Table 4

Estimated normalized collective absorbed dose commitments from particulate airborne releases from uranium milling

	Normalized collective absorbed dose commitment [10^{-5} man Gy (GW[e] a)$^{-1}$]								
	Gonads	Breast	Lungs	Red bone marrow	Bone lining cells	Thyroid	Kidneys	Liver	Remainder tissues
Cloud passage: Inhalation									
^{238}U	-	-	210	0.2	2	-	0.9	0.006	-
^{234}U	-	-	250	0.2	3	-	1	0.006	-
^{230}Th	-	-	26	15	200	-	0.04	0.3	-
^{226}Ra	-	-	0.9	0.03	0.4	-	0.006	0.006	-
^{210}Pb	-	-	0.5	0.2	2	-	0.4	0.8	-
^{210}Po	-	-	1.2	0.02	0.02	-	0.6	0.2	-
Total (rounded) (α)	-	-	490	16	210	-	3	1	-
Activity deposited: Internal irradiation									
^{238}U	2	2	2	5	29	2	17	2	2
^{234}U	2	2	2	3	26	2	16	2	2
^{230}Th	0.01	0.01	0.7	0.8	11	0.01	0.4	0.01	0.01
^{226}Ra	0.1	0.1	0.1	0.4	4	0.1	0.1	0.1	0.1
^{210}Pb-^{210}Po	4	4	2	4	26	4	4	4	4
Total (rounded) (α)	8	8	7	13	96	9	37	8	8
Activity deposited: External irradiation (γ)	23 to all organs and tissues								

Table 5

Normalized collective effective dose equivalent commitments from particulate and gaseous airborne releases from mining and milling

	Collective effective dose equivalent commitment (10^{-2} man Sv [GW(e) a]$^{-1}$)			
	Inhalation during the passage of the cloud	Internal irradiation due to the activity deposited	External irradiation due to the activity deposited	Total
Milling				
Particulates	1.3	0.2	0.02	1.5
Gaseous radon-222 and daughters	2.3	0.1		2.4
Mining				
Gaseous radon-222 and daughters	50	-	-	50
Total				54

Table 6

Normalized collective effective dose equivalent commitment to the local and regional population from tailings at the model mine and mill

(a) Atmospheric releases of radon and airborne particulates as a function of the time for which the erosion continues

	Normalized collective effective dose equivalent commitment (man Sv [GW(e) a]$^{-1}$)		
Release duration (a)	1	10^3	10^5
^{238}U	0.000005	0.005	0.5
^{234}U	0.000006	0.006	0.6
^{230}Th	0.0004	0.44	44
^{226}Ra	0.000009	0.009	0.9
^{210}Pb	0.00002	0.02	2
^{210}Po	0.00002	0.02	2
^{222}Rn	0.025	25	2500
Total (rounded)	0.026	26	2600

(b) Releases of tailings into the marine environment

	Normalized collective effective dose equivalent commitment (man Sv [GW(e) a]$^{-1}$)
^{238}U	0.15
^{234}Th	8.8
^{234}U	0.17
^{230}Th	0.54
^{226}Ra	18.6
^{210}Pb	79.7
^{210}Po	350
Total	460

Table 7

Normalized effluent discharges from the model fuel conversion, enrichment and fabrication facilities

(MBq [GW(e) a]$^{-1}$)
[E1, B2, B22, P1, S6]

Isotope	Atmospheric			Aquatic		
	Conversion	Enrichment	Fabrication	Conversion	Enrichment	Fabrication
^{238}U	74	3.7	0.74	814	370	370
^{235}U	2.0	0.07	0.22	20	7.4	7.4
^{234}U	74	3.7	7.4	814	370	370
^{234}Th	74	3.7	0.74	-	-	370
^{230}Th	0.74	-	-	56	-	-
^{226}Ra	0.07	-	-	126	-	-
^{222}Rn	8140	-	-	-	-	-

Table 8

Meteorological characteristics and population distribution around the model fuel fabrication facility used for assessing radon releases a/

Quantity	Pasquill weather category							
	Dry						Rain	
	A	B	C	D	E	F	C	D
Frequency (%)	0.3	4.5	12.1	63	5	4.6	1.7	8.4
Wind speed (m s^{-1})	1	2	5	5	3	2	5	5
Depth of mixing layer (m)	2000	2000	1000	1000	200	200	1000	1000

a/ The assumed stack height is 60 m.
The assumed population distribution is uniform at 25 km^{-2}.

Table 9

Normalized collective absorbed dose commitments by inhalation for airborne releases from fuel fabrication

	Normalized collective absorbed dose commitment [10^{-6} man Gy (GW[e] a)$^{-1}$]								
	Gonads	Breast	Lungs	Red bone marrow	Bone lining cells	Thyroid	Kidneys	Liver	Remainder tissues
Cloud passage: Inhalation									
^{238}U	-	-	250	0.2	3	-	1	-	-
^{234}U	-	-	320	0.2	3	-	1	-	-
^{230}Th	-	-	3	2	20	-	0.004	-	-
^{226}Ra	-	-	0.02	-	0.007	-	-	-	-
Total (rounded) (α)	-	-	570	2	30	-	2	-	-
Activity deposited: Internal irradiation									
^{238}U	2	2	2	6	35	2	20	2	2
^{234}U	2	2	2	4	34	2	20	2	2
^{230}Th	0.001	0.001	0.07	0.08	1	0.001	4	0.001	0.001
^{226}Ra	0.002	0.002	0.002	0.008	0.08	0.002	0.002	0.002	0.002
Total (rounded) (α)	4	4	4	10	70	4	40	4	4
Activity deposited: External irradiation (γ)	0.4 to all organs and tissues								

Table 10

Normalized collective effective dose equivalent commitment from the model fuel fabrication facility

Radio-nuclide	Normalized collective effective dose equivalent commitment [10^{-4} man Sv (GW[e] a)$^{-1}$]		
	Cloud passage: Inhalation	Activity deposited: Internal irradiation	Activity deposited: External irradiation
^{238}U	6	0.7	0.004
^{234}U	7	0.9	
^{230}Th	0.2	0.01	
^{226}Ra	0.0004	0.001	
^{222}Rn	4	0.02	
Total (rounded)	20	2	0.004

Table 11

World nuclear generating capacity in 1979
[Net values in GW(e) and numbers of units in parentheses]
[I1, K12]

Country or area	Reactor type: PWR	BWR	GCR	HWR	LWGR	FBR	Total capa-city	kW(e) per caput
Argentina				0.34 (1)			0.34	0.015
Belgium	1.66 (3)						1.66	0.17
Bulgaria	0.82 (2)						0.82	0.10
Canada				5.49 (11)			5.49	0.25
Czechoslovakia	0.38 (1)						0.38	0.024
Finland	0.42 (1)	0.66 (1)					1.08	0.23
France	5.71 (7)		2.13 (7)	0.07 (1)		0.25 (1)	8.16	0.15
German Dem. Rep.	1.29 (4)						1.29	0.074
Germany, Fed.Rep.of	5.37 (6)	3.16 (5)	0.01 (1)	0.05 (1)		0.02 (1)	8.61	0.14
India		0.40 (2)		0.20 (1)			0.60	0.001
Italy	0.24 (1)	0.15 (1)	0.15 (1)				0.54	0.01
Japan	6.44 (9)	7.72 (12)	0.16 (1)	0.15 (1)			14.47	0.16
Republic of Korea	0.56 (1)						0.56	0.17
Netherlands	0.45 (1)	0.05 (1)					0.50	0.038
Pakistan				0.13 (1)			0.13	0.002
Spain	0.15 (1)	0.44 (1)	0.48 (1)				1.07	0.031
Sweden	0.80 (1)	2.90 (5)					3.70	0.46
Switzerland	1.62 (3)	0.32 (1)					1.94	0.31
USSR	2.49 (7)	0.09 (5)			7.89 (16)	0.15 (2)	10.62	0.043
United Kingdom			6.75 (32)			0.23 (1)	6.98	0.13
United States	31.88 (42)	17.78 (26)	0.33 (1)				49.99	0.24
Other Asia	1.21 (2)						1.21	0.084
Total	61.49 (92)	33.67 (60)	10.01 (44)	6.43 (17)	7.89 (16)	0.65 (6)	120.14	0.07

Table 12

Noble gases discharged in airborne effluents from PWRs in various countries 1975-1979
[B23, D6, D8, E9, G3, K4, L1, L6, N19, P2, S14]

Country and reactor	Startup year	Electrical capacity [GW(e)]	Release (TBq) 1975	1976	1977	1978	1979
Belgium							
Doel 1,2	1974/75	0.79	7.7	30	28	17	44
Tihange	1975	0.87	17	170	55	58	14
Finland							
Loviisa	1977	0.42	-	-	2.2	1.4	1.6
France							
Fessenheim	1977	1.78	-	-	70	73	
Chooz	1967	0.30	100	183	103	120	
Bugey 2,3	1978	1.85	-	-	-	4.1	
Germany, Fed. Rep. of							
Obrigheim	1968	0.33	296	12	14	17	3.8
Stade	1972	0.63	47	389	132	18	8.5
Biblis A,B	1974/76	2.39	62	54	156	79	43
Neckarwestheim	1976	0.81	-	19	70	4.3	12
Unterweser	1978	1.23	-	-	-	1.9	38
Italy							
Trino	1964	0.25	17	6.6	2.2	20	
Japan							
Mihama 1	1970	0.34	2.7	2.1	2.7	1.7	2727
Mihama 2	1972	0.50	7.0	30	14	6.7	0.59
Mihama 3	1976	0.83	-	10	6.3	0.9	0.26
Takahama 1	1974	0.83	4.8	3.6	4.4	3.1	3.0
Takahama 2	1975	0.83	3.0	3.3	2.3	2.1	2.4
Ohi 1	1977	1.17	-	-	0.4	9.3	3.0
Ohi 2	1978	1.17	-	-	-	0.33	2.3
Ikata 1	1977	0.57	-	-	2.2	3.0	3.4
Genkai 1	1975	0.57	1.5	1.8	2.0	1.6	1.0
Netherlands							
Borssele	1973	0.45	97	144	37	15	8
Sweden							
Ringhals 2	1975	0.80	-	8.5	11	5.4	22
United States							
Arkansas 1	1974	0.84	38	210	514	277	315
Arkansas 2	1979	0.95	-	-	-	-	168
Beaver Valley	1976	0.80	-	-	2	14	65
Calvert Cliffs 1,2	1974	1.62	3.2	286	825	1020	378
Cook 1,2	1975	2.14	-	36	141	1795	403
Crystal River	1977	0.80	-	-	112	254	2802
Davis Besse	1977	0.92	-	-	47	77	62
Farley	1978	0.83	-	-	-	131	118
Fort Calhoun	1973	0.46	16	80	141	50	26
R.E. Ginna	1969	0.47	389	204	118	36	28
Haddam Neck	1968	0.55	18	18	115	79	204
Indian Point	1973/76	1.77	303	392	592	551	343
Kewaunee	1974	0.52	91	59	90	16	5.6
Maine Yankee	1972	0.77	152	48	11	53	73
Millstone Point 2	1975	0.80	-	57	84	28	13
North Anna	1978	0.90	-	-	-	559	232
Oconee	1973/74	2.64	562	1628	1317	1612	1772
Palisades	1971	0.64	97	1.1	2.2	12	2.5
Point Beach 1,2	1970/72	0.99	1676	74	42	19	36
Prairie Island	1973/74	1.01	81	64	25	47	26
Rancho Seco	1974	0.87	4.4	4.7	74	263	326
H.B. Robinson	1970	0.66	43	29	18	33	56
St. Lucie	1976	0.78	-	-	940	1084	570
Salem 1	1976	1.08	-	-	7.3	0.38	9.2
San Onofre	1967	0.44	66	15	5.6	67	24
Surry 1,2	1972/73	0.55	298	710	703	161	66
Three Mile Island 1	1974	0.79	134	102	614	581	83
Trojan	1975	1.08	-	-	113	11	34

Table 12, continued

Country and reactor	Startup year	Electrical capacity [GW(e)]	Release (TBq) 1975	1976	1977	1978	1979
Turkey Point	1972/73	1.32	496	577	862	870	392
Yankee Rowe	1960	0.17	1	1	4.6	24	6.7
Zion 1,2	1973/74	2.08	1676	5254	1191	2505	1262
Total annual energy generated [GW(e) a]			16.9	19.2	23.8	29.4	27.5
Normalized release [TBq (GW[e] a)$^{-1}$]			402	570	388	432	370
		Average 1975-1979			430 TBq [GW(e) a]$^{-1}$		

Table 13

Isotopic composition of noble gases discharged from PWRs in the United States during 1979 [B23]

Reactor	Startup year	Energy generated [GW(e) a]	Release (TBq) ^{41}Ar	^{85m}Kr	^{85}Kr	^{87}Kr	^{88}Kr	^{131m}Xe	^{133m}Xe	^{133}Xe	^{135m}Xe	^{135}Xe	^{138}Xe
Arkansas 1	1974	0.397	0.30	3.2	0.20	0.49	1.7	0.11	2.8	289	-	24	-
Arkansas 2	1979	0.916	5.3	-	-	-	-	0.001	-	143	-	19	-
Beaver Valley	1976	0.221	-	-	0.52	-	0	18	1.6	45	-	0.027	-
Calvert Cliffs 1,2	1975/77	1.161	0.005	1.3	0.036	-	0.045	0.048	0.14	363	-	13	-
Cook 1,2	1975/78	1.373	0.019	0.007	326	-	-	-	0.88	70	-	7.8	-
Crystal River	1977	0.453	17	25	-	7.8	19	36	49	2290	21	212	125
Davis Besse	1977	0.381	0.02	0.26	56	0.61	0.43	0.019	0.023	3.3	0.51	0.24	1.2
Joseph M. Farley	1978	0.211	11	0.001	0.78	0.062	0.007	3.5	1.4	95	-	5.1	0.01
Fort Calhoun	1973	0.440	0.078	0.01	0.48	0.004	0.016	-	0.19	25	-	0.24	-
R.E. Ginna	1969	0.355	0.033	0.11	0.74	-	-	0.036	0.018	25	-	1.9	-
Haddam Neck	1967	0.493	-	0.051	37	0.13	0.12	1.5	0.29	155	0.027	1.1	0.13
Indian Point	1973	1.142	-	0.92	24	0.29	1.0	3.8	3.6	297	0.38	11	0.84
Kewaunee	1974	0.412	0.31	0.016	1.0	-	0.013	-	0.007	1.1	-	0.41	-
Maine Yankee	1972	0.537	-	-	1.0	-	-	2.4	-	67	-	1.4	-
Millstone Point 2	1975	0.520	0.068	-	0.36	-	-	-	-	648	-	0.64	-
North Anna	1978	0.507	0.007	0.67	0.05	0.01	0.02	0.12	0.58	224	0.02	7.3	0.01
Oconee 1,2,3	1973/74	1.708	1.0	3.4	40	0.26	1.1	14	27	1646	1.4	29	0.15
Palisades	1971	0.415	-	-	0.090	-	-	0.021	0.002	2.4	-	0.007	-
Point Beach 1,2	1970/72	0.808	2.1	2.3	1.2	1.2	3.6	-	0.11	11.3	0.78	12	1.2
Prairie Island 1,2	1973/74	0.865	0.1	0.03	0.048	0.09	-	-	0.068	25	-	0.71	-
Rancho Seco	1974	0.687	0.06	0.52	0.27	0.007	0.041	0.085	0.92	300	-	24	-
H.B. Robinson	1970	0.482	0.05	-	-	-	-	-	-	56	-	0.87	-
Salem	1976	0.250	0.011	0.043	0.050	-	0.04	-	0.12	8.4	-	0.56	-
St. Lucie	1976	0.592	0.92	4.9	2.9	5.0	10	31	4.9	492	0.41	9.4	4.7
San Onofre	1967	0.401	0.40	0.08	2.3	0.019	0.084	0.10	0.073	19	-	0.53	-
Surry 1,2	1972/73	0.343	0.083	0.029	0.013	0.041	0.02	-	0.36	63	-	2.5	-
Three Mile Island 1	1974	0.266	0.67	-	0.007	-	0.007	0.093	0.26	81	-	0.95	-
Trojan	1975	0.631	0.016	0.042	0.038	0.034	0.058	0.092	0.28	32	0.13	1.4	0.016
Turkey Point	1972/73	0.811	2.0	0.050	0.035	0.0099	0.036	0.075	0.25	389	0.068	1.1	0.026
Yankee Rowe	1960	0.149	0.062	0.060	0.060	0.050	0.093	0.012	0.069	4.3	0.82	0.94	0.028
Zion	1973	1.238	0.28	0.062	0.097	-	1.5	8.8	0.63	1132	-	118	-
Total annual energy generated [GW(e) a]		19.165											
Normalized release [TBq (GW[e] a)$^{-1}$]			2.1	2.2	25	0.84	2.0	6.3	5.0	469	1.3	26	6.9

Table 14

Noble gases discharged in airborne effluents from BWRs in various countries 1975-1979
[B23, D6, D8, E9, G3, K4, L1, L6, N19, P2, S14]

Country and reactor	Startup year	Electrical capacity [GW(e)]	Release (TBq) 1975	1976	1977	1978	1979
Finland							
Olkiluoto	1978	0.660	-	-	-	0.25	0.014
Germany, Fed. Rep.of							
Gundremmingen	1966	0.237	274	195	9.2	8.5	-
Lingen	1968	0.182	1295	237	4.9	-	-
Würgassen	1971	0.640	4.5	18	29	121	159
Brunsbüttel	1976	0.770	-	36	116	280	46
Isar	1977	0.870	-	-	0.9	40	85
Italy							
Garigliano	1964	0.152	8456'	8861	3328	2886	
Caorso	1978	0.548	-	-	-	-	
Japan							
Tsuruga	1970	0.357	85	70	23	16	8.1
Tokai 2	1978	1.100	-	-	-	-	-
Fukushima 1	1971	0.460	196	1070	17	740	133
Fukushima 2	1974	0.784					
Fukushima 3	1976	0.784	0.63	0.25	1.1	0.77	0.67
Fukushima 4	1978	0.784					
Fukushima 5	1978	0.784	-	-	0.0026	0.024	0.0025
Hamaoka 1	1976	0.540	-	-	-	-	-
Hamaoka 2	1978	0.840	-	-	-	-	-
Shimane	1974	0.460	-	-	-	-	-
Netherlands							
Dodewaard	1968	0.052	78	230	481	159	119
Sweden							
Oskarshamn 1	1970	0.460	-	5402	5217	4613	4700
Oskarshamn 2	1974	0.590	-	1.4	31	44	290
Ringhals 1	1974	0.780	-	1712	78	2900	19300
Barsebäck 1	1975	0.590	-	0.78	3	2.9	0.97
Barsebäck 2	1976	0.590	-	-	0.37	2.0	3.3
United States							
Big Rock Point	1963	0.075	1872	562	496	699	323
Browns Ferry	1973/77	3.195	932	2974	6142	5809	10027
Brunswick	1975/76	1.580	6.8	685	9102	3381	3184
Cooper	1974	0.764	729	1420	47	151	1125
Dresden 1	1960	0.200	19240	17020	19240	31450	6.8
Dresden 2,3	1971/72	1.545	13653	1199	11581	1502	2557
Duane Arnold	1975	0.515	57	195	143	58	342
J.A. Fitzpatrick	1975	0.800	151	1709	862	218	125
Edwin I. Hatch	1975	0.717	57	115	70	60	142
Humboldt Bay	1963	0.065	10952	3441	-	-	-
Lacrosse	1969	0.048	2109	4588	1573	312	385
Millstone Point 1	1971	0.652	109890	18759	22940	20942	762
Monticello	1971	0.536	5735	422	254	238	149
Nine Mile Point	1969	0.510	48100	6512	131	112	38
Oyster Creek	1969	0.520	7622	6142	6549	36926	37470
Peach Bottom	1974	2.086	480	7730	2631	1425	4592
Pilgrim	1972	0.664	3885	6771	15281	1210	514
Quad Cities	1973	1.538	4070	1166	947	1199	1644
Vermont Yankee	1972	0.514	124	106	131	183	299
Total annual energy generated [GW(e) a]			9.53	13.04	13.24	18.1	20.0
Normalized release [TBq (GW(e) a)$^{-1}$]			25447	7104	8103	6500	4407

Average 1975-1979 8800 TBq [GW(e) a]$^{-1}$

Table 15

Isotopic composition of noble gases discharged from BWRs in the United States during 1979 [B23]

Reactor	Startup year	Energy generated [GW(e) a]	Release (TBq)							
			^{41}Ar	^{83m}Kr	^{85m}Kr	^{85}Kr	^{87}Kr	^{88}Kr	^{89}Kr	^{90}Kr
Big Rock Point 1	1962	0.013	-	9.9	12	0.037	31	17	24	26
Browns Ferry 1,2,3	1973/77	2.393	44	-	50	8140	73	101	-	-
Brunswick 1,2	1975/77	0.810	41	-	88	-	316	281	-	-
Cooper	1974	0.591	-	25	74	3.9	100	188	-	-
Dresden 1	1959	1.013	-	-	-	-	-	-	-	-
Dresden 2,3	1970/71		-	54	-	-	69	136	-	-
Duane Arnold	1974	0.352	3.8	-	32	13	3.2	21	-	-
J.A. Fitzpatrick	1974	0.349	1.5	-	4.7	0.13	2.4	4.1	-	-
Edwin I Hatch	1974	0.401	2.0	-	5.8	-	0.37	2.8	0.06	-
Lacrosse	1967	0.024	-	-	6.8	0.36	41	25	0.49	-
Millstone Point 1	1970	0.505	-	-	14.	-	8.4	2.2	-	-
Monticello	1970	0.522	-	0.37	0.31	0.74	1.9	1.0	36	1.2
Nine Mile Point	1969	0.354	-	-	-	-	-	16	-	-
Oyster Creek	1969	0.541	-	-	1613	-	5217	5032	1.1	-
Peach Bottom 2,3	1973/74	1.740	-	-	16	-	4.1	3.1	-	-
Pilgrim	1972	0.574	-	-	96	0.002	83	204	-	-
Quad Cities 1,2	1971/72	1.075	-	-	121	-	488	190	-	-
Vermont Yankee	1972	0.414	-	-	1.3	-	3.8	3.2	-	-
Total annual energy generated [GW(e) a]		11.670								
Normalized release [TBq (GW[e] a)$^{-1}$]			7.9	7.6	180	690	550	530	5.2	2.3

Reactor	Startup year	Energy generated [GW(e) a]	Release (TBq)							
			^{131m}Xe	^{133m}Xe	^{133}Xe	^{135m}Xe	^{135}Xe	^{137}Xe	^{138}Xe	^{139}Xe
Big Rock Point 1	1962	0.013	0.11	0.32	5.8	40	20	38	64	35
Browns Ferry 1,2,3	1973/77	2.393	-	-	319	121	38	-	610	-
Brunswick 1,2	1975/77	0.810	-	29	84	888	1217	-	240	-
Cooper	1974	0.591	1.7	11	310	9.4	358	0.23	45	-
Dresden 1	1959	1.013	-	-	6.8	-	-	-	-	-
Dresden 2,3	1970/71		-	-	219	250	466	-	1365	-
Duane Arnold	1974	0.352	-	-	212	9.4	42	-	5.1	-
J.A. Fitzpatrick	1974	0.349	4.6	1.2	70	0.6	29	-	3.3	-
Edwin I Hatch	1974	0.401	14	1.2	110	0.74	2.1	-	2.4	-
Lacrosse	1967	0.024	0.35	3.0	27	33	120	2.9	120	-
Millstone Point 1	1970	0.505	81	-	12	119	74	269	182	-
Monticello	1970	0.522	0.07	0.02	10	2.8	2.1	47	41	3.7
Nine Mile Point	1969	0.354	-	-	-	6.0	5.1	-	12	-
Oyster Creek	1969	0.541	-	-	1298	3648	8362	23	12284	-
Peach Bottom 2,3	1973/74	1.740	5.0	72	3922	3.2	566	-	0.97	-
Pilgrim	1972	0.574	-	-	71	7.6	19	-	32	-
Quad Cities 1,2	1971/72	1.075	-	-	481	33	97	-	235	-
Vermont Yankee	1972	0.414	-	-	164	36	8.1	-	81	-
Total annual energy generated [GW(e) a]		11.670								
Normalized release [TBq (GW[e] a^{-1}]			9.1	10	630	450	980	33	1300	3.3

Table 16

Noble gases discharged in airborne effluents from HWRs in various countries 1975-1979 [B21, M10]

Country and reactor	Startup year	Electrical capacity [GW(e)]	Release (TBq) 1975	1976	1977	1978	1979
Argentina							
Atucha	1974	0.320	9.3	160	71	311	252
Canada							
Bruce A	1976/79	4 x 0.755	-	-	1254	1550	3084
Pickering A	1971/73	4 x 0.514	162	104	159	152	218
Total annual energy generated [GW(e) a]			2.2	2.6	3.2	4.1	4.3
Normalized release [TBq (GW[e] a)$^{-1}$]			86	102	464	491	827
		Average 1975-1979			460 TBq [GW(e) a]$^{-1}$		

Table 17

Activation gases released from GCRs in various countries 1975-1979

Country and reactor	Startup year	Electrical capacity [GW(e)]	Release (TBq) 1975	1976	1977	1978	1979
France							
Chinon 1	1963	0.070					
Chinon 2	1965	0.210	224	182	145	94	
Chinon 3	1966	0.400					
St. Laurent des Eaux 1	1969	0.460	129	107	155	250	
St. Laurent des Eaux 2	1971	0.515					
Bugey 1	1972	0.540	195	114	89	107	
Italy							
Latina	1963	0.153	96	92	89	97	
Japan							
Tokai	1966	0.166	207	229	289	307	333
United Kingdom							
Calder	1956	0.200		548	962	1073	1100
Chapelcross	1959	0.192		1184	1184	1184	1200
Berkeley	1962	0.276		592	555	444	444
Bradwell	1962	0.250		555	666	592	555
Hunterston A	1964	0.300			555	740	
Hunterston B	1976	1.240		74			
Trawsfynydd	1964	0.390		5550	5550	4810	5180
Hinkley Point A	1965	0.460		2960	2960	2960	2590
Hinkley Point B	1976	1.240					
Dungeness A	1965	0.410		1110	1110	1110	444
Sizewell	1965	0.420		2220	2220	2220	2220
Oldbury	1967	0.416					
Wylfa	1971	0.840					
Total annual energy generated [GW(e) a]			4.42	4.59	5.10	5.07	4.4
Normalized release [TBq (GW[e] a)$^{-1}$]				3381	3241	3153	3194
		Average 1976-1979			3240 TBq [GW(e) a]$^{-1}$		

Table 18

Tritium discharged in airborne effluents from reactors 1975-1979
[B21, B23, D6, D8, E9, G3, K4, L1, L6, M10, N19, P2, S14]

Country and reactor	Release (TBq)				
	1975	1976	1977	1978	1979
P W R					
France					
Bugey 2,3	-	-	-	44	
Chooz	-	-	-	-	
Fessenheim	-	-	-	-	
Germany, Fed.Rep.of					
Obrigheim	0.99	2.3	0.85	0.96	0.63
Stade	0.56	0.78	0.59	0.99	1.2
Biblis, A,B	0.48	0.48	1.26	2.29	2.4
Neckarswestheim		0.074	0.92	1.04	1.1
Unterweser		-	-	-	0.21
Italy					
Trino	0.14	0.60			
Netherlands					
Borssele	0.44	0.33	0.37	0.93	0.9
United States					
Arkansas 1	0.019	0.25	7.0	0.22	0.47
Arkansas 2	-	-	-	-	0.15
Beaver Valley		138	7.9	14	0.82
Calvert Cliffs	0.046		4.3	0.06	0.19
Cook 1	0.0007	0.004	0.007	0.72	0.5P
Crystal River	-	-	4.5	0.96	1.1
Davis Besse	-	-	0.0014	1.2	0.4
Joseph M. Farley	-	-	-	2.9	0.54
Fort Calhoun	0.088	0.093	0.11	0.14	0.054
R.E. Ginna	0.21	0.89	1.90	1.6	3.6
Haddam Neck	2.59	27	0.0004	2.5	6.4
Indian Point	0.48	0.89	0.44	0.38	0.48
Kewaunee	1.37	0.026	0.14	0.46	0.26
Maine Yankee	0.17	0.14	0.078	0.041	0.11
Millstone Point II	0.063	0.56	0.070	1.5	3.8
North Anna	-	-	-	0.66	0.070
Oconee	62.9	18.5	2.31	2.5	0.98
Point Beach	15.5	14.8	7.22	6.3	29.7
Prairie Island	0.37	1.22	3.24	5.3	5.8
Rancho Seco		0.34	0.78	8.9	5.3
H.B. Robinson	7.14	5.85	2.26	1.6	0.38
Salem	-	-	1.9	5.3	108
St. Lucia		0.074	11.8	19.8	12.6
San Onofre	1.26	1.74	2.81	1.1	1.0
Surry	1.18	13.7	32.5	8.1	3.0
Three Mile Island	1.48	26.6	4.77	7.9	2.4
Trojan	-	0.056	0.11	0.15	0.39
Turkey Point	0.13	0.19	0.14	0.13	0.035
Yankee Rowe	0.074	0.074	0.12	0.11	0.13
Total annual energy generated [GW(e) a]	15.7	16.8	21.3	24.4	22.8
Normalized release [TBq (GW[e] a)$^{-1}$]	6.2	15.2	4.5	5.9	8.5
	Average 1975-1979 7.8 TBq [GW(e) a]$^{-1}$				
B W R					
Germany, Fed. Rep.of					
Gundremmingen	3.7	1.0	0.26	0.037	0.014
Lingen	1.1	0.22	0.20	0.078	-
Würgassen	0.07		0.89	0.28	0.33
Brunsbüttel		0.0074	0.18	0.24	0.34
Isar				0.056	0.25
Italy					
Garigliano	0.026	0.55			
Netherlands					
Dosewaard	-	-	-	-	-
United States					
Big Rock Point	0.27	0.31	0.40	0.31	0.12
Browns Ferry	0.19	0.021	0.87	1.1	1.3
Brunswick	0.07	0.81	0.052	0.37	0.88
Cooper	1.6	2.5	1.9	0.21	0.92
Dresden 1	1.3	2.3	0.56	3.3	0.25
Dresden 2,3	8.1	5.2	18	12	6.8

Table 18, continued

Country and reactor	Release (TBq) 1975	1976	1977	1978	1979
Duane Arnold	0.70	0.59	0.56	0.22	0.33
J.A. Fitzpatrick	0.011	0.56	0.26	0.28	0.24
Edwin I. Hatch	0.066	0.052	0.085	0.22	0.54
Humboldt Bay	0.093	0.048	0.0024	0.0015	0.002
Lacrosse	0.63	0.48	0.32	0.29	0.17
Millstone Point I	0.63	1.1	2.4	1.8	2.2
Monticello		2.8	5.1	8.7	8.1
Nine Mile Point	3.4	0.70	1.7	3.2	1.5
Oyster Creek	0.10	0.041	0.044	1.4	1.4
Peach Bottom	0.011	1.0	3.7	0.74	1.0
Pilgrim	2.7	1.4	0.023	3.5	5.8
Quad Cities	1.4	11.0	1.5	3.7	5.4
Vermont Yankee	0.26	0.52	0.85	0.45	0.61
Total annual energy generated [GW(e) a]	7.1	9.6	10.6	13.1	13.2
Normalized release [TBq (GW[e] a)$^{-1}$]	3.8	3.5	3.8	3.2	2.9
	Average 1975-1979		3.4 TBq [GW(e) a]$^{-1}$		
H W R					
Argentina					
Atucha	38	220	224	222	237
Canada					
Bruce	-	-	315	481	1399
Pickering	918	891	1628	962	1147
Total annual energy generated [GW(e) a]	2.0	2.6	3.2	4.1	4.3
Normalized release [TBq (GW[e] a)$^{-1}$]	478	427	677	406	647
	Average 1975-1979		540 TBq [GW(e) a]$^{-1}$		

Table 19

Tritium discharged in liquid effluents from reactors 1975-1979
[B21, B23, D6, D8, E9, G3, G4, K4, L1, L6, M10, N19, P2, S14]

Country and reactor	Release (TBq) 1975	1976	1977	1978	1979
P W R					
Finland					
Loviisa	-	-	1.2	5.0	
France					
Bugey 2,3	-	-	-	3.3	
Chooz	92	71	96	65	
Fessenheim	-	-	3.1	31	
Germany, Fed. Rep. of					
Obrigheim	6.2	4.7	5.5	4.8	5.0
Stade	3.9	1.6	4.8	4.9	5.4
Biblis A,B	4.1	13	13	28	18
Neckarwestheim	-	0.19	3.1	5.0	3.8
Unterweser	-	-	-	0.0081	4.0
Italy					
Trino	44	27	64	77	
Japan					
Mihama 1,2	2.4	5.2	4.1	8.1	7.4
Mihama 3	-	1.7	3.7	5.2	3.6
Takahama 1,2	13	13	11	17	8.5
Ohi 1,2	-	-	0.014	4.4	16
Ikata 1	-	-	3.3	11	4.1
Genkai	2.3	1.1	11	6.7	11

Table 19, continued

Country and reactor	Release (TBq) 1975	1976	1977	1978	1979
Netherlands					
Borssele	2.1	1.5	1.5	8.4	8.3
Sweden					
Ringhals 2	-	10	8.8	11	8.9
United States					
Arkansas 1	17	7.8	9.1	10.8	6.2
Arkansas 2	-	-	-	-	1.95
Beaver Valley	-	0.32	4.0	12.9	3.5
Calvert Cliffs	9.7	10	21	16.8	19
Cook 1	2.1	7.1	11	23	45
Crystal River	-	-	6.1	5.7	6.1
Davis Besse	-	-	0.33	8.0	9.1
Joseph M. Farley	-	-	-	2.2	3.5
Fort Calhoun	4.1	4.5	5.8	5.6	9.5
R.E. Ginna	9.6	8.9	4.4	8.9	8.9
Haddam Neck	210	179	247	146	131
Indian Point	2.9	12	14	28.4	18.2
Kewaunee	10	6.7	11	10.9	9.2
Maine Yankee	6.5	14	5.7	11.7	7.5
Millstone Point 2	0.28	10	7.8	7.4	9.4
North Anna	-	-	-	10.4	11.6
Oconee	131	81	71	43	33
Palisades	1.5	0.36	2.1	3.7	4.7
Point Beach	33	27	37	48	33
Prairie Island	0.017	0.0037	50	20	23.3
Rancho Seco	4.9	0	0.0031	-	-
H.B. Robinson	23	36	25	17.5	15.9
Salem	-	0.0015	11	16.5	86
St. Lucie	-	0.49	9.0	4.7	4.7
San Onofre 1	148	125	66	92.5	85.8
Surry	16	29	15	27.6	13.2
Three Mile Island 1	17	7.0	7.1	5.7	2.1
Trojan	-	1.3	12	5.9	2.5
Turkey Point	29	29	34	43	35
Yankee Rowe	9.1	5.8	5.1	7.2	6.5
Zion	38	28	27	27	22
Total annual energy generated [GW(e) a)]	16.9	19.2	23.8	29.4	25.8
Normalized release [TBq (GW[e] a)$^{-1}$]	52.9	38.7	40.0	33.0	30.0
	Average 1975-1979 38 TBq [GW(e) a]$^{-1}$				
B W R					
Finland					
Olkiluoto	-	-	-	0.0086	0.46
Germany, Fed.Rep.of					
Gundremmingen	4.7	1.9	0.81	0.093	0.026
Lingen	0.63	0.56	0.092	0.070	0.028
Würgassen	0.15	1.1	1.3	2.0	1.5
Brunsbüttel	-	-	0.34	0.70	0.085
Isar	-	-	0.0015	0.17	0.80
Italy					
Garigliano	0.19	0.67	0.56	0.37	
Japan					
Tsuruga	1.5	1.9	1.0	0.78	1.4
Tokai 2	-	-	-	0.14	0.31
Fukushima 1	-	-	0.14	0.067	0.13
Fukushima 2	-	-	0.0017	0.13	0.16
Fukushima 3	-	-	0.13	0.19	0.0052
Fukushima 4	-	-	-	0.034	0.000027
Fukushima 5	-	-	0.0073	0.10	0.078
Hamaoka 1	-	-	0.24	0.037]	0.63
Hamaoka 2	-	-	-	0.085]	
Shimane	0.14	0.24	0.18	0.19	0.16
Sweden					
Oskarshamn		1.3	1.3	1.6	2.7
Ringhals 1		0.85	0.56	0.32	1.7
Barsebäck		0.52	0.74	1.3	1.1
United States					
Big Rock Point	0.22	0.074	0.33	0.15	0.20
Browns Ferry	0.37	0.15	0.89	1.1	0.49
Brunswick	0.11	0.22	0.33	0.52	1.1

Table 19, continued

Country and reactor	Release (TBq) 1975	1976	1977	1978	1979
Cooper	0.30	0.30	0.33	0.28	0.25
Dresden 1	0.01	0.0007	0.0033	0.49	0.056
Dresden 2,3	2.0	0.74	0.19	0.71	0.71
Duane Arnold	0.012	0.013	0.0078	4.4	0.010
J.A. Fitzpatrick	0.18	0.16	0.12	0.070	0.056
Edwin I. Hatch	0.22	0.33	0.44	0.33	0.46
Humboldt Bay	0.74	0.48	0.020	0.001	0.002
Lacrosse	4.7	1.5	1.8	1.7	1.3
Millstone Point 1	3.0	0.74	0.16	0.12	0.29
Monticello	-	-	-	-	-
Nine Mile Point	1.0	0.093	0.092	-	0.25
Oyster Creek	0.67	1.4	0.70	0.73	0.052
Peach Bottom	1.1	2.7	2.6	1.2	1.6
Pilgrim	0.67	1.7	1.2	0.11	0.50
Quad Cities	2.0	1.8	0.98	0.64	0.63
Vermont Yankee	-	0.059	0.031	-	0.15
Total annual energy generated [GW(e) a]	9.53	13.04	13.24	18.1	20.0
Normalized release [TBq (GW[e] a)$^{-1}$]	2.6	1.6	1.3	1.1	1.0
	Average 1975-1979		1.4 TBq [GW(e) a]$^{-1}$		
G C R					
France					
Chinon	-	3.9	4.1	4.8	
St. Laurent	-	19	13	25	
Bugey 1	9.0	7.2	8.9	14	
Japan					
Tokai	-	-	-	0.0006	0.033
United Kingdom					
Calder	-	-	-	-	-
Chapelcross	0.26	0.33	0.074	1.2	2.8
Bradwell	3.3	11	7.4	3.8	4.4
Berkeley	2.6	1.1	1.9	0.59	1.6
Hunterston A	2.0	2.4	2.0	2.0	
Hunterston B		1.6	2.0	85	
Trawsfynydd	3.3	0.59	0.48	0.56	2.1
Hinkley Point A	2.0	0.89	1.2	2.0	3.6
Hinkley Point B		0.11	27	59	160
Dungeness A	0.93	1.3	0.96	1.2	0.78
Sizewell	1.8	2.3	1.6	1.1	1.6
Oldbury	0.52	0.70	0.56	0.27	0.22
Wylfa	4.8	7.3	11	39	4.6
Total annual energy generated [GW(e) a]	4.42	4.59	5.10	5.07	4.4
Normalized release [TBq (GW[e] a)$^{-1}$]	6.91	13.0	16.0	47.2	41.0
	Average 1975-1979		25 TBq [GW(e) a]$^{-1}$		
H W R					
Argentina					
Atucha	31	76	218	229	259
Canada					
Bruce	-	-	36	152	546
Pickering	540	224	703	1188	1421
Total annual energy generated [GW(e) a]	2.0	2.6	3.2	4.1	4.3
Normalized release [TBq (GW[e] a)$^{-1}$]	286	115	299	383	518
	Average 1975-1979		350 TBq [GW(e) a]$^{-1}$		

Table 20

Carbon-14 discharges from LWRs in the Federal Republic of Germany 1976-1978 [R1, S15]

Reactor	Release (GBq)		
	1976	1977	1978
P W R a/			
Obrigheim		111 (15)	33 (19)
Stade		111(111)	55 (55)
Biblis A		178 (15)	78 (22)
Biblis B		181 (4.4)	168 (15)
Neckarwestheim		148 (4.1)	144 (6)
Normalized release [GBq (GW[e] a)$^{-1}$]			222
B W R b/			
Gundremmingen	137	37	3.7
Lingen	42	7.4	-
Würgassen	-	229	229
Brunsbüttel		159	167
Normalized release [GBq (GW[e] a)$^{-1}$]			518

a/ CO_2 bound values in parentheses.
b/ CO_2 values only.

Table 21

Iodine releases to atmosphere from reactors 1975-1979 [B21, B23, D6, D8, E9, G3, K4, L1, L6, N19, P2, S14]

Country and reactor	Release (GBq)				
	1975	1976	1977	1978	1979
P W R					
Belgium					
Doel	0.089	0.19	0.089	-	0.33
Tihange	0.021	0.74	0.081	0.37	0.11
Finland					
Loviisa	-	-	0.04	-	0.0021
Germany, Fed. Rep. of					
Obrigheim	0.41	0.074	0.022	0.026	0.03
Stade	0.37	0.74	0.96	0.14	0.086
Biblis A,B	0.19	0.37	0.15	0.59	0.68
Unterweser	-	-	-	0.00074	0.045
Neckarwestheim	-	0.074	1.7	0.26	0.032
Italy					
Trino	0.0017	0.00003	0.0033		
Japan					
Mihama 1	-	0.012	0.014	0.0089	0.0048
Mihama 2	-	0.18	0.078	0.093	0.037
Mihama 3	-	0.0052	0.0082	0.010	0.0078
Takahama 1,2	0.048	0.0074	0.070	0.010	0.014
Ohoi 1	-	-	0.00067	0.078	0.041
Ohoi 2	-	-	-	0.0022	0.089
Ikata 1	-	-	-	0.00056	0.028
Netherlands					
Borssele	0.52	0.31	0.13	0.0078	-
Sweden					
Ringhals 2	-	0.27	0.81	0.69	0.27
United States					
Arkansas 1	0.81	1.5	0.41	0.11	0.16
Arkansas 2	-	-	-	-	0.17
Beaver Valley	-	0.0081	0.0056	0.63	0.015
Calvert Cliffs	1.3	18.0	14.0	7.4	15.5
Cook 1	0.0063	0.052	3.7	0.48	0.55
Fort Calhoun	0.26	27.0	4.8	0.30	0.47
Crystal River	-	-	0.058	31.0	58.0
Davis Besse	-	-	0.0041	0.11	0.20

Table 21, continued

Country and reactor	Release (GBq) 1975	1976	1977	1978	1979
Joseph M. Farley	-	-	-	0.0017	0.0005
R.E. Ginna	2.4	1.3	0.96	0.32	0.71
Haddam Neck	0.033	0.027	0.030	0.11	1.8
Indian Point	15.0	10.0	5.2	3.0	6.1
Kewaunee	0.74	0.12	0.76	0.15	0.043
Maine Yankee	0.22	0.059	0.21	0.074	4.8
Millstone Point 2	0.0017	1.8	0.22	0.53	0.62
North Anna	-	-	-	1.1	1.4
Oconee	0.41	5.9	14.0	6.3	7.4
Palisades	16.0	1.1	0.89	1.6	1.0
Point Beach	7.0	0.23	0.23	0.56	0.78
Prairie Island	0.78	0.93	0.30	0.74	0.16
Rancho Seco	0.007	0.04	0.096	18	0.20
H.B. Robinson	0.85	9.3	0.44	0.070	0.006
Salem	-	-	-	0.20	0.30
St. Lucie	-	0.074	3.0	38	7.4
San Onofre	9.3	0.17	0.0066	0.0078	0.0045
Surry	4.8	20.0	18.0	2.2	0.23
Three Mile Island 1	0.035	0.32	0.78	0.96	0.41
Trojan	-	-	0.97	0.89	1.7
Turkey Point	17.0	19.0	52.0	18.0	1.7
Yankee Rowe	0.1	0.048	0.0085	0.014	0.014
Zion	-	3.3	1.6	2.6	0.45
Total annual energy generated [GW(e) a]	16.9	19.2	23.8	29.4	27.5
Normalized release [GBq (GW[e] a)$^{-1}$]	4.70	6.41	5.32	4.68	4.18
	Average 1975-1979		5.0 GBq [GW(e) a]$^{-1}$		
B W R					
Finland					
Olkiluoto	-	-	-	0.017	0.023
Germany, Fed.Rep. of					
Gundremmingen	9.3	13	0.19	0.0028	-
Lingen	48	1.9	0.052	0.00074	-
Würgassen	0.052	1.7	1.0	4.1	2.5
Brunsbüttel	-	0.00074	0.56	1.8	0.018
Isar	-	-	-	-	0.003
Italy					
Garigliano	0.59	1.3	0.56		
Japan					
Tsuruga	1.2	1.0	0.37	0.19	0.17
Tokai 2	-	-	-	0.012	0.028
Fukushima 1,2	0.48	8.9	1.0	32.0	5.9
Fukushima 3,4	-	0.0037	0.18	0.048	0.096
Fukushima 5					-
Hamaoka 1,2					0.0052
Shimane					-
Sweden					
Ringhals 1		0.67	0.32	1.2	23
Oskarshamn		2.7	8.9	5.5	5.0
Barsebäck		0.070	0.031	0.089	0.10
United States					
Big Point Rock	10.0	5.9	7.4	5.4	0.24
Browns Ferry	22.0	22.0	5.9	14.4	5.8
Brunswick	0.10	17.0	78.0	38.0	28.0
Cooper	16.0	3.3	1.7	5.4	8.0
Dresden 1	211.0	85.0	2020.0	997.0	0.12
Dresden 2,3	4.1	4.8	4.8	2110.0	1298.0
Duane Arnold	15.0	4.1	4.1	1583.0	569.0
J.A. Fitzpatrick	0.67	215.0	7.0	9.4	0.86
Edwin I. Hatch	0.24	0.13	0.27	0.084	0.92
Humboldt Bay	41.0	14.0	0.00044	-	-
Lacrosse	4.8	3.7	9.3	1.5	0.82
Millstone Point 1	2331.0	1332.0	2257.0	1417.0	141.0
Monticello	555.0	37.0	20.0	15.0	10.3
Nine Mile Point	222.0	318.0	52.0	44.0	5.8
Oyster Creek	1517.0	1702.0	1517.0	2294.0	2868.0
Peach Bottom	1.3	70.0	63.0	52.0	49.0

Table 21, continued

Country and reactor	Release (GBq) 1975	1976	1977	1978	1979
Pilgrim	229.0	74.0	126.0	61.0	52.0
Quad Cities	107.0	159.0	222.0	407.0	523.0
Vermont Yankee	15.0	2.6	0.81	11.0	21.0
Total annual energy generated [GW(e) a]	9.53	13.04	13.24	18.1	20.0
Normalized release [GBq (GW[e] a)$^{-1}$]	561	314	484	501	280
	Average 1975-1979 410 GBq [GW(e) a]$^{-1}$				
G C R					
France					
Chinon	0.78	0.081			
Bugey	0.81	0.070			
St. Laurent	0.59	0.41			
Japan					
Tokai				0.0041	0.0030
H W R					
Argentina					
Atucha [GBq (GW[e] a)$^{-1}$]	0.16	1.2	0.24	5.4	8.7
	Average 1975-1979 3.1 GBq [GW(e) a]$^{-1}$				

Table 22

Isotopic composition of iodine releases from reactors in the United States in 1979 [B23]

Reactor	Release (GBq) ^{131}I	^{132}I	^{133}I	^{134}I	^{135}I
P W R					
Arkansas 1	0.16	-	0.0067	-	-
Arkansas 2	0.17	-	0.0003	-	-
Beaver Valley	0.015	-	0.0015	-	0.0018
Calvert Cliffs	11.1	0.28	4.0	-	0.14
Cook 1	0.53	-	0.026	-	-
Crystal River	0.69	-	0.15	-	58.0
Davis Besse	0.18	-	0.023	-	0.0041
Fort Calhoun	0.048	-	0.067	0	0.35
Joseph M. Farley	0.0005	-	-	-	-
R.E. Ginna	0.35	0.044	0.32	-	-
Haddam Neck	1.7	-	0.093	-	0.14
Indian Point	4.3	-	0.46	-	1.3
Kewaunee	0.020	0.0078	0.011	0.00035	0.0039
Maine Yankee	2.0	-	2.6	-	0.23
Millstone Point 2	0.53	-	0.036	-	0.059
North Anna	1.3	-	0.052	-	-
Oconee	5.1	0.10	1.8	0.033	0.37
Palisades	0.70	-	0.31	-	0.083
Point Beach	0.16	0.36	0.26	0.008	0.0029
Prairie Island	0.14	-	0.023	-	-
Rancho Seco	0.17	-	0.030	-	-
H.B. Robinson	0.0014	-	0.0021	-	0.004
St. Lucie	3.7	-	3.7	-	0.004
Salem	0.20	-	0.10	-	-
San Onofre	0.045	-	-	-	-
Surry 1,2	0.23	0.0044	0.0029	-	-
Three Mile Island 1	0.41	-	-	-	-
Trojan	0.53	0.001	0.47	-	0.70

Table 22, continued

Reactor	Release (GBq)				
	^{131}I	^{132}I	^{133}I	^{134}I	^{135}I
Turkey Point	1.2	-	0.58	-	0.065
Yankee Row	0.0067	-	0.0028	-	0.0048
Zion 1,2	0.23	-	0.22	-	-
Total annual energy generated [GW(e) a]	19.165				
Normalized release [GBq (GW[e] a)$^{-1}$]	1.9	0.042	0.78	0.0017	3.2
B W R					
Big Rock Point	0.011	-	0.11	-	0.13
Browns Ferry 1,2,3	1.0	-	1.1		3.7
Brunswick 1,2	4.7	1.3	17.8	-	4.2
Cooper	2.5	-	0.76	-	4.7
Dresden 1	0.12	-	-	-	-
Dresden 2,3	75	-	390	-	834
Duane Arnold	0.35	-	2.7	-	566
J.A. Fitzpatrick	0.21	-	0.44	-	0.21
Edwin I. Hatch	0.88	-	0.043	-	-
Lacrosse	0.41	0.011	0.28	0.030	0.088
Millstone Point	15	-	59	-	67
Monticello	0.89	-	3.4	-	6.0
Nine Mile Point	1.0	-	1.5	-	3.3
Oyster Creek	326	-	1095	-	1447
Peach Bottom 2,3	9.5	-	23	-	16
Pilgrim	3.7	-	5.7	-	43
Quad Cities 1,2	35	-	210		278
Vermont Yankee	15	-	4.4	-	1.8
Total annual energy generated [GW(e) a]	11.670				
Normalized release [GBq (GW[e] a)$^{-1}$]	42	0.11	155	0.0026	281

Table 23

Particulate releases from reactors in various countries 1975-1979
[B23, D6, D8, E9, G3, K4, L1, L6, N19, P2, S14]

Country and reactor	Release (GBq)				
	1975	1976	1977	1978	1979
P W R					
Belgium					
Doel	6.7	7.8	6.3	6.7	
Tihange	-	0.0018	1.1	3.2	
Finland					
Loviisa	-	-	-	0.042	0.037
France					
Chooz	0.089	0.063	3.4	0.44	
Fessenheim	-	-	-	0.67	
Bugey 2,3	-	-	-	0.059	
Germany, Fed. Rep.of					
Obrigheim	0.93	0.30	0.24	0.16	0.075
Stade	1.1	0.26	0.33	0.37	0.025
Biblis A,B	0.22	0.11	0.20	0.0013	0.016
Neckarwestheim	-	0.019	0.45	0.19	0.025
Italy					
Trino	-	-	0.0037		
Netherlands					
Borssele	0.67	0.052	0.025	0.00052	0.004
Sweden					
Ringhals 2	-	0.30	0.26	0.083	0.009
United States					
Arkansas 1	0.41	0.63	0.0044	0.044	0.00074
Arkansas 2	-	-	-	-	0.0074
Beaver Valley	-	0.00005	0.0002	0.00074	0.00059
Calvert Cliffs	0.41	0.59	5.2	0.50	0.18

Table 23, continued

Country and reactor	Release (GBq) 1975	1976	1977	1978	1979
Cook 1,2	-	0.0002	0.52	3.6	2.2
Crystal River	-	-	0.037	0.0006	0.16
Davis Besse	-	-	0.0088	0.0083	0.033
Joseph M. Farley	-	-	-	1.5	0.81
Fort Calhoun	0.0041	0.01	0.0027	0.0045	0.0059
R.E. Ginna	0.0016	0.001	0.0026	0.0048	0.34
Haddam Neck	0.078	0.0063	0.036	0.081	0.11
Indian Point	46	1.0	0.56	6.9	12
Kewaunee	24	0.012	0.021	0.059	0.003
Maine Yankee	0.0093	0.078	0.012	0.0081	0.037
Millstone Point 2	0.0004	0.11	0.014	0.029	3.0
North Anna	-	-	-	0.036	0.81
Oconee	0.010	3.7	7.8	1.9	3.7
Palisades	0.022	0.56	0.041	0.15	0.059
Point Beach	3.5	0.59	0.067	0.37	0.35
Prairie Island	0.13	0.0089	0.041	0.0015	0.003
Rancho Seco	0.0029	0.002	0.093	0.52	0.048
H.B. Robinson	0.050	0.021	0.093	0.013	0.015
St. Lucie	-	0.00056	2.8	10	3.7
Salem	-	-	0.00001	1.3	0.081
San Onofre	1.3	0.00067	0.00018	0.093	0.00074
Surry	2.9	3.0	0.56	0.13	0.052
Three Mile Island 1	0.0037	0.16	0.44	3.7	0.04
Trojan	-	0.37	0.95	0.24	0.74
Turkey Point	2.2	2.8	1.9	2.9	1.7
Yankee Rowe	0.30	0.00081	0.0012	0.0002	0.003
Total annual energy generated [GW(e) a]	15.7	17.3	21.8	24.8	23.6
Normalized release [GBq (GW(e) a)$^{-1}$]	5.77	1.27	1.54	1.85	1.28
	Average 1975-1979	2.15 GBq [GW(e) a]$^{-1}$			
B W R					
Finland					
Olkiluoto	-	-	-	0.0059	0.33
Germany, Fed.Rep.of					
Gundremmingen	0.30	0.19	0.27	0.15	0.004
Lingen	3.7	0.019	0.070	0.056	0.0013
Würgassen	4.0	0.63	1.4	2.1	1.4
Brunsbüttel	-	0.26	2.7	1.4	7.4
Isar	-	-	0.0011	0.16	0.79
Italy					
Garigliano		1.2	0.74		
Netherlands					
Dodewaard	0.22	0.12	0.11	0.035	
Sweden					
Oskarshamm	-	15	8.3	1.2	1.6
Ringhals 1	-	4.9	20	11	94
Barsebäck	-	0.096	0.72	1.6	0.30
United States					
Big Rock Point	3.6	1.5	0.32	0.22	0.059
Browns Ferry	2.2	2.0	2.4	3.7	4.8
Brunswick	0.14	0.70	5.2	4.1	25
Cooper	1.1	0.41	0.17	0.081	0.11
Dresden 1	13.0	17.0	22.0	41	0.77
Dresden 2,3	153.0	167.0	1561.0	89.0	185.0
Duane Arnold	0.33	0.25	0.27	0.85	0.89
J.A. Fitzpatrick	0.67	0.70	1.1	2.0	0.32
Edwin I. Hatch	0.01	0.017	0.031	0.085	0.078
Humboldt Bay	31.0	1.0	0.015	0.026	0.004
Lacrosse	0.48	0.85	0.41	0.12	0.48
Millstone Point 1	7.0	5.6	7.4	50	7.0
Monticello	24.0	1.9	0.74	0.50	0.37
Nine Mile Point	16.0	3.7	1.8	1.0	0.74
Oyster Creek	6.7	8.1	48.0	296.0	19.0
Peach Bottom	0.14	1.4	1.0	0.46	0.30
Pilgrim	24.0	12.0	7.8	2.1	2.0

Table 23, continued

Country and reactor	Release (GBq) 1975	1976	1977	1978	1979
Quad Cities	15.0	20.0	27.0	41.0	23.0
Vermont Yankee	0.074	0.21	0.28	0.20	1.1
Total annual energy generated [GW(e) a]	7.1	10.9	11.9	15.5	15.5
Normalized release [GBq (GW[e] a)$^{-1}$]	43.0	24.4	144.0	35.5	24.2
	Average 1975-1979 52.7 GBq [GW(e) a]$^{-1}$				
G C R					
France					
Chinon	0.37	0.67	0.48	0.48	
Bugey	0.063	0.30	0.28	0.67	
St. Laurent	0.048	0.070	0.23	0.16	
Japan					
Tokai	-	-	-		
United Kingdom					
Bradwell	0.11	0.096	0.11	0.15	0.15
Berkeley	0.14	0.11	0.11	0.074	0.15
Hunterston A	-	-	0.37	0.37	-
Hunterston B	-	0.27	0.26	0.019	-
Trawsfynydd	0.41	0.48	0.67	0.37	0.41
Hinkley Point A	0.41	0.48	0.37	0.41	0.74
Hinkley Point B	-	0.70	0.67	1.1	1.1
Dungeness A	2.0	0.70	0.41	0.52	0.33
Sizewell	0.37	0.41	0.56	0.48	0.45
Oldbury	1.3	0.067	0.11	0.074	0.10
Wylfa	0.15	0.31	0.37	0.37	0.26
Total annual energy generated [GW(e) a]	4.42	4.59	5.10	5.07	4.3
Normalized release [GBq (GW[e] a)$^{-1}$]	1.19	1.02	0.98	1.03	0.86
	Average 1975-1979 1.0 GBq [GW(e) a]$^{-1}$				
H W R					
Argentina					
Atucha [GBq (GW[e] a)$^{-1}$]	0.018	0.037	0.028	0.060	0.078
	Average 1975-1979 0.044 GBq [GW(e) a]$^{-1}$				

Table 24

Liquid effluent discharges other than tritium from reactors 1975-1979
[B23, D6, D8, E9, G3, K4, L1, L6, N19, P2, S14]

Country and reactor	Release (GBq) 1975	1976	1977	1978	1979
P W R					
Belgium					
Doel	381	1840	625	696	
Tihange	14	31	132	72	
Finland					
Loviisa	-	-	4	18	15
France					
Chooz	318	95	4.1		
Fessenheim	-	-	256	174	
Bugey 2,3	-	-	-	364	
Germany, Fed. Rep.of					
Obrigheim	64	36	9.6	6.3	6.3
Stade	10	12	14	3.7	9.7
Biblis A	27	8.1	3.8	4.7	1.9

Table 24, continued

Country and reactor	Release (GBq) 1975	1976	1977	1978	1979
Biblis B	-	11	1.1	4.4	7.8
Neckarswestheim	-	8.9	5.6	1.1	2.1
Unterweser	-	-	-	-	0.07
Italy					
Trino	54	100	52	48	
Japan					
Mihama 1	0.74	0.22	0.28	0.32	0.34
Mihama 2					
Mihama 3		0.01	0.044	0.048	0.078
Takahama 1	0.16	0.14	0.31	0.074	0.063
Takahama 2					
Ohi 1		0.0014	0.041	0.06	
Ohi 2					
Ikata 1		0.037	0.048	0.007	
Genkai 1	0.033	-	-	-	-
Netherlands					
Borssele	60	31	16	11	11
Sweden					
Ringhals	-	225	427	209	115
United States					
Arkansas 1	115	485	167	223	114
Arkansas 2	-	-	-	-	48
Beaver Valley 1	-	6.3	24	9.7	4.5
Calvert Cliffs 1	53	44	129	227	289
Cook 1	9.6	69	56	55	95
Crystal River	-	-	0.57	1.1	15
Davis Besse	-	-	0.96	3.3	1.6
Joseph M. Farley	-	-	-	3.7	2.2
Fort Calhoun	13	20	13	22	9.0
R.E. Ginna	16	26	2.4	2.2	3.2
Haddam Neck	44	4.8	63	35	32
Indian Point	182	184	112	111	87
Kawaunee	27	105	47	26	33
Maine Yankee	119	105	16	3.8	17
Millstone Point 2	0.74	9.6	57	103	180
North Anna	-	-	-	9.9	22
Oconee 1,2,3	187	293	1340	241	34
Palisades	128	16	3.4	3.6	4.7
Point Beach 1,2	87	120	56	25	27
Prairie Island 1,2	17	3.7	0.49	0.18	0.33
Rancho Seco	0.37	-	-	-	-
H.B. Robinson	17	14	12	6.6	11
St. Lucie	-	3.0	215	104	99
Salem 1	-	0.37	107	148	147
San Onofre 1	45	275	364	437	407
Surry 1,2	343	1246	2424	89	94
Three Mile Island 1	2.6	3.7	7.2	23	18
Trojan	-	102	155	26	21
Turkey Pt. 3,4	114	320	329	123	15
Yankee Rowe	0.74	0.37	0.67	3.0	0.43
Zion 1,2	0.37	5.9	35	35	26
Total annual energy generated [GW(e) a]	16.9	19.2	23.8	29.4	27.5
Normalized release [GBq (GW(e) a)$^{-1}$]	145	310	306	126	74
	Average 1975-1979	184 GBq [GW(e) a]$^{-1}$			
B W R					
Finland					
Olkiluoto	-	-	-	1.2	7.7
Germany, Fed. Rep.of					
Gundremmingen	47	43	64	20	8.3
Lingen	1.5	9.6	0.37	0.37	0.93
Würgassen	69	41	58	20	16
Brunsbüttel	-	83	61	52	17
Isar	-	-	1.5	7.8	9.7
Italy					
Garigliano	116	139	152	111	
Japan					
Tsuruga	1.5	1.9	1.0	0.78	1.4
Tokai 2	-	-	-	0.14	0.31
Fukushima 1	-	-	0.14	0.067	0.13

Table 24. continued

Country and reactor	Release (GBq) 1975	1976	1977	1978	1979
Fukushima 2	-	-	0.017	0.13	0.16
Fukushima 3	-	-	0.13	0.19	0.0052
Fukushima 4	-	-	-	0.034	0.000027
Fukushima 5	-	-	0.0073	0.10	0.078
Hamaoka 1	-	-	0.24	0.037	0.63
Hamaoka 2	-	-	-	0.085	
Shimane	0.14	0.24	0.18	0.19	0.16
Sweden					
Oskarshamn 1,2		903	485	158	155
Ringhals 1		232	249	148	223
Barsebäck 1,2		64	68	140	58
United States					
Big Rock Point 1	74	28	14	10	33
Browns Ferry 1,2,3	100	146	44	488	66
Brunswick 1,2	70	122	230	129	189
Cooper	64	2.6	28	113	92
Dresden 1	31	13	22	12	0.98
Dresden 1,2	30	45	16	15	9.8
Duane Arnold	3.7	3.7	0.085	10	0.02
J.A. Fitzpatrick	197	222	33	58	24
Edwin I. Hatch	2.2	1.5	925	1.5	1.8
Humboldt Bay	140	37	34	7.2	3.5
Lacrosse	525	214	788	328	124.7
Millstone Point 1	7360	357	19	6.5	7.8
Monticello	-	-	-	-	-
Nine Mile Point	780	79	11	-	70
Oyster Creek	15	8.1	3.6	0.55	0.25
Peach Bottom 2,3	34	125	83	189	722
Pilgrim	296	86	126	65	19
Quad Cities	633	258	50	83	48
Vermont Yankee	0.37	0.37	5.7	-	0.01
Total annual energy generated [GW(e) a]	9.53	13.04	13.24	18.1	20.0
Normalized release [GBq (GW[e] a)$^{-1}$]	1100	251	273	121	96
	Average 1975-1979 290 GBq [GW(e)a]$^{-1}$				
G C R					
France					
Chinon	24	21	8.5	13	
Bugey 1	511	133	144	401	
St. Laurent	174	110	181	300	
Japan					
Tokai					
United Kingdom					
Chapelcross	640	1200	337	2830	9100
Bradwell	4400	2420	2450	2000	1576
Berkeley	2000	4140	5480	1180	1687
Hunterston A	4260	5880	5440	2220	-
Hunterston B	-	22	44	220	-
Trawsfynydd	629	740	500	648	289
Hinkley Point A	5880	5110	4440	4070	2812
Hinkley Point B	-	41	44	189	600
Dungeness	2940	1710	1680	1410	1110
Sizewell	740	1090	1590	910	1420
Oldbury	1010	1860	2440	1120	706
Wylfa	125	241	688	977	600
Total annual energy generated [GW(e) a]	4.42	4.59	5.10	5.07	4.3
Normalized release [GBq (GW[e] a)$^{-1}$]	5280	5390	4990	3650	4628
	Average 1975-1979 4767 GBq [GW(e) a]$^{-1}$				
H W R					
Argentina					
Atucha [GBq (GW[e] a)$^{-1}$]	520	750	530	230	390
	Average 1975-1979 473 GBq [GW(e) a]$^{-1}$				

Table 25

Radionuclide composition of liquid discharges other than tritium from reactors in the United States in 1979

Reactor	Release (GBq)									
	^{131}I	^{132}I	^{133}I	^{134}I	^{135}I	^{24}Na	^{51}Cr	^{54}Mn	^{56}Mn	^{57}Co
P W R										
Arkansas 1	10	0.0004	0.012	-	-	0.002	11	1.5	-	0.11
Arkansas 2	8.9	0.0033	1.7	0.0037	0.19	2.5	0.67	1.4	0.0037	0.12
Beaver Valley 1	0.032	-	0.030	-	-	-	0.048	0.27	-	-
Calvert Cliffs 1	24	0.46	14	-	1.3	-	24	4.1	0.024	0.24
Cook 1	0.44	-	0.024	-	-	0.52	5.2	2.9	-	0.085
Crystal River	2.2	0.0063	0.070	-	0.0056	0.0033	0.63	0.20	-	-
Davis Besse	0.13	-	0.0074	-	-	0.0037	0.034	0.24	-	-
Joseph M. Farley	0.049	0.0048	0.0037	-	0.00026	0.056	0.093	0.11	-	0.0036
Fort Calhoun	0.78	-	0.10	-	-	-	0.57	0.13	-	0.089
R.E. Ginna	0.34	-	-	-	-	-	0.13	0.048	-	-
Haddam Neck	2.5	-	-	-	-	-	0.31	0.093	-	0.00015
Indian Point	5.1	0.00096	0.0037	-	-	-	2.9	1.3	-	0.0002
Kawaunee	0.022	-	-	-	-	0.052	1.9	0.63	-	0.0018
Maine Yankee	15	-	0.21	-	-	-	0.0023	0.014	-	0.0023
Millstone Point 2	4.4	0.0059	0.19	-	-	3.0	8.2	5.9	0.0016	-
North Anna	5.9	-	0.89	-	-	0.012	0.033	0.048	-	0.74
Oconee 1,2,3	5.3	0.019	0.36	0.074	0.096	0.0096	0.36	0.27	0.0017	0.018
Palisades	0.014	-	-	-	-	-	0.47	0.46	-	0.00019
Point Beach 1,2	0.33	0.36	6.3	0.78	3.1	-	0.020	0.27	-	0.0059
Prairie Island 1,2	0.028	-	-	-	-	-	0.016	0.0013	-	-
Rancho Seco	-	-	-	-	-	-	-	-	-	-
H.B. Robinson	0.14	-	-	-	-	-	-	1.1	-	0.0042
St. Lucie	1.8	0.0057	0.35	0.0037	0.091	0.0032	5.2	2.1	1.6	0.054
Salem 1	0.70	-	0.11	-	-	0.16	3.5	15	-	-
San Onofre 1	0.93	-	-	-	-	-	8.3	0.28	-	-
Surry 1,2	2.4	5.2	4.9	4.3	7.1	8.9	7.4	1.5	-	0.074
Three Mile Island 1	5.3	-	-	-	-	-	0.25	0.054	-	-
Trojan	0.47	-	0.071	0.0037	0.026	0.0067	2.7	1.3	-	0.048
Turkey Pt. 3,4	0.74	0.49	2.1	0.11	1.2	0.19	0.18	0.041	-	0.005
Yankee Rowe	0.15	-	0.015	-	-	-	0.015	0.004	-	-
Zion 1,2	0.43	-	0.00057	-	-	0.39	2.2	0.61	-	0.024
Total annual energy generated [GW(e) a]	19.165									
Normalized release [GBq (GW[e] a)$^{-1}$]	4.6	0.31	1.7	0.24	0.68	1.1	4.6	2.2	0.085	0.084

Table 25, continued

Reactor	Release (GBq)										
	^{58}Co	^{59}Fe	^{60}Co	^{65}Zn	^{89}Sr	^{90}Sr	^{95}Zr	^{97}Zr	^{95}Nb	^{97}Nb	^{99}Mo
P W R											
Arkansas 1	58	0.74	17	0.013	0.11	0.015	1.1	0.01	2.0	0.16	0.11
Arkansas 2	30	0.56	0.81	0.0013	0.24	-	0.031	-	0.047	0.022	0.031
Beaver Valley 1	1.6	0.033	2.3	-	0.0007	0.0016	0.0033	-	-	-	-
Calvert Cliffs 1	141	1.1	12	-	0.085	0.096	5.6	0.019	0.59	-	0.45
Cook 1	33	0.70	20	0.21	0.0096	0.0044	3.0	0.11	3.0	-	-
Crystal River	4.3	0.093	1.3	0.034	1.8	0.26	0.26	-	-	-	0.52
Davis Besse	0.85	0.0093	0.093	0.01	0.0014	0.0017	0.012	-	-	-	0.036
Joseph M. Farley	0.96	0.019	0.81	0.0011	-	0.00074	0.0074	-	0.023	-	0.0013
Fort Calhoun	0.41	0.074	0.15	0.089	0.018	0.0048	0.079	-	0.046	-	0.032
R.E. Ginna	0.081	0.0074	1.5	-	-	-	0.033	-	0.024	-	0.041
Haddam Neck	0.52	0.00015	3.6	0.00015	0.25	0.13	5.4	-	-	-	0.00015
Indian Point	11	0.56	5.9	1.8	0.18	0.33	0.52	-	-	-	6.3
Kawaunee	11	0.085	6.7	-	0.030	0.0063	0.11	-	0.13	-	-
Maine Yankee	0.67	-	0.052	-	-	0.0017	-	-	-	-	0.0024
Millstone Point 2	60	0.67	58	0.0044	0.048	0.0063	1.1	0.0015	2.6	3.3	0.037
North Anna	4.8	0.0033	0.47	-	0.18	0.13	0.033	-	-	-	-
Oconee 1,2,3	6.7	0.019	1.8	-	3.0	0.27	0.37	0.011	0.15	1.0	0.059
Palisades	2.4	0.047	0.46	-	-	-	0.021	-	0.054	-	-
Point Beach 1,2	1.8	0.0033	0.59	-	0.0026	0.00063	0.081	-	0.046	-	0.070
Prairie Island 1,2	0.11	0.015	0.035	-	-	-	0.00034	-	-	-	0.0025
Rancho Seco	-	-	-	-	-	-	-	-	-	-	-
H.B. Robinson	3.7	0.085	2.9	-	-	-	-	-	-	-	-
St. Lucie	37	0.37	7.0	0.12	0.028	0.00004	0.67	0.0095	-	-	0.0074
Salem 1	52	0.98	70	-	-	-	0.37	-	-	-	-
San Onofre 1	343	7.3	25	-	0.60	0.025	-	-	0.59	-	-
Surry 1,2	67	0.0060	61	-	0.052	0.016	-	-	0.71	-	-
Three Mile Island 1	2.3	0.0049	0.54	0.015	3.4	0.27	0.0011	-	0.34	-	0.00032
Trojan	5.2	0.15	6.4	0.0097	0.065	0.0037	0.48	-	0.78	-	0.00078
Turkey Pt. 3,4	1.8	0.0063	3.1	-	0.29	0.048	0.029	-	0.012	-	0.0044
Yankee Rowe	0.015	-	0.0069	0.0036	0.0006	0.0021	-	-	-	-	0.0083
Zion 1,2	5.2	0.041	7.1	-	0.021	0.016	0.14	-	0.50	-	-
Total annual energy generated [GW(e) a]	19.165										
Normalized release [GBq (GW(e) a)$^{-1}$]	46	0.71	17	0.12	0.54	0.086	1.0	0.0084	0.60	0.23	0.38

Table 25, continued

Reactor	Release (GBq)											
	^{99m}Tc	^{103}Ru	^{106}Ru	^{110m}Ag	^{124}Sb	^{125}Sb	^{134}Cs	^{136}Cs	^{137}Cs	$^{140}Ba/La$	^{141}Ce	^{144}Ce
P W R												
Arkansas 1	-	0.12	0.040	1.1	-	-	3.6	-	5.6	0.25	-	0.037
Arkansas 2	-	0.0051	-	0.061	-	-	0.057	0.0081	0.95	0.018	-	-
Beaver Valley 1	-	-	-	-	-	-	0.023	-	0.10	-	0.0090	-
Calvert Cliffs 1	-	0.93	0.47	3.5	1.0	10	14	0.12	21	0.70	0.21	-
Cook 1	-	-	-	-	-	-	0.048	-	0.15	0.016	-	-
Crystal River	0.014	-	-	0.0074	-	-	1.7	-	2.5	0.013	0.022	0.17
Davis Besse	0.0033	-	-	-	-	-	0.048	-	0.12	0.016	0.0074	-
Joseph M. Farley	0.00004	-	0.0013	0.0063	-	-	0.0052	0.00019	0.016	0.0037	0.00019	0.0033
Fort Calhoun	0.016	0.059	-	-	0.070	-	2.3	0.070	0.37	0.14	0.12	-
R.E. Ginna	-	0.011	0.05	0.028	-	-	0.12	0.049	0.48	0.013	0.0025	0.0070
Haddam Neck	0.00015	2.4	1.4	0.002	-	0.00015	1.5	-	1.8	0.017	2.0	10
Indian Point	0.22	0.0004	-	-	0.0074	0.011	5.2	-	16	1.7	0.50	0.0096
Kawaunee	-	-	-	1.2	2.1	2.4	2.9	-	3.2	0.059	-	-
Maine Yankee	-	-	-	-	-	-	0.12	-	0.78	-	-	-
Millstone Point 2	-	-	-	2.4	-	-	12	1.6	14	0.035	0.018	0.13
North Anna	0.0028	0	0	0	0	-	3.3	-	4.6	-	-	-
Oconee 1,2,3	0.036	0.0020	0.25	0.37	-	0.061	4.6	0.37	8.9	0.12	-	0.17
Palisades	-	-	-	-	-	-	0.074	-	0.29	-	-	-
Point Beach 1,2	-	0.081	-	-	0.0085	0.019	0.56	0.00048	2.0	1.1	-	0.074
Prairie Island 1,2	0.0034	-	-	-	0.027	-	-	-	-	-	-	-
Rancho Seco	-	-	-	-	-	-	-	-	-	-	-	-
H.B. Robinson	-	-	-	-	0.031	0.041	0.13	1.7	1.1	-	0.00070	0.019
St. Lucie	0.036	0.027	-	1.2	1.5	1.0	10	0.12	14	0.013	0.030	0.11
Salem 1	-	-	-	-	0.45	-	2.1	0.019	1.6	-	-	-
San Onofre 1	1.2	0.50	-	1.1	-	-	0.87	-	1.7	-	-	-
Surry 1,2	-	-	-	-	-	-	16	0.0042	36	0.015	0.0060	0.12
Three Mile Island 1	-	0.011	-	0.057	0.016	0.098	0.86	0.058	3.7	0.84	0.0019	0.0013
Trojan	0.008	0.22	-	0.63	0.16	0.37	0.078	0.0032	0.19	0.54	0.074	0.14
Turkey Pt. 3,4	0.0044	0.010	-	0.12	0.58	0.63	1.1	-	1.8	-	-	-
Yankee Rowe	0.0013	-	-	0.0011	0.0016	-	0.075	-	0.098	0.0061	0.0021	0.0083
Zion 1,2	0.029	-	-	0.24	0.80	-	4.4	-	5.3	0.070	-	-
Total annual energy generated [GW(e) a]	19.165											
Normalized release [GBq (GW[e] a)$^{-1}$]	0.087	0.23	0.12	0.63	0.35	0.76	4.4	0.21	7.7	0.29	0.16	0.57

Reactor	Release (GBq)									
	^{131}I	^{132}I	^{133}I	^{134}I	^{135}I	^{24}Na	^{51}Cr	^{54}Mn	^{56}Mn	^{57}Co
B W R										
Big Rock Point	-	-	0.010	-	-	0.0014	0.21	2.2	-	-
Browns Ferry 1,2,3	1.4	-	0.78	-	-	10	17	3.7	0.10	-
Brunswick 1,2	8.0	0	0.65	-	-	60	13	18	0.024	-
Cooper	3.4	-	-	-	-	0.046	2.1	5.5	0.0053	-
Dresden 1	-	-	-	-	-	-	-	0.037	-	-
Dresden 2,3	0.18	-	-	-	-	-	0.012	1.1	-	-
Duane Arnold	-	-	-	-	-	-	-	0.0037	-	-
J.A. Fitzpatrick	0.023	-	0.010	-	0.0023	1.8	0.14	5.3	-	-
Edwin I. Hatch	0.18	0.0002	0.0019	-	0.0007	0.11	0.12	0.035	0.00037	-
Humboldt Bay	-	-	-	-	-	-	-	0.18	-	-
Lacrosse	1.8	0.17	0.94	0.009	0.33	-	0.16	2.4	0.0037	2.5
Millstone Point 1	0.20	0.0004	0.028	0.0008	0.014	-	0.29	1.0	0.0006	-
Monticello	-	-	-	-	-	-	-	-	-	-
Nine Mile Point	-	-	-	-	-	-	-	0.81	-	-
Oyster Creek	0.052	-	0.027	-	0.023	0.0009	0.096	0.0024	-	0.00015
Peach Bottom 2,3	36	0.12	17	-	4.4	343	2.4	0.27	-	-
Pilgrim	0.0007	-	0.005	-	-	-	0.25	0.48	-	-
Quad Cities	4.2	-	-	-	-	-	-	0.26	-	-
Vermont Yankee	0.0002	-	-	-	-	-	0.0019	0.0022	-	-
Total annual energy generated [GW(e) a]	11.670									
Normalized release [GBq (MW[e] a)$^{-1}$]	4.7	0.025	1.7	0.0008	0.41	36	3.1	3.5	0.011	0.22

Table 25, continued

Reactor	Release (GBq)										
	^{58}Co	^{59}Fe	^{60}Co	^{65}Zn	^{89}Sr	^{90}Sr	^{95}Zr	^{97}Zr	^{95}Nb	^{97}Nb	^{99}Mo
B W R											
Big Rock Point 1	0.063	0.19	4.8	0.034	0.016	0.042	-	-	-	-	-
Browns Ferry 1,2,3	0.85	0.47	7.9	11	0.32	0.14	4.9	-	-	-	0.35
Brunswick 1,2	3.6	1.1	18	0.68	0.014	0.008	-	0.17	-	0.035	0.11
Cooper	1.3	0.37	11	6.5	3.6	0.27	0.21	-	0.18	-	0.21
Dresden 1	0.051	0.0037	0.46	-	0.072	0.0074	0.011	-	0.013	-	-
Dresden 1,2	0.24	0.012	5.7	-	0.30	0.07	0.07	-	0.17	-	-
Duane Arnold	-	-	0.0096	-	0.0021	0.0021	-	-	-	-	-
J.A. Fitzpatrick	2.1	0.061	8.9	0.25	0.0074	0.0056	0.0024	-	-	-	0.019
Edwin I. Hatch	0.089	0.0052	0.29	0.30	0.012	0.0031	0.0013	0.00015	0.0033	0.0011	0.0025
Humboldt Bay 3	-	-	0.44	-	-	0.078	-	-	-	-	-
Lacrosse	18	0.061	33	1.1	11	0.43	3.7	-	6.0	0.19	0.062
Millstone Point 1	0.15	0.070	3.6	0.006	0.032	0.0067	0.016	0.0003	0.067	0.002	0.0009
Monticello	-	-	-	-	-	-	-	-	-	-	-
Nine Mile Point	0.22	-	17	-	0.037	0.12	-	-	-	-	-
Oyster Creek	-	-	0.012	-	0.0011	0.00012	-	-	-	-	-
Peach Bottom 2,3	2.9	-	6.0	17	0.74	0.030	-	-	0.017	-	0.0059
Pilgrim	0.059	0.013	3.1	0.025	0.078	0.019	0.0052	-	-	-	0.0074
Quad Cities	0.089	-	7.0	0.17	19	0.20	-	-	-	-	-
Vermont Yankee	0.0004	0.001	0.00056	0.0011	0.0002	0.0001	0.00085	-	-	-	0.00011
Total annual energy generated [GW(e) a]	11.670										
Normalized release [GBq (GW[e] a)$^{-1}$]	2.5	0.20	11	3.2	3.0	0.12	0.76	0.015	0.023	0.019	0.066

Reactor	Release (GBq)									
	^{99m}Tc	^{103}Ru	^{110m}Ag	^{124}Sb	^{134}Cs	^{136}Cs	^{137}Cs	$^{140}Ba/La$	^{144}Ce	^{239}Np
B W R										
Big Rock Point 1	-	-	-	0.16	1.9	-	18	0.059	-	0.047
Browns Ferry 1,2,3	0.35	-	-	0.41	1.9	0.43	2.8	0.19	-	0.41
Brunswick 1,2	0.41	-	0.052	0.003	12	0.014	21	-	-	-
Cooper	0.19	-	0.60	0.11	11	0.042	14	0.70	-	-
Dresden 1	-	0.0037	-	-	0.076	-	0.21	-	0.037	-
Dresden 2,3	-	0.069	0.23	0.0015	0.41	-	1.1	-	0.033	-
Duane Arnold	-	-	0.0003	-	0.0009	-	0.0003	-	-	-
J.A. Fitzpatrick	0.0013	-	0.0022	-	1.6	-	3.4	0.00059	0.0026	-
Edwin I. Hatch	0.0021	-	0.00052	-	0.20	0.01	0.22	0.001	0.0005	0.0022
Humboldt Bay 3	-	-	-	-	0.27	-	2.2	-	0.074	-
Lacrosse	1.3	1.1	-	0.0048	4.5	0.026	18	3.7	12	3.1
Millstone Point 1	-	-	0.0013	0.0048	0.037	-	0.17	0.12	0.026	-
Monticello	-	-	-	-	-	-	-	-	-	-
Nine Mile Point	-	-	-	-	13	-	37	0.023	-	0.059
Oyster Creek	0.014	-	-	-	0.0001	-	0.026	-	-	0.007
Peach Bottom 2,3	3.7	0.0067	0.0037	0.020	145	-	121	0.89	-	1.1
Pilgrim	0.0074	-	-	-	0.22	-	1.1	0.30	0.023	-
Quad Cities	-	-	0.027	-	7.4	0.37	12	6.1	-	-
Vermont Yankee	0.00011	-	-	-	0.00032	-	0.00041	0.0012	-	-
Total annual energy generated [GW(e) a]	11.670									
Normalized release [GBq (GW[e] a)$^{-1}$]	0.51	0.10	0.023	0.060	17	0.076	22	1.0	1.0	0.40

Table 26

Liquid effluents other than tritium discharged from GCRs in the United Kingdom in 1979 [H14]

Reactor	Release (GBq)									
	^{35}S	^{55}Fe	^{60}Co	^{89}Sr	^{90}Sr	^{106}Ru	^{125}Sb	^{134}Cs	^{137}Cs	^{144}Ce
Bradwell	250	79	14	14	150	2	2	120	670	17
Berkeley	350	2	2	2	78	2	30	190	860	15
Trawsfynydd	120	3	0.6	0.1	27	6	10	9	49	3
Hinkley A	210	8	1	11	350	67	140	150	1160	67
Dungeness	46	4	0.6	3	95	1	2	120	730	2
Sizewell	140	4	6	4	91	0.7	4	170	870	7
Oldbury	260	18	3	7	52	4	7	18	200	8
Wylfa	12	4	0.6	0.6	23	1	2	37	480	1
Total annual energy generated	4.3 GW(e) a									
Normalized release [GBq (GW[e] a)$^{-1}$]	320	28	6	10	200	19	46	190	1170	28

Table 27

Population distribution around the model reactor site and meteorological characteristics of its location

METEOROLOGICAL CHARACTERISTICS

Quantity	Pasquill weather category							
	Dry						Rain	
	A	B	C	D	E	F	C	D
Frequency (%)	1	11	19	32	16	18	1	25
Wind speed (m s^{-1})	1	2	5	5	3	1	5	5
Depth of mixing layer (m)	2000	2000	1000	1000	200	200	1000	1000

Distribution of wind direction frequencies (30° sectors)
0.079, 0.08, 0.1, 0.1, 0.044, 0.023, 0.024, 0.061, 0.12, 0.16, 0.13, 0.074

Stack height: 30 m

POPULATION DISTRIBUTION

Distance (km)	0 - 1	1 - 2	2 - 5	5 - 10	10 - 20	20 - 50
Population	1300	3000	26000	90000	430000	2800000
Cumulative	1300	4300	30000	120000	550000	3300000

Distance (km)	50-100	100-200	200-500	500-1000	1000-2000
Population	6100000	20000000	70000000	140000000	17000000
Cumulative	9400000	29000000	99000000	240000000	260000000

Table 28

Normalized local and regional collective dose commitments for noble gases from the model PWR

Radio-nuclide	Normalized collective absorbed dose commitment (10^{-4} man Gy [GW(e) a]$^{-1}$)									Normalized collective effective dose equivalent commitment (10^{-4} man Sv [GW(e) a]$^{-1}$)
	Gonads	Breast	Red bone marrow	Lungs	Thyroid	Bone lining cells	Liver	Skin	Remainder tissues	
^{41}Ar	4.3	5.3	5.7	5.0	4.8	5.7	5.0	9.8	5.3	5.1
^{85m}Kr	1.2	1.3	2.2	1.3	1.5	2.2	1.3	6.4	1.4	1.5
^{85}Kr	1.2	1.7	2.0	1.6	1.4	2.0	1.6	410	1.7	5.7
^{87}Kr	0.7	0.9	1.0	0.9	0.9	1.0	0.9	3.9	0.9	0.9
^{88}Kr	12	15	16	22	15	16	15	41	15	16
^{131m}Xe	0.8	0.8	1.2	0.6	0.7	1.2	0.6	47	0.9	1.3
^{133m}Xe	2.4	2.6	4.2	2.4	2.7	4.2	2.4	44	2.8	3.2
^{133}Xe	220	270	560	250	350	560	250	2700	310	340
^{135m}Xe	0.2	0.2	0.3	0.2	0.2	0.3	0.2	0.5	0.2	0.2
^{135}Xe	40	43	64	42	42	64	42	180	46	48
^{138}Xe	1.8	2.2	2.4	2.1	2.1	2.4	2.1	4.8	2.2	2.2
Total (rounded)	280	350	660	330	420	660	320	3450	380	420

Table 29

Normalized collective effective dose equivalent commitment for noble gases from the model PWR as a function of distance

Distance (km)	Normalized collective effective dose equivalent commitment [10^{-4} man Sv (GW[e] a)$^{-1}$]	Percentage distribution
0-2	5	1.2
2-5	12	2.9
5-10	18	4.2
10-20	27	6.5
20-50	40	9.6
50-100	55	13.2
100-200	114	27.2
200-500	122	29.0
500-1000	20	4.8
1000-2000	6.3	1.5
Total (rounded)	420	100

Table 30

Normalized local and regional collective dose commitments for noble gases from the model BWR

Radio-nuclide	Normalized collective absorbed dose commitment (man Gy [GW(e) a]$^{-1}$)									Normalized collective effective dose equivalent commitment (man Sv [GW(e) a]$^{-1}$)
	Gonads	Breast	Red bone marrow	Lungs	Thyroid	Bone lining cells	Liver	Skin	Remainder tissues	
^{41}Ar	0.003	0.004	0.005	0.004	0.004	0.005	0.004	0.008	0.004	0.004
^{85m}Kr	0.02	0.02	0.04	0.02	0.03	0.04	0.02	0.11	0.03	0.03
^{85}Kr	0.007	0.01	0.01	0.009	0.008	0.01	0.009	2.5	0.01	0.034
^{87}Kr	0.10	0.13	0.14	0.12	0.13	0.14	0.12	0.56	0.13	0.13
^{88}Kr	0.69	0.87	0.92	1.2	0.88	0.92.	0.83	2.3	0.87	0.90
^{131m}Xe	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.02	0.001	0.001
^{133}Xe	0.06	0.08	0.16	0.07	0.10	0.16	0.07	0.79	0.09	0.10
^{135m}Xe	0.13	0.02	0.02	0.02	0.01	0.02	0.02	0.04	0.02	0.02
^{135}Xe	0.32	0.35	0.52	0.34	0.34	0.52	0.34	1.5	0.37	0.39
^{138}Xe	0.21	0.26	0.28	0.35	0.25	0.28	0.25	0.55	0.26	0.26
Total (rounded)	1.4	1.7	2.2	2.2	1.8	2.1	1.7	9.1	1.8	1.9

Table 31

Normalized collective effective dose equivalent commitment for noble gases from the model BWR as a function of distance

Distance (km)	Normalized collective effective dose equivalent commitment [man Sv (GW[e] a)$^{-1}$]	Percentage distribution
0-2	0.19	10
2-5	0.27	14
5-10	0.30	16
10-20	0.34	18
20-50	0.46	24
50-100	0.18	9.3
100-200	0.10	5.4
200-500	0.04	2.2
500-1000	0.01	0.5
1000-2000	0.01	0.5
Total	1.9	100

Table 32

Normalized local and regional collective absorbed dose commitments from tritium in airborne discharges from the model reactor

Reactor	Normalized discharge [TBq (GW[e] a)$^{-1}$]	Normalized collective whole-body absorbed dose commitment [man Gy (GW[e] a)$^{-1}$]		
		Ingestion	Inhalation	Total
BWR	3.4	0.03	0.005	0.04
PWR	7.8	0.07	0.01	0.08
GCR	11	0.1	0.02	0.1
HWR	540	4.8	0.8	5.6

Table 33

Normalized local and regional collective absorbed dose commitments from carbon-14 releases to atmosphere

Reactor	Normalized discharge [TBq (GW[e] a)$^{-1}$]	Normalized collective whole-body absorbed dose commitment [man Gy (GW[e] a)$^{-1}$]		
		Ingestion	Inhalation	Total
BWR	0.5	0.92	0.001	0.92
PWR	0.2	0.39	0.00006	0.39
GCR	1.1	2.2	0.0003	2.2
HWR	17	30	0.005	30

Table 34

Normalized local and regional collective dose commitments for iodine releases from the model PWR

Pathway	Normalized collective absorbed dose commitment (10^{-4} man Gy [GW(e) a]$^{-1}$)									Normalized collective effective dose equivalent commitment (10^{-4} man Sv [GW(e) a]$^{-1}$) a/
	Gonads	Breast	Red bone marrow	Lungs	Thyroid	Bone lining cells	Liver	Skin	Remainder tissues	
Direct cloud irradiation	0.04	0.05	0.06	0.05	0.04	0.06	0.05	0.11	0.02	0.05
Inhalation	0.01	0.04	0.03	0.42	120	0.03	0.02	0.03	0.04	3.7
Ingestion b/	0.006	0.02	0.02	0.02	84	0.02	0.009	0.01	0.02	2.6
External dose from ground deposits	0.18	0.22	0.32	0.13	0.19	0.35	0.11	0.27	0.22	0.22
Resuspension	0.000005	0.00002	0.00001	0.0002	0.07	0.00001	0.000009	0.00001	0.00002	0.002
Total (rounded)	0.24	0.33	0.42	0.62	210	0.45	0.19	0.42	0.32	6.6

a/ Percentage contribution by iodine isotopes to collective effective dose equivalent commitment: ^{131}I 96 %; ^{133}I 2 %; ^{135}I 2 %.

b/ Percentage contribution of each pathway to ingestion doses: milk 90 %; beef 5 %, green vegetables 5 %.

Table 35

Normalized local and regional collective dose commitments for iodine releases from the model BWR

Pathway	Normalized collective absorbed dose commitment (10^{-4} man Gy [GW(e) a]$^{-1}$)									Normalized collective effective dose equivalent commitment (10^{-4} man Sv [GW(e) a]$^{-1}$) a/
	Gonads	Breast	Red bone marrow	Lungs	Thyroid	Bone lining cells	Liver	Skin	Remainder tissues	
Direct cloud irradiation	3.5	4.4	5.1	4.2	3.8	5.1	4.2	9.8	4.4	4.2
Inhalation	0.91	1.7	1.5	32	3900	1.4	1.4	1.2	1.7	120
Ingestion b/	0.16	0.55	0.38	0.44	2000	0.36	0.22	0.35	0.50	62
External dose from ground deposits	7.2	9.0	12	6.8	7.8	13	5.9	11	8.7	8.7
Resuspension	0.0002	0.0005	0.0003	0.006	1.6	0.0003	0.0003	0.0003	0.0005	0.05
Total (rounded)	12	16	19	43	5900	20	12	22	15	190

a/ Percentage contribution by iodine isotopes to collective effective dose equivalent commitment: ^{131}I 78 %; ^{132}I 0.001 %; ^{133}I 17 %; ^{135}I 5 %.

b/ Percentage contribution of each pathway to ingestion doses: milk 90 %; beef 5 %, green vegetables 5 %.

Table 36

Normalized local and regional collective dose commitments for particulate releases from the model PWR and BWR

Pathway	Normalized collective absorbed dose commitment (10^{-3} man Gy [GW(e) a]$^{-1}$)									Normalized collective effective dose equivalent commitment (10^{-3} man Sv [GW(e) a]$^{-1}$)
	Gonads	Breast	Red bone marrow	Lungs	Thyroid	Bone lining cells	Liver	Skin	Remainder tissues	
PWR										
Direct cloud irradiation	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.002	0.002
Inhalation	0.04	0.06	0.41	1.4	0.05	0.82	0.11	0.04	0.06	0.27
Ingestion a/	2.1	1.9	14	1.9	1.9	28	2	1.9	1.9	4.4
External dose from ground deposits	5.9	7.7	8.3	7.2	6.4	8.6	6.6	9.6	7.3	7.3
Resuspension	0.001	0.002	0.02	0.04	0.002	0.04	0.004	0.001	0.002	0.009
Total (rounded)	8.1	9.7	23	11	8.4	37	8.9	11	9.2	12
BWR										
Direct cloud irradiation	0.03	0.04	0.05	0.04	0.04	0.05	0.04	0.07	0.04	0.04
Inhalation	0.93	1.4	10	35	1.3	20	2.8	0.91	1.4	6.6
Ingestion a/	52	47	350	45	48	680	52	36	46	110
External dose from ground deposits	150	190	200	180	160	210	160	240	180	180
Resuspension	0.03	0.05	0.42	1.1	0.04	0.85	0.09	0.03	0.05	0.22
Total (rounded)	200	240	560	260	210	910	220	270	230	290

a/ The pathways contributing to the ingestion dose are: grain 30 %; green vegetables 25%; milk 15 %; milk products 10 %; root vegetables 10 %; beef 5 %; others 5 %.

Table 37

Radionuclides considered for liquid effluent calculations from the model reactor site, normalized releases and concentration factors for marine and freshwater media

Radio-nuclide	Normalized release [GBq/(GW[e] a)]			Marine concentration factor (m^3 t^{-1})					Freshwater concentration factor (m^3 t^{-1})	
	BWR	PWR	GCR	Fish	Crus-tacea	Moll-uscs	Sedi-ments	Sea-weed	Sedi-ments	Fish
^{54}Mn	10	4.0	-	500	10000	10000	10000	10000	10000	300
^{58}Co	6.9	90		100	1000	1000	10000	1000	30000	300
^{60}Co	30	34	25	100	1000	1000	10000	1000	30000	300
^{65}Zn	8.8	-	-	2000	5000	100000	10000	1000	1000	1000
^{89}Sr	8.2	1.0	-	1	10	10	500	10	2000	30
^{90}Sr	0.33	0.2	420	1	10	10	500	10	2000	30
^{106}Ru	-	-	34	1	500	2000	10000	2000	40000	10
^{110m}Ag	-	1.2	-	1000	5000	50000	10000	1000	200	3
^{125}Sb	-	-	80	500	300	100	10000	100	300	1000
^{131}I	13	9	-	10	100	100	100	1000	200	30
^{134}Cs	46	9	392	50	30	30	500	30	30000	1000
^{137}Cs	60	16	2600	50	30	30	500	30	30000	1000
^{144}Ce	-	-	50	10	1000	1000	10000	1000	30000	1000

Table 38

Parameters for the river model used to assess reactor releases

Section	Water velocity ($m\ s^{-1}$)	Sediment velocity ($m\ s^{-1}$)	Suspended sediment load ($g\ m^{-3}$)	Drinking water extraction ($m^3\ a^{-1}$)	Fish production ($t\ a^{-1}$)
1	0.8	0.0002	40	100000	100
2	0.75	0.00015	45	140000	66
3	0.7	0.0001	50	31000	600

Table 39

Normalized collective dose commitments from liquid reactor effluents discharged into the model river

Reactor type and pathway	Normalized collective absorbed dose commitment (10^{-4} man Gy [GW(e)a]$^{-1}$)							Normalized collective effective dose equivalent commitment (10^{-4} man Sv [GW(e) a]$^{-1}$)
	Gonads	Breast	Red bone marrow	Lungs	Thyroid	Bone lining cells	Remainder tissues	
P W R								
Drinking water								
^{131}I	0.008	0.02	0.02	0.02	94	0.02	-	2.8
^{58}Co	0.58	0.33	0.39	0.29	0.27	0.29	0.79	0.53
^{60}Co	1.4	0.70	0.82	0.56	0.49	0.59	3.1	1.6
^{90}Sr	0.009	0.009	1.2	0.009	0.009	2.6	-	0.21
^{134}Cs	1.2	1.1	1.2	1.1	1.2	1.1	1.3	1.2
^{137}Cs	1.6	1.5	1.5	1.5	1.5	1.5	1.4	1.5
Total	4.8	3.7	5.1	3.5	97	6.1	6.5	7.8

Table 39, continued

Reactor type and pathway	Normalized collective absorbed dose commitment (10^{-4} man Gy [GW(e)a]$^{-1}$)							Normalized collective effective dose equivalent commitment (10^{-4} man Sv [GW(e) a]$^{-1}$)
	Gonads	Breast	Red bone marrow	Lungs	Thyroid	Bone lining cells	Remainder tissues	
Fish								
^{131}I	0.0006	0.002	0.001	0.002	6.7	0.001	-	0.20
^{58}Co	0.11	0.06	0.07	0.06	0.05	0.06	0.14	0.10
^{60}Co	0.26	0.13	0.15	0.11	0.09	0.11	0.59	0.30
^{90}Sr	0.0003	0.0003	0.05	0.0003	0.0003	0.10	-	0.008
^{134}Cs	0.76	0.68	0.76	0.68	0.72	0.68	0.81	0.75
^{137}Cs	1.0	0.93	0.93	0.93	0.93	0.93	0.91	0.94
Total	2.1	1.8	2.0	1.8	8.5	1.9	2.4	2.3
External								
^{58}Co	0.0014		to all organs and tissues					0.0014
^{60}Co	0.033		to all organs and tissues					0.033
^{134}Cs	0.0023		to all organs and tissues					0.0023
^{137}Cs	0.0079		to all organs and tissues					0.0079
Total	0.045		to all organs and tissues					0.045
B W R								
Drinking water								
^{131}I	0.01	0.03	0.02	0.03	130	0.02	-	4.0
^{60}Co	1.3	0.63	0.75	0.53	0.46	0.55	3.3	1.6
^{65}Zn	1.0	1.0	1.4	0.88	0.88	1.4	1.2	1.1
^{89}Sr	0.06	0.06	0.75	0.06	0.06	1.1	1.1	0.49
^{90}Sr	0.01	0.01	1.9	1.3	1.3	3.9	-	0.34
^{134}Cs	5.8	5.2	5.8	5.2	5.4	5.2	5.3	5.4
^{137}Cs	5.6	5.2	5.2	5.2	5.2	5.2	5.2	5.6
Total	14	12	16	12	140	18	18	19
Fish								
^{131}I	0.08	0.002	0.002	0.002	10	0.002	-	0.29
^{60}Co	0.24	0.12	0.14	0.10	0.10	0.10	0.62	0.30
^{65}Zn	1.2	1.2	1.7	1.2	1.1	1.7	1.6	1.4
^{89}Sr	0.002	0.002	0.03	0.002	0.002	0.04	0.05	0.02
^{90}Sr	0.0005	0.0005	0.07	0.0005	0.0005	0.15	-	0.01
^{134}Cs	3.6	3.2	3.6	3.2	3.4	3.2	4.7	3.8
^{137}Cs	3.5	3.3	3.3	3.3	3.3	3.2	3.8	3.5
Total	8.8	7.5	8.8	7.5	18	8.1	11	9.3
External								
^{60}Co	0.033		to all organs and tissues					0.033
^{134}Cs	0.012		to all organs and tissues					0.012
^{137}Cs	0.030		to all organs and tissues					0.030
Total	0.075		to all organs and tissues					0.075

Table 40

Normalized collective dose commitments for the model PWR, BWR and GCR on a notional site in the eastern English Channel

Reactor type and pathway	Normalized collective absorbed dose commitment (10^{-4} man Gy [GW(e) a]$^{-1}$)								Normalized collective effective dose equivalent commitment (10^{-4} man Sv [GW(e) a]$^{-1}$)
	Gonads	Breast	Red bone marrow	Lungs	Thyroid	Bone lining cells	Upper large intestine	Lower large intestine	
PWR									
Fish									
^{54}Mn	0.29	0.14	0.25	0.11	0.06	0.30	0.72	1.1	0.37
^{58}Co	0.48	0.15	0.21	0.071	0.05	0.10	1.7	3.3	0.64
^{60}Co	4.0	2.0	2.4	1.6	1.4	1.7	11	20	4.9
^{110m}Ag	0.45	0.20	0.25	0.22	0.05	0.13	1.6	2.9	0.77
^{134}Cs	3.8	3.4	3.8	3.4	3.6	3.4	4.2	4.4	4.0
^{137}Cs	8.2	7.6	7.6	7.6	7.6	7.6	8.8	8.8	8.2
Total	17	13	15	13	13	13	28	41	19
Crustacea									
^{54}Mn	0.29	0.14	0.25	0.11	0.06	0.30	0.72	1.1	0.37
^{58}Co	0.28	8.6	0.12	0.04	0.03	0.06	0.96	1.9	0.37
^{60}Co	1.5	0.73	0.87	0.59	0.51	0.62	3.9	7.3	1.8
^{110m}Ag	0.11	0.05	0.06	0.05	0.01	0.03	0.37	0.68	0.18
^{134}Cs	0.09	0.08	0.09	0.08	0.09	0.08	0.10	0.10	9.5
^{137}Cs	0.17	0.16	0.16	0.16	0.15	0.16	0.18	0.18	0.17
Total	2.4	1.2	1.5	1.0	0.86	1.2	6.2	11	3.0
Molluscs									
^{54}Mn	2.5	1.2	2.1	0.98	0.49	2.6	6.2	9.8	3.2
^{58}Co	2.8	0.89	1.2	0.42	0.32	0.59	9.9	23	3.8
^{60}Co	11	5.3	6.3	4.3	3.7	4.5	28	53	13
^{110m}Ag	9.4	4.2	5.1	4.6	1.0	2.7	33	61	16
^{134}Cs	0.70	0.63	0.70	0.63	0.67	0.63	0.78	0.81	0.74
^{137}Cs	1.1	1.0	1.0	1.0	1.0	1.0	1.2	1.2	1.1
Total	28	13	16	12	7.2	12	79	150	38
Grand total	47	28	32	26	21	26	110	200	60

Table 40, continued

Reactor type and pathway	Normalized collective absorbed dose commitment (10^{-4} man Gy [GW(e) a]$^{-1}$)								Normalized collective effective dose equivalent commitment (10^{-4} man Sv [GW(e) a]$^{-1}$)
	Gonads	Breast	Red bone marrow	Lungs	Thyroid	Bone lining cells	Upper large intestine	Lower large intestine	
B W R									
Fish									
^{54}Mn	0.62	0.30	0.54	0.25	0.12	0.65	1.6	2.5	0.81
^{60}Co	3.7	1.8	2.2	1.5	1.3	1.5	9.7	18	4.5
^{65}Zn	13	13	18	12	12	18	16	19	15
^{134}Cs	19	17	19	17	18	17	21	22	20
^{137}Cs	31	29	29	29	29	29	33	33	31
Total	67	61	69	60	60	66	81	95	71
Crustacea									
^{54}Mn	0.62	0.30	0.54	0.25	0.12	0.65	1.6	2.5	0.81
^{60}Co	1.3	0.65	0.77	0.53	0.46	0.55	3.4	6.5	1.6
^{65}Zn	1.1	1.2	1.6	1.0	1.0	1.6	1.4	1.6	1.3
^{134}Cs	0.47	0.42	0.47	0.42	0.44	0.42	0.51	0.54	0.49
^{137}Cs	0.64	0.59	0.59	0.59	0.59	0.59	0.69	0.69	0.64
Total	4.1	3.1	4.0	2.8	2.6	3.8	7.6	12	4.8
Molluscs									
^{54}Mn	5.4	2.6	4.7	2.1	1.1	5.6	13	21	7.0
^{60}Co	9.8	4.9	5.8	4.0	3.4	4.1	26	49	12
^{65}Zn	280	270	390	250	250	390	340	400	320
^{134}Cs	3.6	3.2	3.6	3.2	3.4	3.2	4.0	4.2	3.8
^{137}Cs	4.1	3.8	3.8	3.8	3.8	3.8	4.4	4.4	4.1
Total	300	280	410	260	260	410	390	480	350
Grand total	370	350	480	330	320	480	480	580	420

Table 40, continued

Reactor type and pathway	Normalized collective absorbed dose commitment (10^{-4} man Gy [GW(e) a]$^{-1}$)								Normalized collective effective dose equivalent commitment (10^{-4} man Sv [GW(e) a]$^{-1}$)
	Gonads	Breast	Red bone marrow	Lungs	Thyroid	Bone lining cells	Upper large intestine	Lower large intestine	
G C R									
Fish									
^{60}Co	3.0	1.5	1.8	1.2	1.1	1.3	7.9	15	3.7
^{90}Sr	0.39	0.39	55	0.39	0.39	120	1.7	6.1	10
^{106}Ru	0.02	0.01	0.01	0.01	0.01	0.01	0.23	0.66	5.4
^{125}Sb	6.1	2.1	4.6	1.3	0.96	20	48	130	14
^{134}Cs	160	140	160	140	150	140	180	190	170
^{137}Cs	1300	1200	1200	1200	1200	1200	1400	1400	1300
^{144}Ce	0.004	0.001	0.009	0.0006	0.0005	0.13	2.2	6.4	0.51
Total	1500	1300	1400	1300	1400	1500	1600	1700	1500
Crustacea									
^{60}Co	1.1	5.3	0.63	0.43	0.37	0.45	2.8	5.3	1.3
^{90}Sr	0.14	0.14	20	0.14	0.14	42	0.62	2.2	3.6
^{106}Ru	0.33	0.29	0.31	0.29	0.29	0.29	5.2	15	1.2
^{125}Sb	0.15	0.51	0.11	0.03	0.02	0.49	1.2	3.0	0.34
^{134}Cs	4.0	3.6	4.0	3.6	3.8	3.6	4.4	4.6	4.2
^{137}Cs	27	25	25	25	25	25	29	29	27
^{144}Ce	0.02	0.006	0.04	0.003	0.002	0.06	11	31	2.5
Total	33	34	50	29	30	72	54	90	39
Molluscs									
^{60}Co	8.1	4.1	4.8	3.3	2.9	3.4	0.00002	41	10
^{90}Sr	0.91	0.91	130	0.91	0.91	260	3.9	14	23
^{106}Ru	12	10	11	10	10	10	190	530	43
^{125}Sb	0.37	0.13	0.28	0.08	0.06	1.2	3.0	7.7	0.86
^{134}Cs	30	27	30	27	29	27	34	35	32
^{137}Cs	180	170	170	170	170	170	190	190	180
^{144}Ce	0.20	0.06	0.45	0.03	0.03	0.64	110	320	26
Total	230	210	350	210	210	470	530	1100	310
Grand total	1700	1600	1800	1600	1600	2000	2200	3000	1800

Table 41

Radionuclides discharged to the atmosphere from fuel reprocessing plants 1975-1979 [B2, B22, L1, L6]

Year	Energy [GW(e) a]	Activity released (TBq)										
					Particulate release		Isotopic composition of particulate release (total β)					
		^{3}H	^{14}C	^{85}Kr	Total α	Total β	^{90}Sr	^{106}Ru	^{129}I	^{131}I	^{134}Cs	^{134}Cs
						WINDSCALE (United Kingdom)						
1975	3.2	444		44000	0.0028	0.070						
1976	3.2	444		44000	0.0019	0.13						
1977	2.1	296		33000	0.0010	0.28	0.041		0.0059	0.0026		0.23
1978	1.8	222	4.1	26000	0.00089	0.34	0.048	0.0078	0.0026	0.015	0.027	0.24
1979	2.5	290	3.5	35000	0.0010	0.31	0.009	0.003	0.006	0.03	0.025	0.24
1975-1979 Normalized release [TBq (GW[e] a)$^{-1}$]		133	1.8	14000	0.0006	0.088						
						LA HAGUE (France)						
1975	1.6	3.3		24000	$5.9\ 10^{-10}$	0.0006						
1976	0.84	1.8		13000	$7.4\ 10^{-10}$	0.0003						
1977	1.8	11		25000	$1.1\ 10^{-7}$	0.0001						
1978	2.1	4.1		29000	$1.1\ 10^{-6}$	0.0001						
1975-1979 Normalized release [TBq (GW[e] a)$^{-1}$]		3.2		14000	$1.9\ 10^{-7}$	0.0002						
						MARCOULE (France)						
1975	0.24	4.4		3700	$8.1\ 10^{-7}$	0.001						
1976	0.22	4.4		3500	$6.7\ 10^{-7}$	0.001						
1977	0.32	2.8		4400	$3.2\ 10^{-6}$	0.0002						
1978	0.83	63		11000	$1.7\ 10^{-6}$	0.0003						
1975-1978 Normalized release [TBq (GW[e] a)$^{-1}$]		46		14000	$4.0\ 10^{-6}$	0.002						

Table 42

Radionuclides released to the aquatic environment from fuel reprocessing [B2, B22, L1, L6]

Year	Activity released (TBq)				
	Total α	Total β (other than ^{3}H)	^{3}H	^{90}Sr	^{106}Ru
		WINDSCALE (United Kingdom)			
1975	85	9065	1400	466	762
1976	60	6771	1200	381	766
1977	46	7129	910	427	816
1978	68	7124	1050	597	810
1979	62	4100	1200	250	390
1975-1979 Normalized release [TBq (GW[e] a)$^{-1}$]	25	2671	450	166	277
		LA HAGUE (France)			
1975	0.49	1180		75	829
1976	0.37	714		40	555
1977	0.67	765	331	73	540
1978	0.51	1092	728	140	801
1975-1978 Normalized release [TBq (GW[e] a)$^{-1}$]	0.32	592	272	52	430
		MARCOULE (France)			
1975	0.019	42		0.93	33
1976	0.011	23		0.41	20
1977	0.013	30	117	0.37	27
1978	0.013	35	270	0.88	25
1975-1978 Normalized release [TBq (GW[e] a)$^{-1}$]	0.035	81	337	1.6	65

Table 43

Isotopic composition of liquid effluents from the Windscale reprocessing plant [B2, B22]

Radionuclide	Annual discharge (TBq)		
	1977	1978	1979
^{35}S		1.8	1.4
^{54}Mn		0.22	0.037
^{55}Fe		2.3	1.8
^{60}Co		1.0	0.52
^{63}Ni		1.5	0.18
^{65}Zn		0.037	0.022
^{89}Sr		9.9	7.5
^{90}Sr	427	597	250
^{95}Zr	92	82	60
^{95}Nb	203	148	98
^{99}Tc		179	43
^{103}Ru		8.5	5.8
^{106}Ru	816	810	390
^{110m}Ag		0.33	0.033
^{125}Sb		29	14
^{129}I	0.11	0.074	0.12
^{134}Cs	594	404	240
^{137}Cs	4480	4090	2600
^{144}Ce	152	104	83
^{152}Eu		10	3.7
^{154}Eu		38	1.9
^{155}Eu		7.8	4.0
Uranium		10936 (kg)	6000 (kg)
^{237}Np		0.60	0.33
^{238}Pu		12	12
$^{239+240}Pu$	36	46	37
^{241}Pu	981	1773	1500
^{241}Am	3.6	7.9	7.9
^{242}Cm		0.55	0.37
$^{243+244}Cm$		0.33	0.15
Electricity production from fuel reprocessed [GW(e) a]	2.1	1.8	2.5

Table 44

Population distribution around the Windscale reprocessing plant and meteorological characteristics of its location

METEOROLOGICAL CHARACTERISTICS

Quantity	Pasquill weather category							
	Dry						Rain	
	A	B	C	D	E	F	C	D
Frequency (%)	0.3	4.5	12.1	63	5	4.6	1.7	8.4
Wind speed (m s^{-1})	1	2	5	5	3	1	5	5
Depth of mixing layer (m)	2000	2000	1000	1000	200	200	1000	1000

Distribution of wind direction frequencies (30° sectors): 0.091, 0.089, 0.096, 0.11, 0.098, 0.069, 0.049, 0.034, 0.056, 0.10, 0.11, 0.094

Stack height: 100 m (effective)

POPULATION DISTRIBUTION

Distance (km)	0 - 1	1 - 2.5	2.5 - 6	6 - 12.5	12.5-17.5
Population	36	230	1100	12000	17000
Cumulative	35	220	1400	14000	31000

Distance (km)	17.5-60	60-150	150-375	375-900	900-2700
Population	71000	20000000	36000000	110000000	82000000
Cumulative	74000	21000000	57000000	170000000	260000000

Table 45

Averaged local and regional normalized whole-body absorbed dose commitments from tritium and carbon-14 discharges to the atmosphere from Windscale (United Kingdom)

Radio-nuclide	Normalized collective absorbed whole-body dose commitment [man Gy (GW'e] a)$^{-1}$]		
	Ingestion	Inhalation	Total
^{3}H	0.30	0.049	0.35
^{14}C	0.69	0.0001	0.69

Table 46

Collective dose commitments from atmospheric annual discharges from Windscale (United Kingdom) averaged between 1975 and 1979

Pathway	Collective effective dose equivalent commitment (man Sv)	Collective absorbed dose commitment (man Gy)								
		Gonads	Breast	Red bone marrow	Lungs	Thyroid	Bone lining cells	Liver	Skin	Remainder tissues
CLOUD										
^{85}Kr	0.26	0.058	0.078	0.095	0.074	0.065	0.095	0.074	19	0.078
DEPOSIT										
^{137}Cs	1.1	0.87	1.2	1.4	1.1	0.97	1.4	1.0	1.4	1.1
INHALATION										
^{3}H	0.3	0.13	0.3	0.13	0.13	0.13	0.13	0.13	0.13	0.13
^{239}Pu	0.11	0.00074	-	0.0043	0.02	-	0.059	0.012	-	-
^{240}Pu	0.10	0.00068	-	0.0044	0.018	-	0.054	0.011	-	-
^{241}Am	0.08	0.000095	-	0.0056	0.00052	-	0.075	0.016	-	-
^{238}Pu	0.04	0.00022	-	0.0015	0.0071	-	0.019	0.0041	-	-
^{129}I	0.007	-	-	-	-	0.24	-	-	-	-
^{137}Cs	0.006	0.006	0.005	0.006	0.0056	0.005	0.005	0.0054	0.0041	0.005
Total	0.47									
INGESTION										
^{3}H	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78
^{134}Cs	0.13	0.13	0.11	0.13	0.11	0.11	0.11	0.13	0.11	0.086
^{137}Cs	1.1	1.1	0.98	0.98	0.98	0.98	0.98	1.1	0.98	0.76
^{14}C	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
^{90}Sr	0.24	-	-	1.3	-	-	2.8	0.0096	0.0096	0.0096
^{129}I	0.34	-	-	-	-	11	-	-	-	-
Total	4.4									
GRAND TOTAL	6.2									

Table 47

Collective absorbed dose commitments for average releases between 1975 and 1979 into the Eastern Irish Sea from Windscale (United Kingdom) and into the Eastern English Channel from La Hague (France)

Pathway		Collective absorbed dose commitment (man Gy)							
		Gonads	Breast	Red bone marrow	Lungs	Thyroid	Bone lining cells	Liver	Lower large intestine
					WINDSCALE (United Kingdom)				
Fish									
^{137}Cs		270	250	250	250	250	250	250	270
Mollusc and crustacea									
^{106}Ru		8.7	7.4	8.1	7.4	7.4	7.4	-	380
Fish, crustacea, mollusc									
^{90}Sr		-	-	25	-	-	54	-	-
Mollusc									
^{239}Pu and ^{240}Pu		0.024	-	0.16	-	-	2	0.42	0.50
^{241}Pu		0.46	-	2.7	-	-	36	5.9	2.3
Total	βγ	280	260	290	260	260	350	260	650
	α	0.024	-	0.16	-	-	2	0.42	0.50
		Collective effective dose equivalent commitment: 311 man Sv							
					LA HAGUE (France)				
Fish									
^{137}Cs		9.5	8.8	8.8	8.8	8.8	8.8	8.8	9.5
Mollusc and crustacea									
^{106}Ru		20	17	19	17	17	17	-	880
Mollusc									
^{239}Pu and ^{240}Pu ^{241}Pu		0.005	-	0.036	-	-	0.42	0.09	0.11
Total	βγ	30	26	28	26	26	26	11	890
	α	0.005	-	0.036	-	-	0.42	0.09	0.11
		Collective effective dose equivalent commitment: 84 man Sv							

Table 48

Local and regional collective effective dose equivalent commitments for normalized discharges from the model reprocessing facility to atmospheric and marine environments

Radionuclide	Normalized release [TBq (GWe) a)$^{-1}$]	Normalized collective effective dose equivalent commitment [man Sv (GWe) a)$^{-1}$]
ATMOSPHERIC		
^{3}H	60	0.1
^{14}C	0.4	0.2
^{85}Kr	10000	0.03
^{90}Sr	0.0007	0.006
^{129}I	0.0002	0.004
$^{238,239,240}Pu$	0.00001	0.002
	Total	0.3
AQUATIC		
^{137}Cs	7	0.4
^{106}Ru	10	0.3
^{90}Sr	2	0.02
^{129}I	0.04	0.008
$^{238,239,240}Pu$	0.5	0.0006
	Total	0.7

Table 49

Representative annual effective dose equivalents to most exposed individuals from reprocessing LWR fuel at the model facility

Radionuclide	Annual effective dose equivalent (μSv)
ATMOSPHERIC	
^{3}H	5
^{14}C	10
^{85}Kr	5
^{90}Sr	2
^{129}I	2
α emitters	1
Total	25
AQUATIC	
^{90}Sr	2
^{106}Ru	50
^{137}Cs	150
^{129}I	1
α emitters	0.5
Total (rounded)	200

Table 50

Summary of normalized releases of radionuclides of global significance and of the corresponding collective effective dose equivalent commitments

Radio-nuclide	Normalized release [TBq (GW[e] a)$^{-1}$]	Normalized collective effective dose equivalent commitment [man Sv (GW[e] a)$^{-1}$]				
		Integration time (a)				
		10^1	10^2	10^4	10^6	10^8
^3H	640	0.015	0.02	0.02	0.02	0.02
^{85}Kr	11000	0.9	1.9	1.9	1.9	1.9
^{14}C	17	3	10	70	110	110
^{129}I	0.04	-	0.02	0.2	28	560

Table 51

Collective effective dose equivalent commitments from high-level waste disposal per unit electrical energy generated for different fuel cycles [11]

	Normalized collective effective dose equivalent commitment [man Sv (GW[e] a)$^{-1}$]				
	LWR	HWR			
DISPOSAL OF UNREPROCESSED FUEL					
Uranium content of fuel					
Migration time 10^6 a	62	300			
Migration time 10^5 a	71	170			
All other elements					
Migration time 10^6 a	27	10			
Migration time 10^5 a	200	280			
Total (rounded) (10^6 a)	89	310			
(10^5 a)	270	450			
	LWR (Plutonium recycle)	FBR	HWR		HTR
			Uranium Plutonium	Uranium Thorium	Uranium Thorium
DISPOSAL OF REPROCESSING WASTES					
Uranium content of fuel					
Migration time 10^6 a	22	0.8	130	22	1.1
Migration time 10^5 a	23	1.1	72	120	6.0
All other elements					
Migration time 10^6 a	9	18	6	14	24
Migration time 10^5 a	27	51	45	140	110
Total (rounded) (10^6 a)	31	19	140	36	25
(10^5 a)	50	52	120	260	120

Table 52

Summary of normalized collective effective dose equivalent commitments to the public from nuclear power production

	Normalized collective effective dose equivalent commitment [man Sv (GW[e] a)$^{-1}$]		
LOCAL AND REGIONAL CONTRIBUTION			
Mining			
Radon	0.5	Total	0.5
Milling (excluding releases from tailings)			
Uranium, thorium, radium	0.015		
Radon	0.02		
		Total	0.04
Fuel fabrication			
Uranium	0.002	Total	0.002
Reactor releases			
Atmospheric			
- Noble gases	0.6		
- Tritium	0.5		
- Carbon-14	2.8		
- Iodines	0.06		
- Particulates (caesium, ruthenium, cobalt)	0.1		
		Total	4.1
Aquatic			
- Tritium	0.04		
- Other (caesium, ruthenium, cobalt)	0.02		
		Total	0.06
Fuel reprocessing			
Atmospheric			
- Tritium	0.1		
- Krypton-85	0.03		
- Carbon-14	0.2		
- α emitters	0.002		
		Total	0.3
Aquatic			
- Caesium 134, 137	0.4		
- Ruthenium-106	0.3		
- Strontium-90	0.02		
- α emitters	0.0006		
- Iodine-129	0.008		
		Total	0.7
Transportation	0.003	Total	0.003
TOTAL for operations in the nuclear fuel cycle		5.7 man Sv [GW(e) a]$^{-1}$	

	Complete and incomplete normalized collective effective dose equivalent commitment [man Sv (GW[e] a)$^{-1}$]				
	Integration period (a)				
	10^1	10^2	10^4	10^6	10^8
GLOBAL CONTRIBUTION FROM OPERATIONS IN THE NUCLEAR FUEL CYCLE					
Tritium	0.015	0.02	0.02	0.02	0.02
Krypton-85	0.9	1.9	1.9	1.9	1.9
Carbon-14	3	10	70	110	110
Iodine-129	-	0.02	0.2	28	560
TOTAL (rounded)	3.9	12	72	140	670
WASTE DISPOSAL (assuming LWR fuel reprocessed and plutonium utilization in LWRs and FBRs)					
Mill tailings (radon) a/	0.25	0.25	250	2800	2800
(uranium) b/			460	460	460
High-level wastes	-	-	-	30	30

a/ Assuming radon emanation continued at the same rate as at disposal with 2 m earth covering.

b/ Assuming that at 10^3 a the tailings are eroded into fresh water, then marine environments.

Table 53

Annual per caput doses from the continued generation of nuclear electric power to the year 2500

	Year			
	1980	2000	2100	2500
Annual projected nuclear generation [GW(e) a]	80	1000	10000	10000
Annual collective effective dose equivalent (man Sv)	500	10000	200000	250000
World population	$4\ 10^9$	10^{10}	10^{10}	10^{10}
Annual per caput effective dose equivalent (μSv)	0.1	1	20	25
Percentage of average exposure to natural sources of radiation (%)	0.005	0.05	1	1

REFERENCES

A1 Adams, N., B.W. Hunt and J.A. Reissland. Annual limits of intake of radionuclides for workers. NRPB-R82 (1978).

A2 Aarkrog, A. Variation of direct plutonium contamination in Danish cereal grains. Health Phys. 35: 489–491 (1978).

A3 Ancellin, J., P. Guegueniat and P. Germain. Radioécologie Marine. Edition Eyrolles, Paris, 1979.

A4 Adams, J.A. and V.L. Rogers. A classification system for radioactive waste disposal – what waste gas where? NUREG-0456 (1978).

B2 British Nuclear Fuels Ltd. Annual report on radioactive discharges and monitoring of the environment, 1978. BNFL Health and Safety Directorate report (1979).

B3 Blanchard, B.L. Radiological surveillance studies at the Oyster Creek BWR nuclear generating station. EPA-520/5-76-003 (1976).

B4 Bonka, H., K. Brüssermann, G. Schwarz et al. Production and emission of carbon-14 from nuclear power stations and reprocessing plants and its radioecological significance. p. 945–948 in: Proceedings of the IVth International Congress of the IRPA, Paris, 1977.

B5 Bonka, H. Production and emission of tritium from nuclear facilities, and the resulting problems. p. 105–121 in: Behaviour of Tritium in the Environment. IAEA, Vienna, 1979.

B6 Bartlett, B.O., L.J. Middleton, G.M. Milbourn et al. Surveys of radioactivity in human diet and experimental studies. ARCRL-5 (1960).

B7 Booth, R.S., S.V. Kaye and P.S. Rohwer. A radiological assessment of radionuclides in liquid effluents of light water nuclear power stations. ORNL-TM-4762 (1975).

B8 Booth, R.S. A systems analysis model for calculating radionuclide transport between receiving waters and bottom sediments. Chapter 7: Models and Mechanisms in: Environmental Toxicity of Aquatic Radionuclides. Ann Arbor Science Publishers Inc., 1976.

B9 Bayer, A. The radiological exposure of the population of the Rhine-Meuse region by nuclear installations during normal operation. CEC document V/1647/77 (1978).

B10 Bernero, R.M., D.F. Harmon and K.G. Steyer. Cost-benefit considerations of reducing environmental exposures and effluents from uranium fuel cycle facilities to levels below limits set by the U.S. Environmental Protection Agency. p. 653–682 in: Radioactive Effluents from Nuclear Fuel Reprocessing Plants. CEC document V/2266/78 (1978).

B11 Bryant, P.M. The discharge to atmosphere of radionuclides from reprocessing plants and the associated radiation exposure of the public. p. 247–272 in: Radioactive Effluents from Nuclear Fuel Reprocessing Plants. CEC document V/2266/78 (1978).

B12 Berg, R. and H. Schüttelkopf. Die Messung der Verteilung in und der Abgabe von I-129 aus der Wiederaufarbeitungsanlage Karlsruhe. p. 81–94 in: Radioactive Effluents from Nuclear Fuel Reprocessing Plants. CEC document V/2266/78 (1978).

B13 Bergman, R., U. Bergström and S. Evans. Environmental transport and long-term exposure for tritium released in the biosphere. p. 535–554 in: Behaviour of Tritium in the Environment. IAEA, Vienna, 1978.

B14 Bryant, P.M. and J.A. Jones. The future implications of some long-lived fission product nuclides discharged to the environment in fuel reprocessing wastes. p. 131–149 in: Management of Radioactive Wastes from Fuel Reprocessing. OECD (1973).

B15 Beninson, D. Population doses resulting from radionuclides of world wide distribution. p. 227–232 in: Population Dose Evaluation and Standards for Man and His Environment. IAEA, Vienna, 1974.

B16 Bergman, R., U. Bergström and S. Evans. Environmental transport and long-term dose: a preliminary study of iodine-129. NEA Specialist Meeting (Proceedings). OECD/NEA (1977).

B17 Blanchard, R.L., D.M. Montgomery, H.E. Kolde et al. Supplementary radiological measurements at the Maxey Flats radioactive waste burial site 1976–1977. EPA 520/5/-78-011 (1978).

B18 Beach, S.A. and J.H. Mairs. Radiation exposure from the normal movement of irradiated fuel elements by road and rail from Magnox power stations. NRPB-R114 (1982).

B19 Battist, L., J. Buchanan, F. Congel et al. Population dose and health impact of the accident at Three Mile Island nuclear station. Report of an Ad Hoc Dose Assessment Group. U.S. Government Printing Office 017-001-00408-1 (1979).

B20 Baverstock, K.F. and J. Vennart. Emergency reference levels for reactor accidents: a re-examination of the Windscale reactor accident. Health Phys. 30: 339–344 (1976).

B21 Beninson, D. Communication (1980).

B22 British Nuclear Fuels Ltd. Annual report on radioactive discharges and monitoring of the environment, 1979. BNFL Health and Safety Directorate (1980).

B23 Beebe M. Communication (1981).

B24 Babaev, N.S., V.F. Demin, L.A. Ilyin et al. Nuclear Energy Man and the Environment. Energoizdat, Moscow, 1981 (in Russian).

B25 Barretto, P.M. Uranium exploration in developing countries—facts and trends. IAEA Bulletin 21(2/3): 18–28 (1979).

C1 Clarke, R.H. and R. Wilson. Individual and collective doses due to ^{41}Ar based on measured discharge rates from CEGB reactors. p. 577–583 in: Proceedings of the IVth International Congress of the IRPA, Paris, 1977.

C2 Chilton, A.B. Broad beam attenuation. in: Engineering Compendium on Radiation Shielding. Vol. 1: Shielding Fundamentals and Methods. (R.G. Jaeger et al. eds.). Springer-Verlag, New York 1968.

C3 Conseil International pour l'Exploitation de la Mer. Bull. Stat. Pêches Maritimes 60, 1975. Copenhagen, 1978.

C4 Central Electricity Generating Board. Statistical Year Book (1979).

C5 Commission of the European Communities. The differential radiological impact of plutonium recycle in the light-water reactor fuel cycle: effluent discharges during normal operation. EUR-6992 (1980).

C6 Clarke, R.H. An analysis of the 1957 Windscale accident using the reactor safety code WEERIE. Annal. Nuc. Sci. Eng. 1: 73–82 (1974).

C7 Costello, J.M., D.R. Davey, F.C.R. Cattell et al. A review of the environmental impact of mining and milling radioactive ores, upgrading process and fabrication of nuclear fuels. in: Nuclear Energy and the Environment (El-Hinnawi, ed.). Pergamon Press, 1980.

C8 Clark, M.J., P.D. Grimwood and W.C. Camplin. A model to calculate exposure from radioactive discharges into the coastal waters of Northern Europe. NRPB-R109 (1980).

C9 Crick, M.J. and G.S. Linsley. An assessment of the radiological impact of the 1957 Windscale reactor fire. NRPB-R135 (1982).

C10 Commission of the European Communities. Methodology for evaluating the radiological consequences of radioactive effluents released in normal operation. CEC document V/3865/79 (1979).

D2 Davis, W. Carbon-14 production in nuclear reactors. ORNL-NUREG-TM-12 (1977).

D3 Decker, R.R. Radioactive materials released from nuclear power plants (1976). NUREG-0367 (1978).

D4 Davis, J.F., R.H. Fakundiny and J. Pferd. Evaluation of radionuclide pathways at a shallow low level radioactive waste burial site in western New York. National Meeting of the Geological Society of America, November 1976.

D5 Diekamp, F. The accident at Three Mile Island. Workshop on emergency preparedness and accident management. International Institute of Applied Systems Analysis (IIASA) (1980).

D6 Decker, T.R. Radioactive material released from nuclear power plants (1977). NUREG-0521 (1979).

D7 Davy, D.R. Environmental aspects of uranium mining and milling in Australia. Pacific Basin Conference "Nuclear Power Development and the Fuel Cycle", ANS Honolulu (1976).

D8 van Daatsellar, J. Communication (1981).

D9 Despres, A., A. Bouville, J.-M. Guezengar et al. Irradiation externe pendant et après le passage d'un nuage radioactif. CEA-R-4844 (1977).

E1 Environmental Protection Agency, United States. Radiological impact caused by emissions of radionuclides into air in the United States. EPA-520/7-79-006 (1979).

E2 Eckerman, K., N. Dayem and R. Emch. Radiological assessment branch memo. Communication from the Division of Technical Review, U.S. Nuclear Regulatory Commission (1975).

E3 Erdman, C.A. and A.B. Reynolds. Radionuclide behaviour during normal operation of LMFBRs. Part 1: Production. Nucl. Saf. 16: 43 (1975).

E4 Environmental Protection Agency, United States. Radioactive isotopic characterization of the environment near Wiscasset, Maine, using pre- and post-operational surveys in the vicinity of the Maine Yankee nuclear reactor. ORP/EAD-76-3 (1976).

E5 Ekdahl, C.A., R. Bacastow and C.D. Keeling. Atmospheric carbon dioxide and radiocarbon in the natural carbon cycle. p. 51–135 in: Carbon in the Biosphere. CONF-720510 (1973).

E6 Environmental Protection Agency, United States. State of geological knowledge regarding potential transport of high-level waste from deep continental repositories. Report of an Ad Hoc Panel of Earth Scientists. EPA/520/4-78-004 (1978).

E7 El-Hinnawi, E.E. (ed). Nuclear Energy and the Environment. Vol. II: Environmental Sciences and Application. Pergamon Press, 1980.

E8 Environment Canada. An interim assessment of the radiological impact of uranium mining in Northern Saskatchewan. T-3511 (1980).

E9 Errera, N. Communication (1981).

F1 Flew, E.M. Radioactive waste disposal by UKAEA establishments during 1978 and associated environmental monitoring results. AERE-R-9445 (1979).

F2 Fluss, M.J., N.D. Dudey and R.L. Malewicki. Tritium and alpha-particle yields in fast and thermal fission of ^{235}U. Phys. Rev. C6(6)2252–2259 (1972).

F3 Fletcher, J.F. and W.L. Dotson. HERMES—a digital computer code for estimating regional radiological effects from the nuclear power industry. HEDL-TME-71-168 (1971).

F4 Frigerio, N.A. and R.S. Stowe. Plutonium and uranium emission experience in U.S. nuclear facilities using HEPA filters. p. 457–471 in: High Efficiency Aerosol Filtration. CEC document V/835/77 (1977).

F5 Facer, J.F. Uranium production. p. 193–204 in: Uranium Industry Seminar, Grand Junction. GJO-108 (1979).

G1 Grand Junction Office. U.S. Department of Energy. Statistical data of the uranium industry. GJO-100 (1979).

G2 Gera, F. Geochemical behaviour of long-lived radioactive wastes. ORNL-TM- 4481 (1975).

G3 Godas, T. Communication (1979).

G4 Groome, D.J. and A. Short. Report on radioactive discharges associated environmental monitoring and personal radiation doses arising from operation of CEGB nuclear power stations during 1977. NHS/R148/78 (1978).

G6 Groome, D.J. Carbon-14 released from gas cooled reactors. Central Electricity Generating Board. Communication (1978).

G7 Gorman, D.J. and K.Y. Wong. Environmental aspects of tritium from CANDU station releases. p. 623–634 in: Behaviour of Tritium in the Environment. IAEA, Vienna, 1979.

G8 Garner, R.J. Transfer of radioactive materials from the terrestrial environment to animals and man. Chemical Rubber Co. Ltd., Ohio, 1972.

G10 Gat, U., J.D. Thomas and D.T. Clark. Radioactive waste inventory at the Maxey Flats nuclear waste burial site. Health Phys. 30: 281–289 (1976).

G12 Grand Junction Office. U.S. Department of Energy. Statistical data of the uranium industry. GJO-100 (1978).

H1 Her Majesty's Stationery Office. Handbook of Radiological Protection. Part I: Data. Panel of the Radioactive Substances Advisory Committee (1971).

H2 Hayes, D.W. and K.W. MacMurdo. Carbon-14 production by the nuclear industry. Health Phys. 32: 215–219 (1977).

H3 Heinemann, K., M. Stoeppler, K.J. Vogt et al. Untersuchungen zur Ablagerung und Desorption von Jod auf Vegetation. Jül-1287 (1976).

H4 Hoffman, F.O. A reassessment of the deposition velocity in the prediction of the environmental transport of radioiodine from air to milk. Health Phys. 32: 437–441 (1977).

H5 Hetherington, J.A. Radioactivity in surface and coastal waters of the British Isles 1974. FRL-11 (1976).

H6 Hetherington, J.A., D.F. Jeffries and M.B. Lovett. Some investigations into the behaviour of plutonium in the marine environment. p.193–212 in: Impacts of Nuclear Releases into the Aquatic Environment. IAEA, Vienna, 1975.

H7 Herrman, R. Communication (1978).

H8 Howells, H. Windscale and Calder Works—radioactive waste disposals and associated environmental monitoring data 1976. BNFL report HP/ER/76 (1977).

H9 Hetherington, J.A., D.F. Jeffries, N.T. Mitchell et al. Environmental and public health consequences of the controlled disposal of transuranic elements to the marine environment. p. 139–154 in: Transuranium Nuclides in the Environment. IAEA, Vienna, 1976.

H11 Hill, M.D. and P.D. Grimwood. Preliminary assessment of the radiological protection aspects of disposal of high-level waste in geologic formations. NRPB-R69 (1978).

H12 Hill, M.D. Analysis of the effect of variations in parameter values on the predicted radiological consequences of geologic disposal of high-level waste. NRPB-R86 (1979).

H13 Hansen, M.V. World uranium resources. IAEA Bulletin 23(2): 10–14 (1981).

H14 Heap, G.F. and A. Short. Report on radioactive discharges, associated environmental monitoring and personal radiation doses arising from operation of CEGB nuclear power stations during 1979. HS/R162/80 (1980).

I1 International Atomic Energy Agency. Power Reactors in Member States—1980 Edition. IAEA, Vienna, 1980.

I2 International Commission on Radiological Protection. Limits for Intakes of Radionuclides by Workers. ICRP Publication 30. Pergamon Press, Oxford, 1979.

I5 International Commission on Radiological Protection. Report of the Task Group on Reference Man. ICRP Publication 23. Pergamon Press, Oxford, 1975.

I6 International Atomic Energy Agency. The radiological basis of the IAEA revised definition and recommendations concerning high-level radioactive waste unsuitable for dumping at sea. Technical document IAEA-211. IAEA, Vienna, 1978.

I7 International Atomic Energy Agency. Safety Series No. 6 (1961), revised (1964, 1967, 1973).

I9 International Nuclear Fuel Cycle Evaluation (INFCE). Reports of Working Groups 1 to 8. IAEA, Vienna, 1980.

I10 International Nuclear Fuel Cycle Evaluation (INFCE). Release consequence analysis for a hypothetical geologic radioactive waste repository in hard rock. INFCE/DEP/WG7/21 (1979).

I11 International Nuclear Fuel Cycle Evaluation (INFCE). Safeguards for geologic repositories. INFCE/DEP/WG7/18 (1979).

I12 International Atomic Energy Agency. Power Reactors in Member States—1981 Edition. IAEA, Vienna, 1981.

J1 Jackson, P.O. Radon-222 emissions in ventilation air exhausted from underground uranium mines. NUREG-CR-0627 (PNL-2888) (1979).

J2 Jones, J.A. ESCLOUD: a computer program to calculate the air concentration, deposition rate and external dose rate from a continuous discharge of radioactive material to the atmosphere. NRPB-R101 (1980).

K1 Kouts, H. and J. Long. Tritium production in nuclear reactors. p. 38–45 in: Tritium (A.A. Moghissi and M.W. Carter, eds.). Messenger Graphics, Las Vegas, Nevada, 1973.

K2 Kelly, G.N., J.A. Jones, P.M. Bryant et al. The predicted radiation exposure of the population of the European Community resulting from discharges of ^{85}Kr, ^{3}H, ^{14}C and ^{129}I from the nuclear power industry to the year 2000. CEC document V/2676/75 (1975).

K3 Kahn, B., R.L. Blanchard and W.L. Brinck. Radiological surveillance at the Haddam Neck PWR nuclear power station. EPA-520/3-74-007 (1974).

K4 Kumatori, T. Radioactivity discharges in effluents from nuclear power plants in Japan. Communication (1981).

K5 Kullen, B.J., L.E. Trevorrow and M.J. Steindler. Tritium and noble-gas fission products in the nuclear fuel cycle. II. Fuel Reprocessing Plants. ANL-8135 (1975).

K6 Killough, G.G. and P.S. Rohwer. A new look at the dosimetry of ^{14}C released to the atmosphere as carbon dioxide. Health Phys. 34: 141–159 (1978).

K7 Kelly, G.N. Global circulation of iodine-129. p. 40–41 in: Proceedings of a Specialist Meeting. OECD/NEA (1977).

K8 Kärnbränslesäkerhet Project. Handling of spent nuclear fuel and final storage of vitrified high level waste. Stockholm, 1977.

K9 Kemeny, J.G. The President's Commission on the accident at Three Mile Island. Pergamon Press, 1979.

K10 Kristan, J., I. Kobal and F. Legat. Measurements of radon under various working conditions in the explorative mining of uranium. p.217–223 in: Population Dose and Standards for Man and his Environment. IAEA, Vienna, 1974.

K11 Kühn, K. and B. Verkerk. Disposal in salt formations. p. 385 in: Radioactive Waste Management Disposal (R. Simon et al. eds.). CEC Conference, Harwood, 1981.

K12 Krymm, R. and J.P. Charpentier. Nuclear power development: present role and medium-term prospects. IAEA Bulletin 22(2): 11–22 (1980).

L1 Luykx, F. and G. Fraser. Radioactive effluents from nuclear power stations and nuclear fuel reprocessing plants in the European Community: Discharge data 1972–1976—radiological aspects. CEC document V/4604/78 (1978).

L2 Lindell, B. Communication (1977).

L3 Linsley, G.S., J.R. Simmonds and G.N. Kelly. An evaluation of the foodchain pathway for transuranium elements dispersed soils. NRPB-R81 (1979).

L4 Larkin, M.J. Liquid and airborne effluents from Windscale nuclear reprocessing plant. p. 29–42 in: Radioactive Effluents from Nuclear Fuel Reprocessing Plants. CEC document V/2266/78 (1978).

L5 Lu, A.H. and J.M. Matuszek. Transport through a trench cover of gaseous tritiated compounds from buried radioactive wastes. p. 655–670 in: Behaviour of Tritium in the Environment. IAEA, Vienna, 1979.

L6 Luykx, F. and G. Fraser. Radioactive effluents from nuclear power stations and nuclear fuel reprocessing plants in the European Community: Discharge data 1974–1978—radiological aspects. CEC document V/4116/80 (1980).

L7 Linsley, G. Communication (1980).

L8 Leach, V.A., K.H. Lokan and L.J. Martin. A study of radiation parameters at Nabarlek uranium mine, N. T. ARL/TR-028 (1980).

L9 Lokan, K.H. Atmospheric discharges from the Nabarlek mine. Communication (1981).

L10 Loutit, J.F., W.G. Marley and R.S. Russell. Appendix H (p. 129–139) of Second Report to the Medical Research Council on the Hazards to Man of Nuclear and Allied Radiations. HMSO, London, 1960.

M1 Moore, R.E. The AIRDOS II computer code for estimating radiation dose to man from airborne radionuclides in areas surrounding nuclear facilities. ORNL-5245 (1977).

M2 Magno, P.J., C.B. Nelson and W.H. Ellett. A consideration of the significances of carbon-14 discharges from the nuclear power industry. p. 1047–1054 in: Proceedings of the Thirteenth AEC Air Cleaning Conference. CONF-740807 (1975).

M3 Martin, J.A. and C.B. Nelson. Calculations of dose and population dose in general environment due to boiling-water nuclear power reactor radionuclide emissions in the US in 1971. p. 319–333 in: Physical Behaviour of Radioactive Contaminants in the Atmosphere. IAEA, Vienna, 1974.

M4 Mitchell, N.T. Radioactivity in surface and coastal waters of the British Isles, 1975. FRL-12 (1977).

M5 Mitchell, N.T. Radioactivity in surface and coastal waters of the British Isles, 1976. Part 1: The Irish Sea and its environs. FRL-13 (1977).

M6 Martin, A. and H. ApSimon. Population exposure and the interpretations of its significance. p. 15–26 in: Population Dose Evaluation and Standards for Man and his Environment. IAEA, Vienna, 1975.

M7 Montgomery, D.E., H.E. Kolde and R.L. Blanchard. Radiological measurements at the Maxey Flats radioactive waste burial site. EPA 520/5-76/020 (1977).

M8 Murata, H. Meeting the need for advanced reactors and fusion. Nucl. Eng. Int. 24(293): 68–70 (1979).

M10 Muller, E.F. Communication (1981).

N2 Nuclear Regulatory Commission, United States. Generic environmental impact statement on uranium milling. NUREG-0511 (1979).

N3 Nielson, K. Prediction of the net radon emission from a model open pit uranium mine. NUREG-CR-0628 (1979).

N4 Nuclear Regulatory Commission, United States. Bear Creek Project. Draft environmental statement (Converse Country, Wyoming). NUREG-0129 (1977).

N5 Nuclear Regulatory Commission, United States. Final environmental impact statement related to operation of Lucky McGas Hills uranium. NUREG-0356 (1977).

N6 Nuclear Regulatory Commission, United States. Final environmental impact statement related to operation of Moab uranium mill. NUREG-0341 (1977).

N7 Nuclear Regulatory Commission, United States. Draft environmental statement related to Morton Ranch mill. NUREG-0439 (1978).

N8 Nuclear Regulatory Commission, United States. Final environmental statement related to operation of the Sweetwater uranium project. NUREG-0403 (1979).

N9 Nuclear Regulatory Commission, United States. Calculation of releases of radioactive materials in gaseous and liquid effluents from PWRs. NUREG-0017 (1976).

N10 Nuclear Regulatory Commission, United States. Calculation of releases of radioactive materials in gaseous and liquid effluents from BWRs. NUREG-0016 (1976).

N11 Nichols, A.L. The UK chemical nuclear data committee file: a summary of the primary data available in ENDF/B format. AERE-R8904 (1977).

N12 Nichols, A.L. Radioactive-nuclide decay data for reactor calculations: activation products and related isotopes. AERE-R8903 (1977).

N13 Nair, S. and H.J. Henning. A users guide to the reactor inventory code RICE. RD-B-N4079 (1978).

N14 Nuclear Energy Agency. Report of an expert group on the radiological significance and management of ^{3}H, ^{14}C, ^{85}Kr and ^{129}I from the nuclear fuel cycle. OECD/NEA (1980).

N15 Ng, Y.C., C.A. Burton, S.E. Thompson et al. Prediction of maximum dosage to man from fallout of nuclear devices. in: Handbook for estimating the maximum internal dose from radionuclides released to the biosphere. UCRL-50163 (1968).

N16 Ng, Y.C., C.S. Colsher and S.E. Thompson. Transfer factors for assessing the dose from radionuclides in agricultural products. p. 295–318 in: Biological Implications of Radionuclides Released from Nuclear Industries. IAEA, Vienna, 1979.

N17 Nuclear Regulatory Commission, United States. Final generic environmental statement on the use of recycle plutonium in mixed oxide fuel in light water cooled reactors (GESMO). NUREG-0002, Vol. 1 (1976).

N18 Nuclear Regulatory Commission, United States. Office of Inspection and Enforcement. Licensed fuel facility status summary report: Data for decisions fuel cycle operations. NUREG-0430, Vol. 1, No. 3 (1978).

N19 Norlinder, S. Communication (1980).

N20 National Council on Radiation Protection and Measurements. Tritium in the environment. NCRP-R62 (1979).

N21 Nuclear Regulatory Commission, United States. Final generic environmental impact statement on uranium milling. NUREG-0706 (1980).

O1 Oak Ridge National Laboratory. Siting of fuel reprocessing plants and waste management facilities. ORNL-4451 (1970).

P1 Pechin, W.H., R.E. Blanco, R.C. Dahlman et al. Correlation of waste treatment costs and environmental impact of waste effluents in the nuclear fuel cycle for use in establishing "as low as practicable" guides—fabrication of LWR fuel from enriched uranium dioxide. ORNL-TM-4902 (1975).

P2 Phillips, J.W. and J. Gruhlke. Summary of radioactivity released in effluents from nuclear power plants from 1973 thru 1976. EPA-520/3-77-012 (1977).

P3 Passant, F.H. Environmental radiation from advanced gas-cooled reactors in normal operation. p. 326–371 in: Proceedings of the Third International Congress of the International Radiation Protection Association. CONF-730907-P1 (1974).

P4 Poston, J.W. and W.S. Snyder. A model for exposure to a semi-infinite cloud of a photon emitter. Health Phys. 26: 287–293 (1974).

P5 Pentreath, R.J., M.B. Lovett and B.R. Harvey et al. Alpha-emitting nuclides in commercial fish species caught in the vicinity of Windscale, United Kingdom and their radiological significance to man. p. 227–245 in: Biological Implications of Radionuclides released from Nuclear Industries. IAEA, Vienna, 1979.

P6 Preston, A., D.F. Jefferies and N.T. Mitchell. The impact of caesium-134 on the marine environment from Windscale. p. 401–420 in: Radioactive Effluents from Nuclear Fuel Reprocessing Plants. CEC document V/2266/78 (1978).

P7 Pelletier, C.A., J.E. Cline and J.H. Keller. Measurements on sources of I-131 releases to atmosphere from nuclear power plants. IEEE Trans. Nuc. Sci. NS-21: 478 (1974).

P8 Parker, The Honorable Mr. Justice. The Windscale Inquiry. Vol. 1 (p. 7, para. 2.28; p. 46, para. 10.38). HMSO, London, 1978.

P9 Palms, J.M. and V.R. Veluri. The environmental impact of the most critical nuclides released by a fuel reprocessing plant. p. 273–303 in: Radioactive Effluents from Reprocessing Plants. CEC document V/2266/78 (1978).

R1 Riedel, H. and P. Gesewsky. Zweiter Bericht über Messungen zur Emission von Kohlenstoff-14 mit der Abluft aus Kernkraftwerken mit Leichtwasserreaktor in der Bundesrepublik Deutschland. STH-13/77 (1977).

R2 Rohloff, F., E. Brunen, H.D. Brenk et al. LIGA. Ein Programm zur Berechnung der lokalen individuellen Gammasubmersiondosis durch Abluftfahnen aus kerntechnischen Anlagen. Jül-1577 (1979).

R3 Rasmussen, N. Reactor safety study: an assessment of accident risks in U.S. commercial nuclear power plants. WASH-1400 (1975).

S1 Sears, M.B., R.E. Blanco, R.C. Dahlman et al. Correlation of radioactive waste treatment costs and the environmental impact of waste effluents in the nuclear fuel cycle for use in establishing "as low as practicable" guides—milling of uranium ores. ORNL-TM-4903/1 (1975).

S2 Snelling, R.N. and S.D. Shearer. Environmental survey of uranium mill tailings pile, Tuba City, Ariz. Radiol. Health Data 10: 475–587 (1969).

S3 Snelling, R.N. Environmental survey of uranium mill tailings pile, Monument Valley, Ariz. Radiol. Health Data 11: 511–517 (1970).

S4 Snelling, R.N. Environmental survey of uranium mill tailings pile, Mexican Hat, Utah. Radiol. Health Data 12: 17–28 (1971).

S5 Schiager, K.J. Analysis of radiation exposures on or near uranium mill tailings piles. Rad. Data Rep. 15: 411–425 (1974).

S6 Sears, M.B., R.E. Blanco, B.C. Finney et al. Correlation of radioactive waste treatment costs and the environmental impact of waste effluents in the nuclear fuel cycle—conversion of yellowcake to uranium hexafluoride. Part I: The fluorination—fractionation process. ORNL-NUREG-TM-7 (1977).

S7 Smith, J.M. and R.S. Gilbert. Tritium experience in boiling water reactors. p. 57–68 in: Tritium (A.A. Moghissi and M.W. Carter, eds.). Messenger Graphics. Las Vegas, Nevada, 1973.

S8 Schuettelkopf, H. and G. Herrmann. $^{14}CO_2$-Emissionen aus der Wiederaufarbeitungsanlage Karlsruhe (WAK). p. 189–201 in: Radioactive Effluents from Reprocessing Plants. CEC document V/2266/78 (1978).

S9 Slinn, W.G.N. Parameterizations for resuspension and for wet and dry deposition of particles and gases for use in radiation dose calculations. Nucl. Saf. 19: 205–219 (1978).

S10 Simmonds, J.R., G.S. Linsley and J.A. Jones. A general model for the transfer of radioactive materials in terrestrial foodchains. NRPB-R89 (1979).

S11 Scott Russell, R. Radioactivity and Human Diet. Pergamon Press, 1966.

S12 Simmonds, J.R. and G.S. Linsley. Agricultural data grid for the United Kingdom. NRPB-R (to be published 1982).

S13 Siegenthaler, U. and H. Oeschger. Predicting future atmospheric carbon dioxide levels. Science 199: 388–395 (1978).

S14 Salo, A. Communication (1980).

S15 Schwibach, J., H. Riedel and J. Bretschneider. Investigations into the emission of carbon-14 compounds from nuclear facilities. CEC document V-3062/78 (1978).

S16 Seidel, D.C. Extracting uranium from its ores. IAEA Bulletin 23(2): 10–14 (1981).

S17 Stippler, R. and H. Kleiman. Strahlenschutz und Umgebungsüberwachung bei der Lagerung von radioaktiven Abfällen in einem Salzbergwerk. Seventh Regional Congress of IRPA, Köln, 1979.

T1 Tanner, A.B. Radon migration in the ground. A supplementary review. U.S. Geological Survey Open File report 78-1050 (1978).

T2 Trevorrow, L.E., B.J. Kullen, R.L. Jarry et al. Tritium and noble-gas fission products in the nuclear fuel cycle. I. Reactors. ANL-8102 (1974).

T3 Thompson, S.E., C.A. Burton, D.J. Quinn et al. Concentration factors of chemical elements in edible aquatic organisms. UCRL-5-564 Rev. 1 (1972).

T4 Taylor, F.E. and G.A.M. Webb. Radiation exposure of the UK population. NRPB-R77 (1978).

U1 United Nations. Sources and Effects of Ionizing Radiation. United Nations Scientific Committee on the Effects of Atomic Radiation 1977 report to the General Assembly, with annexes. United Nations publication. (Sales No. E.77.IX.1). New York, 1977.

U2 United Kingdom Atomic Energy Authority. Overseas Relations Branch. Nuclear power in the Soviet Union and Eastern Europe. Atom 276: 276–277 (1979).

U3 United States Atomic Energy Commission. Environmental survey of the nuclear fuel cycle. WASH-1248 (1974).

U4 United States Atomic Energy Commission. Environmental survey of transportation of radioactive materials to and from nuclear power plants. WASH-1238 (1972).

U5 United Nations Environment Programme. The environmental impacts of production and use of energy. Part II: Nuclear Energy. UNEP Energy Report Series (1979).

V1 Vogt, K.J., H. Geiss, F. Rohloff et al. LIGA: Ein Programm zur Berechnung der lokalen individuellen Gammasubmersionsdosis durch Abluftfahnen aus kerntechnischen Anlagen. KfA-Jül 1577 (1980).

V2 Vilquin, A., R. Coulon and J. Le Grand. Méthode d'évaluation des conséquences des rejets radioactifs du Centre de La Hague. p. 363–383 in: Radioactive Effluents from Nuclear Fuel Reprocessing Plants. CEC document V/2266/78 (1978).

W1 Williams, L. The world energy situation and the response of the European Community. J. Inst. Nucl. Eng. 21(1): 3–10 (1980).

W2 Winkelman, I. Bericht über die in Filterproben aus der Abluftüberwachungsanlage von Kernkraftwerken in der Bundesrepublik Deutschland in Jahre 1976 nachgemessenen Einzelnuklide. STH-4/77 (1977).

W3 Wong, K.Y. Communication (1979).

W4 White, I.F. Communication (1980).

W5 Wilks, R. Operational experience in the control of radioactive liquid effluent discharges from the Windscale Works, BNFL. p. 203–218 in: Radioactive Effluents from Nuclear Fuel Reprocessing Plants. CEC document V/2266/78 (1978).

W6 W and W, Radiological and Environmental Consultant Services, Inc. Monitoring Program Design Recommendations for Uranium Mining Localities. EPS 3-EC-78-10 (1978).

Z1 Zuker, M., J.M. Ridgeway and D.R. Miller. A study of atmospheric radionuclide transport and exposure using trajectory analysis. p. 381–398 in: Biological Implications of Nuclides released from Nuclear Industries. IAEA, Vienna, 1980.