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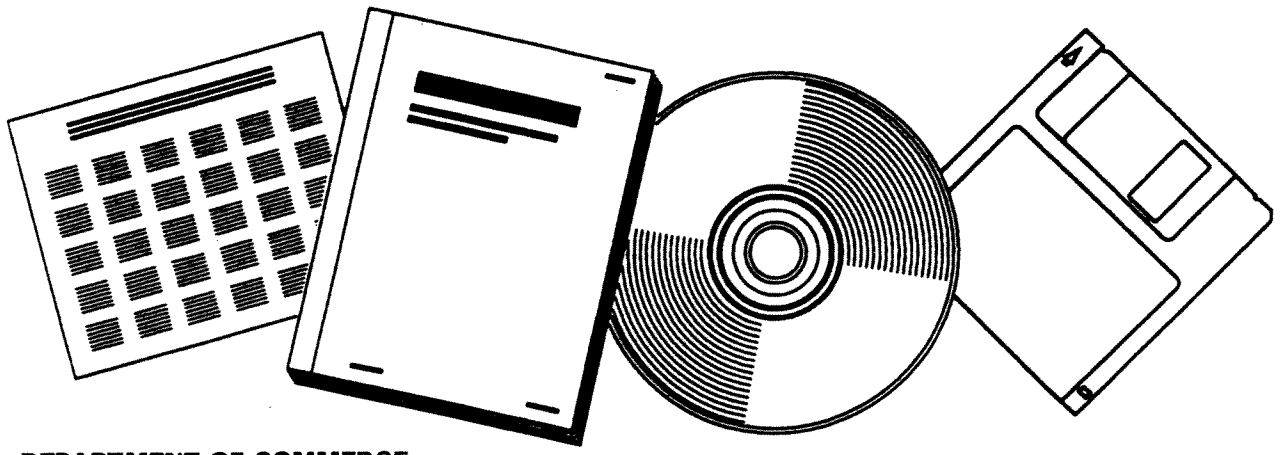
ENVIRONMENTAL SURVEY OF TRANSPORTATION OF RADIOACTIVE MATERIALS TO AND FROM NUCLEAR POWER PLANTS SUPPLEMENT I

U.S. NUCLEAR REGULATORY COMMISSION
WASHINGTON, DC

APR 75



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SUPPLEMENT I

To

WASH-1238

Introduction

This supplement to WASH-1238, "Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants," December 1972, has been prepared to present the data and identify the methods used in deriving the values in Summary Table S-4, "Environmental Impact of Transportation of Fuel and Waste To and From One Light-Water-Cooled Nuclear Power Reactor," referred to in and set out following 10 CFR 51.20 (g)[1/] of the Commission's regulations. Summary Table S-4 was published in Part 51 for use by power reactor license applicants in their environmental reports and by the Nuclear Regulatory Commission in its detailed statements to account for the environmental effects of transportation of fuel and waste to and from nuclear power reactors within the scope of that paragraph.

Derivation of Values in Summary Table S-4

With the exception of the values used for cumulative doses to the exposed population, the values in Summary Table S-4 are those derived for the "typical" nuclear power reactor in WASH-1238. The calculative methods, assumptions, and parameters used in deriving the values in WASH-1238 are described in detail in that report. The results of individual analyses

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[1/] The amendments to 10 CFR Part 51 (§ 51.20 (g), Summary Table S-4, and § 51.23 (a) became effective February 5, 1975 (40 FR 1005 - 1009, January 6, 1975). In the Statement of Considerations accompanying the Notice of Rule Making, it was stated that the Regulatory staff intended to issue a supplement to WASH-1238 showing how the impact values in the Summary Table S-4 were derived (40 FR 1007 and 1008, January 6, 1975).

by the Commission during the period January 1972 through March 1973 of the environmental impact of such transportation for 84 individual nuclear power reactors at 53 different sites are given in Table S-1, "Summary of Transportation Data for Nuclear Power Reactor Sites." The values used for cumulative doses are based on data tabulated in Table S-1.

The value of 250,000 Btu/hr for the heat output from an irradiated fuel cask in transit is based on an actual design of a shipping cask for LWR fuel. Shipments of unirradiated fuel and solid radioactive waste release negligible amounts of heat (see pages 5, 27, 38, and 50 of WASH-1238). As indicated in the table, the gross weights of trucks are limited by state restrictions to about 73,000 pounds, which limit the cask weight to about 50,000 pounds. The weight of a cask for routine shipment by rail or barge in most cases will not exceed about 100 tons (see pages 7, 20, 39, and 40 of WASH-1238). Shipments of unirradiated fuel and solid radioactive waste, although made up of several packages, are subject to the same weight restrictions.

The estimated numbers of shipments per year of fuel and waste and return of empty containers that were used to estimate the traffic densities for truck and rail were derived in WASH-1238 (see pages 20, 22, 23, 27, 34, 39, and 50 of WASH-1238). Those "typical" numbers are compared, in Table S-5, to the numbers of shipments estimated for the individual reactors tabulated in Table S-1.

Data in Table S-1 were analyzed to determine the values for average estimated annual doses to transport workers and the general public from the transportation of fuel and waste for the operation of a single reactor for one year. Those values, along with other average values for numbers of shipments and shipping distances, are given in Tables S-2 through S-5. As can be seen from these data, there is a considerable range of estimated values for distances, numbers of shipments, and doses to people, but the average values did not differ greatly from the "typical" numbers derived in WASH-1238.

As shown in Table S-2 and Figures 1, 2, and 3, the values for cumulative doses to transport workers and the general public given in Summary Table S-4 exceed the doses calculated for 90% of the more than 80 reactors for which specific analysis of the environmental impact of transportation has been made.

The environmental risks from accidents due to radiological effects were evaluated in WASH-1238 based on probabilities of a wide spectrum of accidents and estimates of a range of consequences from each category of accidents, taking into account such variables as weather conditions, population density, type of shipment involved, and effect of the accident conditions on the package (see Appendixes A and B of WASH-1238). The risks from common causes were extrapolated from data provided by the Department of Transportation on reportable accidents of all types of hazardous material (see Appendix C of WASH-1238).

TABLE S-1

SUMMARY OF TRANSPORTATION DATA FOR NUCLEAR POWER REACTOR SITES

Site	Data from Final Environmental Statement Dated	Number of Reactors At Site	Type of Reactor[1]	Net Power Rating, MWe	Unirradiated Fuel: Number of Truck Shipments	Unirradiated Fuel: Shipping Distance, Miles	Irradiated Fuel: Number of Truck Shipments[2]	Irradiated Fuel: Number of Rail Shipments[2]	Irradiated Fuel: Shipping Distance, Miles	Packaged Waste: Number of Truck Shipments	Packaged Waste: Shipping Distance, Miles	Estimated Accumulated Radiation Doses man-rem/year[3]: Transport Workers	Estimated Accumulated Radiation Doses man-rem/year[3]: General Public: Onlookers	Estimated Accumulated Radiation Doses man-rem/year[3]: General Public: Along the Route	Combined Transport Workers & General Public, man-rem/year per reactor
Midland 1, 2	03/29/72	2	PWR	500/850	5	650	20		400	12-15	400	1.5T .13R	.5T .37R	.4T .25R	1.2
Oconee 1	03/27/72	1	PWR	885	3		30			15		1.2	.5	.4	2.1
Pilgrim	05/09/72	1	BWR	655	5	850	80	(8)	700	45	200	6.4T 1.5R	1.6T .7R	.23T .05R	8.23
Point Beach 1, 2	05/18/72	2	PWR	2@ 497	12	1000	12		200	12	200	2.7	.2	.12	1.51
Surry 1** Surry 2	05/25/72 06/30/72	1 1	PWR	2@ 800	8	400	104		500	60	500	7.8	2.2	2.1	6.05
Farley	06/23/72	2	PWR	2@ 840	10	500		20	500	30	500	1	.7	.1	0.9
Palisades	06/28/72	1	PWR	700	5	850	20	(10)	700	6-9	500	1.3T	.4T	.6T	2.3
Vermont Yankee	07/06/72	1	BWR	513	3	700	15	(5)	900	12	500	1.4T .5R	.4	.3	2.1
Fermi 2	07/07/72	1	BWR	1150	6	900		8	900	12	500	.5	.3	.1	0.9
Turkey Point	07/14/72	2	PWR	2@ 740	10	700	30	(12)	700	45	1000	3.4	1	.2	2.3
Maine Yankee	07/19/72	1	PWR	792	5		27-40	(8-10)		16	500	2.9	.7	.2	3.8
Fort St. Vrain	08/04/72	1	HTGR	330	4	1200	40		700	1	900		.3	.3	---
Fort Calhoun	08/30/72	1	PWR	457	5	1000	25	(6)	1000	40	1000	2.7	.8	1.6	5.1
Zimmer	09/07/72	1	BWR	840	4	700		5-8	300	40-55	300	2.4	.8	.1	3.3
Quad Cities	09/08/72	2	BWR	2@ 809	5	850		7	700	45	500	1.5	.6	.7	1.4
Indian Point[2]	09/29/72	1	PWR	873	5	800	22	(10)	1000	5-10	600	1.4	.7	1.1	3.2
Arkansas 2	09/29/72	1	PWR	925	5			10	750	12	750	.5	.3	.2	1.0
Shoreham	10/02/72	1	BWR	820	5	700	70	(6)	900	40	500	5.2T 1.3R	1.4T .6R	1.5T .5R	8.1
McGuire 1, 2	10/26/72	2	PWR	2@ 1100	11	100	144	(24)	150	33	400	3.9T 1.1R	2.1T .6R	.5R .2R	3.25

TABLE S-1 (Continued)

SUMMARY OF TRANSPORTATION DATA FOR NUCLEAR POWER REACTOR SITES

Site	Data from Final Environmental Statement Dated	Number of Reactors At Site	Type of Reactor[1]	Net Power Rating, MWe	Unirradiated Fuel: Number of Truck Shipments	Unirradiated Fuel: Shipping Distance, Miles	Irradiated Fuel: Number of Truck Shipments[2]	Irradiated Fuel: Number of Rail Shipments[2]	Irradiated Fuel: Shipping Distance, Miles	Packaged Waste: Number of Truck Shipments	Packaged Waste: Shipping Distance, Miles	Estimated Accumulated Radiation Doses man-rem/year[3]: Transport Workers	General Public: Onlookers	General Public: Along the Route	Combined Transport Workers & General Public, man-rem/year per reactor
Hatch	10/30/72	2	BWR	2@ 790	10			10-16	800	55-70	800	2.2	.5	1.2	1.95
Monticello	11/22/72	1	BWR	545	4	1400	20	(6)	500	40	500	1.6	.8	.1	2.5
Zion	12/06/72	2	PWR	2@ 1100	6		(40)	(10)	900	40	500	1.3R 3.6T	.6R 1.T	.7R 1.4T	3.0
Three Mile Island	12/06/72	2	PWR	850/930	10			15	800	50-200	600	1.6-6.1	.8-2.8	1.- 3.3	6.1
Hanford 2	12/07/72	1	BWR	1100	15	10		10	3000	50	10	1.1	.1	.15	1.35
Kewaunee	12/20/72	1	PWR	540	4		10-40		700	8		2.65	.6	.8	4.05
Virgil C. Summer	01/12/73	1	PWR	900	6	40	28	(6)	100	21	500	.66R 1.2T	.28R .67T	.2R .24T	2.11
La Salle	02/10/73	2	BWR	2@ 1100	10			14	800	40	600	1.3	0.7	0.9	1.45
Arkansas 1	02/09/73	2	PWR	820/902	10			20	870 790	24		0.82	0.7	0.7	1.11
Bailly	02/12/73	1	BWR	660	4			6		40		1.2	0.58	0.2	1.98
Cooper	02/21/73	1	BWR	778	5			6-13		68		2.2	.98	1.2	4.38
Forked River	02/16/73	1	PWR	1093	5R 12T	140	72	(12)	600	37	600	3.42T 1.2R	1.4T 0.7R	1.21T 0.53R	6.03
Duane Arnold	03/12/73	1	BWR	569	4			6	500	25	500	0.84	0.4	0.28	1.52
Davis Besse	03/12/73	1	PWR	872	5			6	700	9	300	.24	.18	.06	.48
Rancho Seco	03/13/73	1	PWR	913	5	2800		4(5,6)	2600	14(15,35)	650	1.44	0.6	0.64	2.68
Waterford	03/21/73	1	PWR	1165	5		50-72	5-7	700	15	900	2.75 .6R	1.2T .3R	1.1T .3R	5.05
FitzPatrick		1	BWR	821	5	800	70		1000	20	1000	2.7	.4	1.7	4.8
San Onofre 2, 3	03/21/73	2	PWR	2@1140	11	3000	145	26	2000	50	500	12.5T 1.6R	2.6T 1. R	2 T .6R	8.55

TABLE S-1 (Continued)

SUMMARY OF TRANSPORTATION DATA FOR NUCLEAR POWER REACTOR SITES

Site	Data from Draft Environmental Statement Dated	Number of Reactors At Site	Type of Reactor[1]	Net Power Rating, MWe	Unirradiated Fuel: Number of Truck Shipments	Unirradiated Fuel: Shipping Distance, Miles	Irradiated Fuel: Number of Truck Shipments[2]	Irradiated Fuel: Number of Rail Shipments[2]	Irradiated Fuel: Shipping Distance, Miles	Packaged Waste: Number of Truck Shipments	Packaged Waste: Shipping Distance, Miles	Estimated Accumulated Radiation Doses man-rem/year[3]: Transport Workers	General Public: Onlookers	General Public: Along the Route	Combined Transport Workers & General Public, man-rem/year per reactor
Calvert Cliffs 1, 2	01/20/72	2	PWR	2@ 910	12		144	4(Barge)	550	12	600	9.4T .5Barge	2.6T .2Barge	2.2T .2Barge	7.1
Hutchison Island	09/13/72	1	PWR	850	5	1400	36		500	15-20	800	1.3	.8	.6	2.7
Peach Bottom 2,3	10/06/72	2	BWR	2@1065	12	460	200	(16)	650	164	600	11 T 5.1R	4.4T 2.2R	3.2T 2 R	9.3
Salem 1,2	10/31/72	2	PWR	2@1090	11	250	130-150		775	40	500	4.2	2.4	2.5	4.55
Shearon Harris 1-4	11/22/72	4	PWR	4@ 900	18			31	300	180	400	5.2	2.7	1.5	2.35
Limerick 1, 2	12/06/72	2	BWR	2@1055	12	500	200	(16)	775	70	500	5 T 1.1R	3.1T .7R	3.1T .2R	5.6
North Anna 1-4	12/11/72	4	PWR	4@ 900	18	300	200	(20)	500	200	500	8T 4.1R	5.2T 2.9R	3.6T 2R	4.2
Crystal River 3	09/11/72	1	PWR	830	5			10	350	18	850	.6	.3	.4	1.3
Diablo Canyon 1,2	12/12/72	2	PWR	2@1150	10-14	3000		10-18	3000	9	1000	1.4	.8	.7	1.45
Newbold 1,2	12/20/72	2	BWR	2@1088	6		92	(16)	900		400	3.4	1.4	1.6	3.2
Cook 1,2	11/09/72	2	PWR	2@1100	10		64	(21)	900	36	500	3	1.4	1.3	2.85
Millstone	12/30/72	2	BWR/PWR	650/830	4/5		70/72	(6/8)	1000	80	800	6.7T 2.5R	2.8T 1.2R	4 T 1.7R	6.75
Trojan	01/05/73	1	PWR	1130	5	3100		7	3100	9	250	.3	.2	.2	0.7
Nine Mile Point	01/17/73	1	BWR	1120	6	800	76	(6)	1000	42	1000	3.6T 1.3R	.7R	.9R	5.2
Susquehana 1,2	01/19/73	2	BWR	2@1100	13			21	600	52	400	1.1	.8	.6	1.25
Prairie Island 1,2	01/22/73	2	PWR	2@ 540			80		1000	16	1000	6.9	1.2	1.2	4.65
Beaver Valley	03/ /73	1	PWR	852	5		53	(6)	520	22	750	1.7	1	.8	3.5
Haddam Neck	03/26/73	1	PWR	600	4		50	(7)	950	4	800	1.6	.7	1.	3.3

FES's for SURRY 1 and SURRY 2 were issued separately, but both FES's treated both units.

1 All reactors listed except Fort St. Vrain are light-water-cooled power reactors fueled with pelletized 1-4% enriched UO_2 in Zircalloy rods.

2 In most cases, shipment is either by truck or by rail. Where truck and rail are optional, rail is shown in parenthesis.

3 In most cases, two values are give; the dose identified with a T is for truck only and an R is for rail only; if neither T nor R, the transport is by truck only. For averaging, the higher values were used.

TABLE S-2

ESTIMATED RADIATION DOSES TO TRANSPORT WORKERS AND THE GENERAL PUBLIC FROM TRANSPORTATION OF FUEL AND WASTE FOR A NUCLEAR POWER REACTOR

	Range of Values, man-rem/year Min	Max	Average Doses, man-rem/year	Standard Deviation, man-rem/year	90 Percentile Value,[3] man-rem/year
Transport Workers[1]	0.24	6.4	2.04	1.48	4
General Public[2]	0.24	3.8	1.45	0.92	3
Combined:[1] Transport Workers and General Public	0.48	9.3	3.50	2.26	7

[1] Based on data for 83 reactors.

[2] Based on data for 84 reactors.

[3] The cumulative doses calculated for 90% of the 83 or 84 reactors are lower than these values.

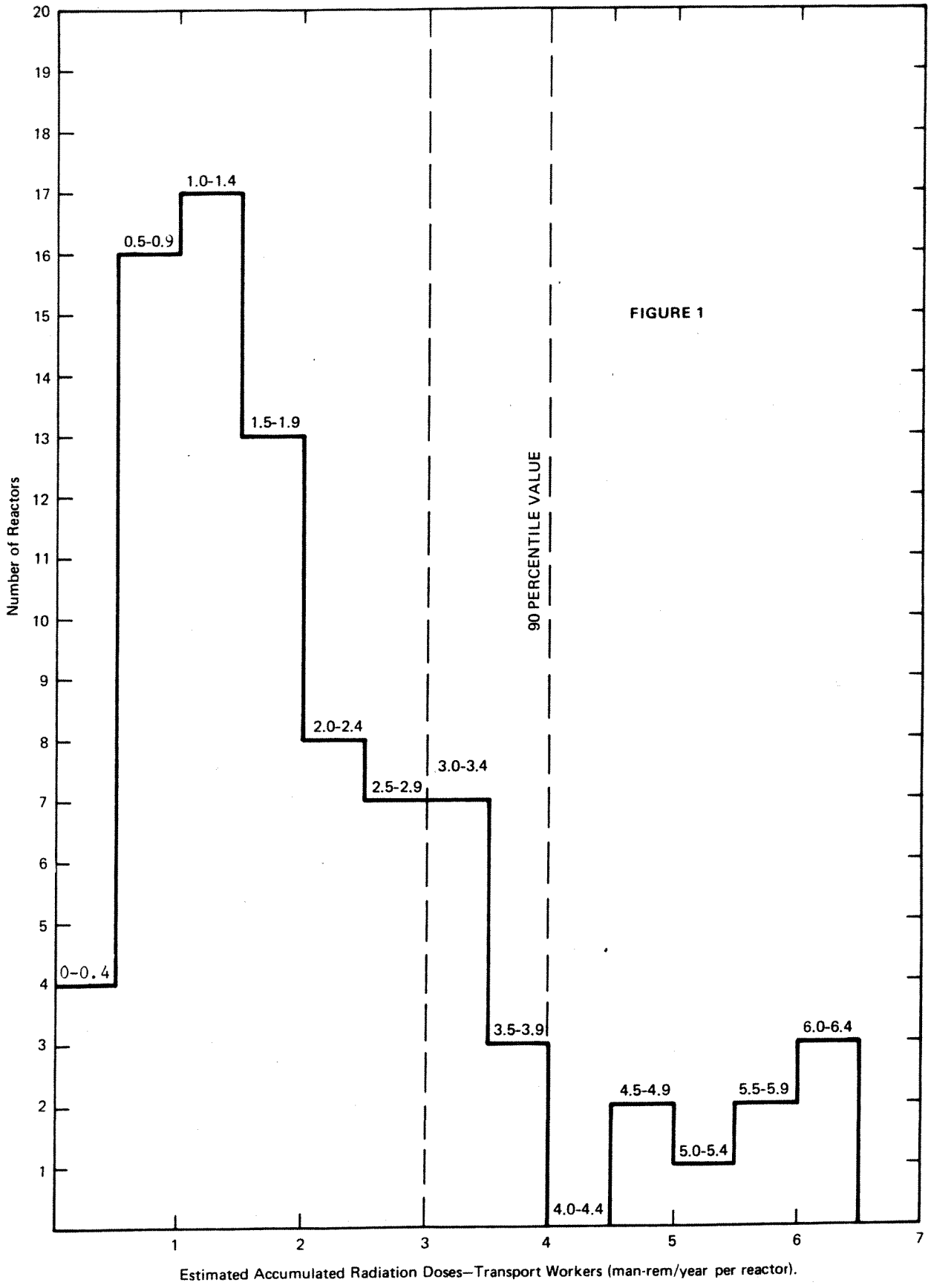
Number of Reactors
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0-0.4
0.5-0.9
1.0-1.4
1.5-1.9
2.0-2.4
2.5-2.9
3.0-3.4
3.5-3.9
4.0-4.4
4.5-4.9
5.0-5.4
5.5-5.9
6.0-6.4
90 PERCENTILE VALUE
1
2
3
4
5
6
7
Estimated Accumulated Radiation Doses—Transport Workers (man-rem/year per reactor).

FIGURE 1

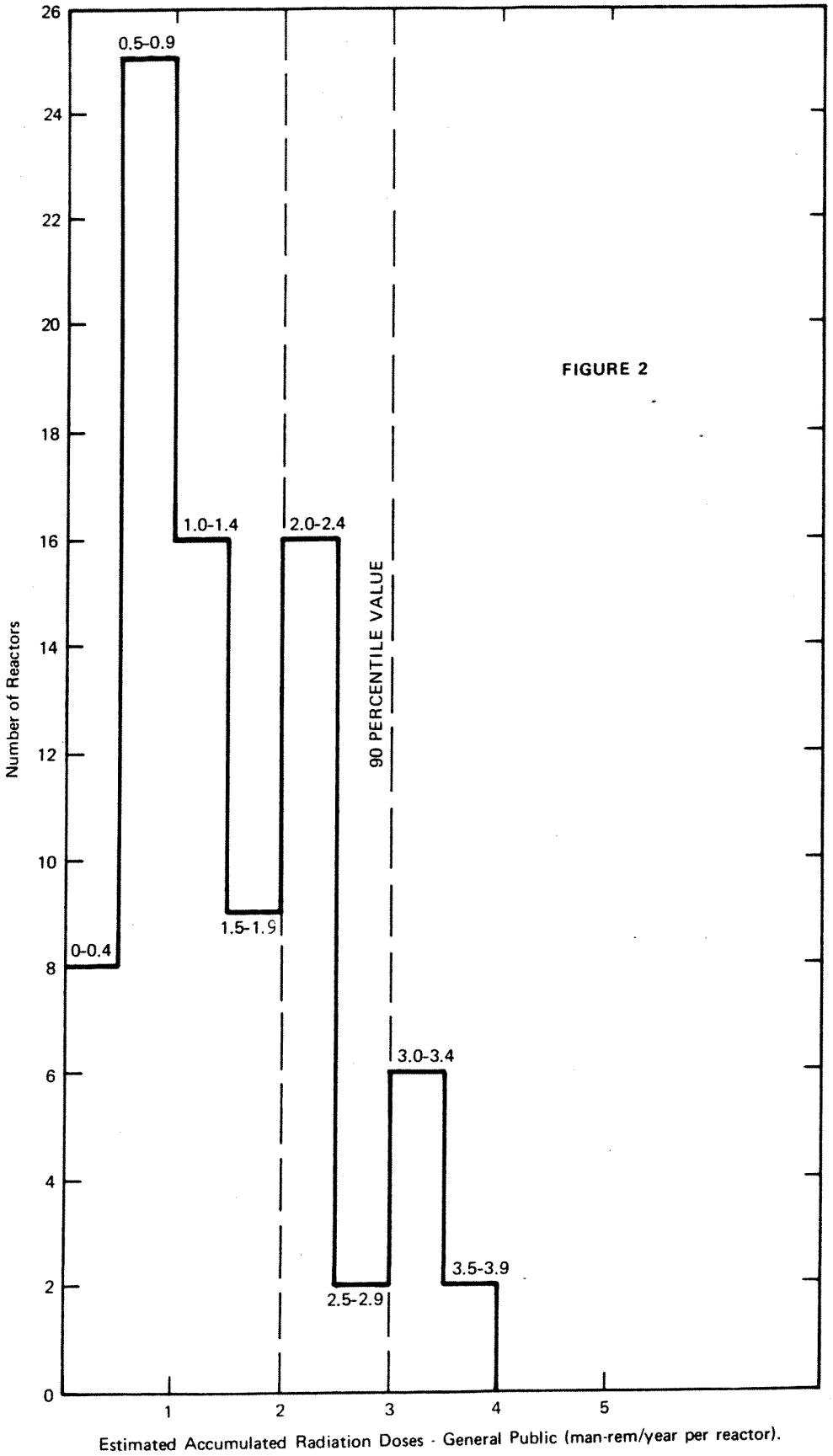
26
24
22
20
18
16
14
12
10
8
6
4
2
0
Number of Reactors
0.5-0.9
1.0-1.4
2.0-2.4
1.5-1.9
0-0.4
90 PERCENTILE VALUE
3.0-3.4
3.5-3.9
2.5-2.9
1
2
3
4
5
Estimated Accumulated Radiation Doses - General Public (man-rem/year per reactor).

FIGURE 2

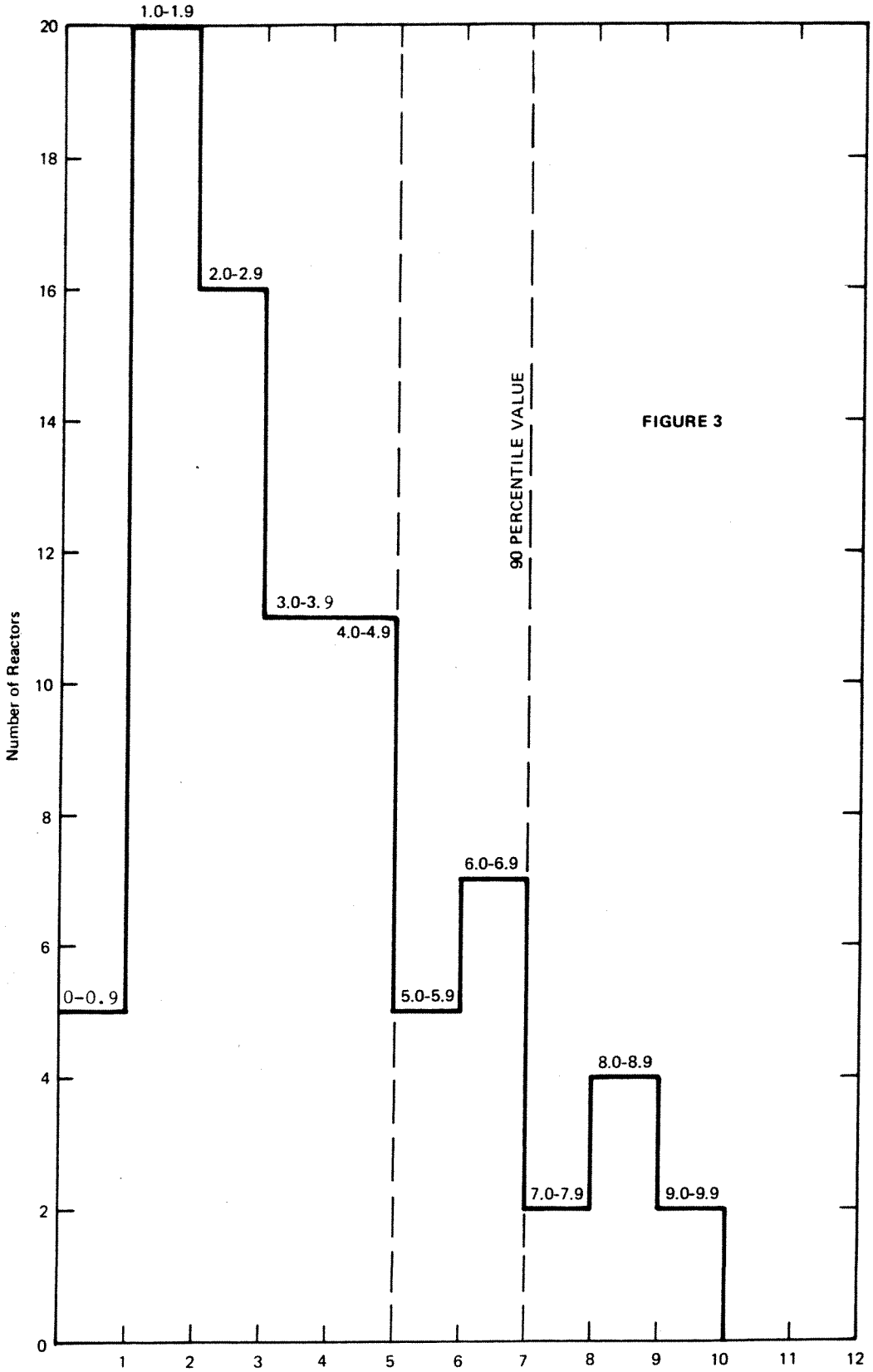

FIGURE 3

Estimated Accumulated Radiation Dose - Combined Transport Workers and General Public (man-rem/year per reactor).

TABLE S-3

ESTIMATED RADIATION DOSES TO INDIVIDUALS
FROM SHIPMENTS OF FUEL AND WASTE FOR A NUCLEAR POWER REACTOR

	Range in Numbers of Persons Exposed	Range in Individual Doses, millirem/year	Overall Average Individual Doses, millirem/year
Transport Workers	20 to 200	5 to 500	10[1/]
General Public			
Onlookers	10 to 1100	1.3	1.3[2/]
Along the route	36,000 to 1,200,000	0 to 0.06	0.002[2/]

1/ For 83 reactors

2/ For 84 reactors

SUMMARY TABLE S-4

ENVIRONMENTAL IMPACT OF TRANSPORTATION OF FUEL AND WASTE[1] TO AND FROM ONE LIGHT-WATER-COOLED NUCLEAR POWER REACTOR

Normal Conditions of Transport

	Environmental Impact
Heat (per irradiated fuel cask in transit)	250,000 Btu/hr
Weight (governed by federal or state restrictions)	73,000 lbs. per truck; 100 tons per cask per rail car
Traffic density	
Truck	less than 1 per day
Rail	less than 3 per month

Exposed Population	Estimated Number of Persons Exposed	Range of Doses to Exposed Individuals[2] (per reactor year)	Cumulative Dose to Exposed Population[3] (per reactor year)
Transportation workers	200	0.0 to 300 millirem	4 man-rem
General public			
Onlookers	1,100	0.003 to 1.3 millirem)	3 man-rem
Along Route	600,000	0.0001 to 0.06 millirem)	

Accidents in Transport

	Environmental Risk
Radiological effects	Small[4]
Common (nonradiological) causes	1 fatal injury in 100 reactor years; 1 non-fatal injury in 10 reactor years; $475 property damage per reactor year.

[1] Data supporting this table are given in the Commission's "Environmental Survey of Transportation of Radioactive Materials To and From Nuclear Power Plants," WASH-1238, December 1972.

[2] The Federal Radiation Council has recommended that the radiation doses from all sources of radiation other than natural background and medical exposures should be limited to 5,000 millirem per year for individuals as a result of occupational exposure and should be limited to 500 millirem per year for individuals in the general population. The dose to individuals due to average natural background radiation is about 130 millirem per year.

[3] Man-rem is an expression for the summation of whole body doses to individuals in a group. Thus, if each member of a population group of 1,000 people were to receive a dose of 0.001 rem (1 millirem), or if 2 people were to receive a dose of 0.5 rem (500 millirem) each, the total of man-rem dose in each case would be 1 man-rem.

[4] Although the environmental risk of radiological effects stemming from transportation accidents is currently incapable of being numerically quantified, the risk remains small regardless of whether it is being applied to a single reactor or a multi-reactor site.

TABLE S-5

NUMBER OF SHIPMENTS AND SHIPPING DISTANCES
FOR FUEL AND WASTE FOR NUCLEAR POWER REACTORS

	Method of Shipment	Number of Shipments Per Year Per Reactor			"Typical" Number of Shipments in WASH-1238	Shipping Distance, miles			"Typical" Distance in WASH-1238, miles
		Min	Max	Average		Min	Max	Average	
Unirradiated Fuel	Truck[1/]	3	7	4.9	6*	10	3000	922	1000
Irradiated Fuel	Truck[2/]	10	100	48.8	60*	150	2000	739	1000
	Rail[3/]	4	13	8.35	10*	300	3100	1102	1000
Packaged Waste	Truck[1/]	1	250	34.6	46	10	1000	510	500

1/ For 82 reactors

2/ For 53 reactors

3/ For 31 reactors

* plus an equal number of shipments for return of empty packagings.

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