				
1987	37[f]	Herbs				24 (3)		
		Others				13 (11)		
1989	3[f]	Herbs				3 (2)		
Canada								
1986	450[d]	Herbs	26 (0.5)	13 (42)				
		Others	10 (0.5)	1 (3)				
1987	390[d]	Herbs	10 (0.05)	75 (22)			58 (9)	3 (0.9)
		Others		2 (19)				
1988	76	Herbs		30 (10)			26 (4)	
1989	20	Herbs		9 (4)			4 (2)	

(a) For herbs (which include herbs, spices, and flavorings), a dilution factor of ten was applied to the concentrations. No dilution factor was applied for other foods.
(b) Number of samples analyzed for the featured radionuclides. Not equal to number of samples analyzed for principal radionuclides.
(c) The reported Ru-106 concentrations in FDA reports were usually the sum of Ru-103 + Ru-106. Values in this table are the individual Ru-103 and Ru-106 concentrations.
(d) Approximate number.
(e) Number of samples tested for Sr-90, one of which exceeded the 1986 LOC for Cs-134 + Cs-137.
(f) Only samples with Cs-134 + Cs-137 in excess of 0.3 of 1986 LOC were analyzed for Sr-90.

Table C-3

Ru-103, Ru-106, Ba-140, AND Sr-90
IN SAMPLES FROM U.S. EMBASSIES IN CENTRAL AND EASTERN EUROPE
AND FROM THE AMERICAN SPICE TRADE ASSOCIATION (ASTA)

Number of Samples Analyzed	Number of Samples with Measurable Concentrations in 1986 (Range, as Percent of Derived Intervention Level)			
	Ru-103[(a)]	Ru-106	Ba-140	Sr-90
EMBASSY SAMPLES:				
<u>Leafy Vegetables</u>				
28	28 (0.1-507)	28 (1-3500)	14 (0.1-6.3)	NA
<u>Non-leafy Vegetables</u>				
12	12 (1-222)	12 (9-1570)	5 (0.2-5.4)	NA
<u>Fruit</u>				
3	3 (0.3-1.4)	3 (4-14)	ND	NA
<u>Processed Food</u>				
5	2 (0.6-2)	2 (4-29)	3 (0.2-1.4)	NA
ASTA SAMPLES:				
28	28 (0.2-4.5)	28 (6-1640)	ND	28 (0.9-30)

(a) Embassy samples were received primarily in May and June 1986 and the ASTA samples in September 1986. Due to radioactive decay, the relative concentration of Ru-103 compared to Ru-106 is considerably lower for the ASTA samples than for the embassy samples.

NA - Not analyzed.
ND - Not detected.

APPENDIX D - DERIVATION OF RECOMMENDED DERIVED INTERVENTION LEVELS

The Derived Intervention Level (DIL) for a specific radionuclide is calculated as follows:

$$\text{DIL (Bq/kg)} = \frac{\text{PAG (mSv)}}{\text{f x Food Intake (kg) x DC (mSv/Bq)}}$$

Where:

DIL = Derived Intervention Level

PAG = Protective Action Guide

DC = Dose coefficient

Food Intake = Quantity of food consumed in an appropriate period of time

f = Fraction of food intake assumed to be contaminated

The recommended Protective Action Guides (PAGs) are 5 mSv[17] committed effective dose equivalent, or 50 mSv committed dose equivalent to individual tissues and organs, whichever is more limiting. These PAGs are consistent with the consensus of international organizations on the levels of radiation dose below which ingestion pathway interventions are generally not appropriate (see Appendix B).

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[17] 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 (DCs) are given in Table D-1 and food intakes are given in Tables D-2 and D-3. The fraction of food intake assumed to be contaminated (f) equals 0.3, except for I-131 in infant diets where f equals 1.0.

(a) Radionuclides

Based upon data on radionuclides in human food following the Chernobyl accident, DILs for I-131, Cs-134, Cs-137, Ru-103 and Ru-106 would facilitate application of food monitoring programs following accidents involving nuclear reactors. For accidents at nuclear fuel reprocessing facilities and nuclear waste storage facilities, DILs for Sr-90, Cs-137, Pu-239, and Am-241 would be used. For nuclear weapons accidents and accidents involving radioisotope thermal generators (RTGs) and radioisotope heater units (RHUs) used in space vehicles, DILs for Pu-239 and Pu-238, respectively, would be used. The selection of these radionuclides as the major contributors to radiation dose through ingestion is consistent with recommendations on DILs published by NEA, WHO, CODEX, and CEC (NEA 1989, WHO 1988, CODEX 1989, CEC 1989b, IAEA 1994).

(b) Age Groups and Dose Coefficients (DCs)

The general population was divided into six age groups ranging from infants to adults and corresponding to the age groups in ICRP Publication 56 (ICRP 1989) for which ICRP has published

DCs. The age groups are 3 months, 1 year, 5 years, 10 years, 15 years, and adult. The radionuclides, age groups and dose coefficients used in the calculations are presented in Table D-1.

(c) Food Intake

Food intake included all dietary components including tap water used for drinking, and is the overall quantity consumed in one year, with exceptions in the period of time for I-131 ($T_{1/2}$ = 8.04 days) and Ru-103 ($T_{1/2}$ = 39.3 days). For these, the quantities consumed were for a 60-day period and a 280-day period, respectively, due to the more rapid decay of these radionuclides. The intake periods for I-131 and Ru-103 are the nearest whole number of days for decay of these radionuclides to less than 1% of the initial activities.

Dietary intakes were derived from a 1984 EPA report which presented average daily food intake by age and gender (EPA 1984a, EPA 1984b). The EPA intakes were based on data from the 1977-1978 Nationwide Food Consumption Survey published by the U. S. Department of Agriculture (USDA 1982, USDA 1983). The age groups and annual dietary intakes for various food classes and the total, calculated from data in the EPA report, are given in Table D-2.

The dietary intakes derived for the ICRP age groups for which DCs are available, using the results in Table D-2, are presented in Table D-3.

(d) Fractions of Food Intake Assumed to be Contaminated (f)

For food consumed by most members of the general public, ten percent of the dietary intakes was assumed to be contaminated. This assumption recognizes the ready availability of uncontaminated food from unaffected areas of the United States or through importation from other countries, and also that many factors could reduce or eliminate contamination of local food by the time it reaches the market[18].

Use of ten percent of the dietary intake as the portion contaminated was consistent with recommendations made by a Group of Experts to the Commission of the European Communities (CEC 1986a) and by the Nuclear Energy Agency (NEA) of the Organization for Economic Cooperation and Development (NEA 1989). The NEA noted that modification of this value would be appropriate if justified by detailed local findings.

FDA applied an additional factor of three to account for the fact that sub-populations might be more dependent on local

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[18] In most situations, one would expect less than ten percent of the dietary intakes to be contaminated.

food supplies. Therefore, during the immediate period after a nuclear accident, a value of 0.3 (i.e., thirty percent) is the fraction of food intake that FDA recommends should be presumed to be contaminated. If, subsequently, there is convincing local information that the actual fraction of food intake that is contaminated (f) is considerably higher or lower, there will be adequate time for State and local officials to determine whether to adjust the value of f (and therefore adjust the values of the DILs) for the affected area.

For infants, (i.e., the 3-months and 1-year age groups) the diet consists of a high percentage of milk and the entire milk intake of some infants over a short period of time might come from supplies directly impacted by an accident. Therefore, f was set equal to 1.0 (100%) for the infant diet.

(e) Selection of Recommended Derived Intervention Levels

DILs are presented in Table D-4 for Sr-90, I-131, Cs-134, Cs-137, Ru-103, Ru-106, Pu-238, Pu-239, and Am-241 for six population age groups and applicable PAGs. To facilitate the execution of food monitoring programs, two criteria were used in selecting FDA's recommended DILs.

First, the most limiting DIL for either of the applicable PAGs was selected for each of the nine radionuclides. These DILs are presented in Table D-5 for each of the six age groups. In addition, the average DIL is presented for the radionuclide group Pu + Am, composed of Pu-238, Pu-239, and Am-241, and the radionuclide group Cs, composed of Cs-134 + Cs-137. The three radionuclides in the Pu + Am group deposit on the bone surface and are alpha-particle emitters. The radionuclides in the Cs group are deposited throughout the body and are beta-particle and gamma-ray emitters. The average values are recommended for these groups because the calculated DILs for radionuclides in each group are similar.

The radionuclides Ru-103 and Ru-106 are chemically identical, are deposited throughout the body, and are beta-particle and gamma-ray emitters. However, their widely differing half lives (i.e., 39.3 days and 373 days, respectively) result in markedly differing individual DILs which do not permit simple averaging. Instead, the concentrations of Ru-103 (C_3) and Ru-106 (C_6) are divided by their respective DILs and are then summed[19]. The sum must be less than one.

Therefore, $$\frac{C_3}{DIL_3} + \frac{C_6}{DIL_6} < 1.0 \qquad \text{(equation D-1)}$$

This assures that the sum of the separate radiation dose contributions from the Ru-103 and Ru-106 concentrations will be less than that required by the Protective Action Guide

19 Laboratories that are not equipped to resolve separately the concentrations for Ru-103 and Ru-106 should contact FDA for alternate procedures.

during the first year after an accident.

Second, there are dietary components which are common to all six age groups. A principal example is fresh milk, for which the consumer of particular supplies cannot be identified in advance. Therefore, the most limiting DIL for all age groups in Table D-5, for each radionuclide or radionuclide group, was selected and is applicable to all components of the diet.

These DILs are presented in Table D-6 and were rounded to two significant figures (one significant figure for the Pu + Am group). These are the FDA's recommended DILs.

The DILs in Table D-6 apply independently to each radionuclide or radionuclide group, because they apply to different types of accidents, or in the case of a nuclear reactor accident, to different limiting age groups. However, the DILs for Ru-103 and Ru-106 are used in equation D-1 to evaluate that criterion for the radionuclide group Ru-103 + Ru-106.

The FDA recommended DILs in Table D-6 are given in Table 2 in the main text, along with clarifying notes on application of the DILs.

Table D-1

DOSE COEFFICIENTS (mSv/Bq)[a]

	Age Group					
Radionuclide	3 month	1 year	5 years	10 years	15 years	Adult
Sr-90 bone surface	1.0E-03	7.4E-04	3.9E-04	5.5E-04	1.2E-03	3.8E-04
Sr-90	1.3E-04	9.1E-05	4.1E-05	4.3E-05	6.7E-05	3.5E-05
I-131 thyroid	3.7E-03	3.6E-03	2.1E-03	1.1E-03	6.9E-04	4.4E-04
I-131	1.1E-04	1.1E-04	6.3E-05	3.2E-05	2.1E-05	1.3E-05
Cs-134	2.5E-05	1.5E-05	1.3E-05	1.4E-05	2.0E-05	1.9E-05
Cs-137	2.0E-05	1.1E-05	9.0E-06	9.8E-06	1.4E-05	1.3E-05
Ru-103	7.7E-06	5.1E-06	2.7E-06	1.7E-06	1.0E-06	8.1E-07
Ru-106	8.9E-05	5.3E-05	2.7E-05	1.6E-05	9.2E-06	7.5E-06
Pu-238 bone surface	1.6E-01	1.6E-02	1.5E-02	1.5E-02	1.6E-02	1.7E-02
Pu-238	1.3E-02	1.2E-03	1.0E-03	8.8E-04	8.7E-04	8.8E-04
Pu-239 bone surface	1.8E-01	1.8E-02	1.8E-02	1.7E-02	1.9E-02	1.8E-02
Pu-239	1.4E-02	1.4E-03	1.1E-03	1.0E-03	9.8E-04	9.7E-04
Am-241 bone surface	2.0E-01	1.9E-02	1.9E-02	1.9E-02	2.1E-02	2.0E-02
Am-241	1.2E-02	1.2E-03	1.0E-03	9.0E-04	9.1E-04	8.9E-04

(a) Dose coefficients are from ICRP Publication 56 (ICRP 1989). The committed effective dose equivalents or committed dose equivalents are computed to age 70 years.

Table D-2

ANNUAL DIETARY INTAKES (kg/y)[(a)]

FOOD CLASS	AGE GROUP (years)									
	< 1	1-4	5-9	10-14	15-19	20-24	25-29	30-39	40-59	60 & up
Dairy	208	153	180	186	167	112	98.2	86.4	80.8	90.6
(fresh milk)[(b)]	(99.3)	(123)	(163)	(167)	(148)	(96.5)	(79.4)	(66.8)	(61.7)	(70.2)
Egg	1.8	7.2	6.2	7.0	9.1	10.3	10.2	11.0	11.4	10.5
Meat	16.5	33.7	46.9	58.4	69.2	71.2	72.6	73.4	70.7	56.3
Fish	0.3	2.5	4.0	4.9	6.1	6.8	7.6	7.1	8.0	6.3
Produce	56.6	59.9	82.3	96.0	97.1	91.4	99.1	102	115	121
Grain	20.4	57.6	79.0	90.6	89.4	77.3	78.4	73.7	70.2	67.1
Beverage	112	271	314	374	453	542	559	599	632	565
(tap water)[(b)]	(62.3)	(159)	(190)	(226)	(243)	(240)	(226)	(232)	(268)	
	(278)									
Misc	2.0	9.3	13.3	14.8	13.9	10.9	11.9	12.5	13.3	13.0
TOTAL ANNUAL INTAKE, (kg/y)	418	594	726	832	905	922	937	965	1001	930

[(a)] Computed from daily intake values in grams per day provided in (EPA 1984b). The total annual intakes are rounded to nearest 1 kg/y.

[(b)] Fresh milk is included in the dairy entry, and tap water used for drinking is included in the beverage entry. The total annual intakes (kg/y) for fresh milk and tap water are also each given separately in parentheses.

Table D-3

DIETARY INTAKES
FOR ICRP AGE GROUPS

ICRP AGE GROUP	ANNUAL INTAKE[a] (kg)	280-DAY INTAKE RUTHENIUM-103 (kg)	60-DAY INTAKE IODINE-131 (kg)
3 months	418	320	69
1 year	506	387	83
5 years	660	506	109
10 years	779	597	128
15 years	869	666	143
Adult	943	723	155

(a) The annual dietary intakes for the ICRP age groups were obtained by assigning or averaging the appropriate annual dietary intakes given in Table D-2 for the EPA age groups, as follows:

3 months:	used <1
1 year:	average of <1 and 1-4
5 years:	average of 1-4 and 5-9
10 years:	average of 5-9 and 10-14
15 years:	average of 10-14 and 15-19
Adult:	average of 15-19, 20-24, 25-29, 30-39, 40-59, 60 and up

Table D-4

PAGs AND DERIVED INTERVENTION LEVELS[a]
(individual radionuclides, by age groups)

Radionuclide	PAG (mSv)	Derived Intervention Levels (Bq/kg) 3 months	1 year	5 years	10 years	15 years	Adult
Sr-90 bone surface[b]	50	400	445	648	389	160	465
Sr-90	5	308	362	616	497	286	505
I-131 thyroid	50	196	167	722	1200	1690	2420
I-131	5	659	548	2410	4110	5540	8180
Cs-134	5	1600	2190	1940	1530	958	930
Cs-137	5	2000	2990	2810	2180	1370	1360
Ru-103	5	6770	8410	12200	16400	25000	28400
Ru-106	5	449	621	935	1340	2080	2360
Pu-238 bone surface	50	2.5	21	17	14	12	10
Pu-238	5	3.1	27	25	24	22	20
Pu-239 bone surface	50	2.2	18	14	13	10	9.8
Pu-239	5	2.9	24	23	21	20	18
Am-241 bone surface	50	2.0	17	13	11	9.1	8.8
Am-241	5	3.3	27	25	24	21	20

(a) Derived Intervention Levels were computed using dose coefficients from Table D-1, dietary intakes from Table D-3, and "f" as given below:

0.3 (except for I-131 in infant diets, i.e., the 3-month and 1-year age groups)

1.0 (I-131 in infant diets)

(b) The observed trend in Derived Intervention Levels for Sr-90 as a function of age, i.e. minimum values at 15 years, results primarily from the mass of exchangeable strontium in bone as a function of age (Leggett et al 1982).

Table D-5

DERIVED INTERVENTION LEVELS (Bq/kg)
(individual radionuclides, by age group, most limiting of either PAG)

Radionuclide	3 months	1 year	5 years	10 years	15 years	Adult
Sr-90	308	362	616	389	160	465
I-131	196	167	722	1200	1690	2420
Cs-134	1600	2190	1940	1530	958	930
Cs-137	2000	2990	2810	2180	1370	1360
Cs group[a]	1800	2590	2380	1880	1160	1150
Ru-103	6770	8410	12200	16400	25000	28400
Ru-106	449	621	935	1340	2080	2360
Pu-238	2.5	21	17	14	12	10
Pu-239	2.2	18	14	13	10	9.8
Am-241	2.0	17	13	11	9.1	8.8
Pu+Am group[b]	2.2	19	15	13	9.6	9.3

[a] Computed as: (DIL for Cs-134 + DIL for Cs-137)/2

[b] Computed as: (DIL for Pu-238 + DIL for Pu-239 + DIL for Am-241)/3

Table D-6

DERIVED INTERVENTION LEVELS (Bq/kg)
(radionuclide groups, most limiting of all diets)

Radionuclide Group	Derived Intervention Levels
Sr-90	160 (15 years)
I-131	170 (1 year)
Cs group	1200 (adult)
Ru-103[a]	6800 (3 months)
Ru-106[a]	450 (3 months)
Pu + Am group	2 (3 months)

[a] Due to the large differences in DILs for Ru-103 and Ru-106, the individual concentrations of Ru-103 and Ru-106 are divided by their respective DILs and then summed. The sum must be less than one.

To Part 3 of Document