whole family. A related factor affecting the percent of vehicles evacuated is the length of warning time given before the evacuation advisory is issued. If the warning is long enough, individuals could return home from work, school, and elsewhere and the family could then evacuate in one vehicle. On the other hand, with more warning time, families may try to take with them as many of their belongings as possible and use extra vehicles to do so.

Other factors include the perceived nature of the disaster and the expected duration of the evacuation. If people feel their belongings, including their vehicles, are likely to be damaged, and if they expect that more than a few days will pass before they can return to their homes, then they may try to take more of their possessions with them, again using extra vehicles.

According to a source at the Federal Emergency Management Agency (FEMA) about 20 percent of the population evacuates on its own when danger is perceived. About 60 percent evacuates when instructed to do so. It is common, even when danger is imminent and evacuation orders have been given, for about 20 percent of the population to remain unless compelled to evacuate. For the purposes of this work, however, it is assumed that all of the resident population evacuates.

In general, sources were unable to supply specific information about the percent of vehicles that would be evacuated. The most useful information was supplied by a representative of the Federal Emergency Management Agency in Bothell, Washington. This source uses as an example the area around the Trojan nuclear power plant in Oregon. The population in the vicinity of the reactor is about 67,000. There are approximately 26,800 households with an average of 2.5 people per household. Based on an average of 2.2 vehicles per household in this largely rural area, there are about 58,960 vehicles.

In the event of an evacuation due to a radiological release from the reactor, this source expects vehicle occupancy for the evacuation to range from a low of 1.5 up to 3.0 people per vehicle. At 1.5 people per vehicle, there are (2.5 vehicles/household)/(1.5 people/vehicle) = 1.667 vehicles per household used in the evacuation. This is roughly 76 percent of the vehicles in the area.

At 3.0 people per vehicle, only 0.833 vehicles per household, or about 38 percent of the vehicles, are used. At the lower occupancy rate about 24 percent of the vehicles would remain. At the higher occupancy rate 62 percent of the vehicles would remain.

Repeating the same calculations but using the national average of 1.57 vehicles per household with the same assumption of 1.5 and 3.0 people per vehicle, the percent of vehicles not evacuated ranges from about 50 to about 100 percent. On this basis it is estimated that approximately 70 percent of noncommercial automobiles would be evacuated, leaving 30 percent.

To compute the number of noncommercial autos that would be on commercial

and industrial property, the following data were developed from the Delaware Valley Regional Planning Commission 1980 Land Use File. The figures are in acres.

Residential	371,925
Manufacturing	33,668
Transportation	141,012
Communications & Utilities	10,166
Commercial	36,181
Community Svcs	62,354
Recreation	64,479
Resource Pro.	746,410
Mining	7,203
Undeveloped	985,394

Assume 1) Manufacturing and Communications and Utilities are in the Industrial land use category; 2) Trade and Services are in the Commercial land use category; and 3) vehicles on streets, roads and parking surfaces (the transportation category) are distributed according to whether they are in residential, commercial or industrial areas.

Number of Households in Region in 1980 is 1,868,164

We have:

households per acre = 1,868,164/371,925 = 5.023

ratio of residential acreage to commercial acreage =
371,925/(36,181+62,354) = 3.77

ratio of residential acreage to industrial acreage =
371,925/(33,668+10,166) = 8.48

If

d(j) is the distribution of cars in land use category j

A(j) is the acreage in land use category j

and

CPH is the number of cars per household,

then

the number of cars on commercial property, C(c), and industrial property, C(i), is

$$C(c) = A(c) \cdot 5.023 \cdot 3.77 \cdot d(c) \cdot CPH$$
$$C(i) = A(i) \cdot 5.023 \cdot 8.48 \cdot d(i) \cdot CPH$$

For values of d(c) and d(i), consider the distribution of cars between residential, commercial and industrial property over a 24-hour period on a weekday and on a weekend shown in Table A.6.4.1.

The time and day of the accident are used to distribute the cars among residential, commercial and industrial properties. However, if there is an evacuation, the time and day of the accident are assumed not to be important, since it seems likely that noncommercial automobiles located within commercial and industrial areas would first be driven to residential areas, where families would reunite prior to evacuation. In other words, nearly all noncommercially owned cars would first vacate from commercial and industrial areas.

On the other hand, if the accident occurs and there is insufficient warning and/or no evacuation, then the geographical distribution of noncommercial cars will depend upon the time of day and whether or not the accident occurs on a weekend. The distribution given in Table A.6.4.1 can be used to obtain values for d(c) and d(i). It is noted that the values in this table are based on judgment rather than on empirical evidence.

Table A.6.4.1. Distribution of Cars by Land Use, by Accident Time

Weekday

Hour	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200
Resid	92	93	94	95	94	92	84	50	30	30	30	35
Comm	6	5	4	3	3	4	4	35	55	55	55	41
Indus	2	2	2	2	3	4	12	15	15	15	15	14

Hour	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400
Resid	30	30	35	45	60	70	77	79	80	80	87	90
Comm	55	55	51	43	32	25	18	16	15	15	9	8
Indus	15	15	14	12	8	5	5	5	5	5	4	2

Weekend

Hour	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200
Resid	89	90	91	92	91	90	91	86	81	71	51	51
Comm	9	8	7	6	6	6	5	10	15	25	45	45
Indus	2	2	2	2	3	4	4	4	4	4	4	4

Hour	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400
Resid	46	46	51	61	66	76	81	86	86	87	89	89
Comm	50	50	45	35	30	20	15	10	10	10	9	9
Indus	4	4	4	4	4	4	4	4	4	3	2	2

APPENDIX B

This appendix discusses the decontamination efficiency figures used in this report. It is important to understand how these numbers were derived in order to properly interpret them. In general, existing decontamination efficiency data of the type relevant for this report is both scarce and weak. This reflects a different concern in previous decontamination studies. In particular, works such as Decontamination of Nuclear Reactors, edited by J. A. Ayres, Technology, Safety and Costs of Decommissioning Reference Non-Fuel-Cycle Nuclear Facilitites, prepared by E. S. Murphy, as well as others are directed principally at intensive, highly effective decontamination measures applied to a relatively restricted area. In contrast, the hypothesized accident with which the present report deals is of a much larger scale. The scope of such an event precludes the use of decontamination methods which, though extremely effective, are too costly and too slow to be practical. Moreover, it would be necessary to employ techniques which could be performed in large part by personnel lacking in special training and skills for radiological decontamination. Thus, the focus of this study is on operations that are relatively inexpensive, that can be applied to large surface areas, and that require little or no special equipment or skills.

The hazard of radiation occurs through two distinct pathways. Inhalation and ingestion comprise one pathway, and external exposure is the other. Some methods, therefore, will be more effective with respect to one pathway than the other. For example, a fixative may virtually eliminate resuspension and thereby prevent the inhalation of radiation. However, a fixative would not normally have any effect on the risk from external exposure. For this reason, each method has two efficiencies, one for each exposure pathway.

The radionuclide composition of the contamination can affect the relative hazards from the two pathways. For example, a weapons accident could release plutonium into the environment, posing a health risk primarily through the inhalation pathway. On the other hand, the radiological products released during a nuclear reactor accident would pose a risk primarily from external exposure.

In general, decontamination methods will be more effective against inhalation than external exposure. For instance, methods that involve fixing the contaminants are effective in reducing external exposure only to the extent that they also provide shielding.

Methods that remove particles will reduce risk from both pathways. However, the particles that remain after decontamination treatment will tend to be more tenacious and thus less likely to become resuspended. Therefore, methods that remove radioactive particles, while effective for both pathways, will generally be more effective against inhalation and ingestion.

Most of the sources reviewed for this report estimated decontamination efficiencies in terms of the inhalation pathway. Also, during the efficiency experiments, the effect of rain between the original deposition and the decontamination activity was not evaluated. For methods in which the particles are removed, rain will generally reduce the efficiency. On the other hand, since rain will tend to drive contaminants into the surfaces, it will have the effect of reducing resuspension and lowering the inhalation hazard.

While several published sources were reviewed, there was sufficient novelty in our perspective that only a limited number provided substantial assistance. Among these, the often-cited report, "Operation Plumbob; Monitoring and Decontamination Techniques for Plutonium Fallout on Large-Area Surfaces" by Dick and Baker (1961), the Nuclear Weapon Accident Response Procedures Manual (NARP), prepared by the Department of Defense (1983), a paper "Feasibility and Alternate Procedures for Decontamination and Post-Treatment Management of Pu Contaminated Areas in Nevada" by A. Wallace and E. M. Romney (1975), and "Decontamination After Widespread Release to the Environment" by J. R. Horan and L. J. Cunningham (printed in Decontamination of Nuclear Reactors, J. A. Ayres (1970)) were particularly helpful. They provided decontamination effectiveness data for operations such as vacuuming, sandblasting, high pressure hosing, and others when used on different type of surfaces. This information is presented in Table B.1.

Additional data come from a Product Information Network report on street sweepers. This report lists removal rates for particles of various sizes and surface loadings. For example, for particle sizes less than 45 microns with an average surface loading of 11 pounds per curb mile, the average removal with a vacuumized street sweeper was 55 percent. The minimum removal was 18 percent and the maximum 77 percent.

Also, some useful information was found in the Nuclear Regulatory Commission document Reactor Safety Study: An Assessment of Accident Risks in U.S. Commercial Nuclear Power Plants, Appendix VI, Calculation of Reactor Accident Consequences, Appendix K (1975). Table VI K-2 presents decontamination efficiencies of seven operations on different surfaces. That table is reproduced here. There are also a number of graphs in this report showing a negative relationship between particle size and decontamination efficiency. These are reproduced here as well. Care should be taken against reading too much into these graphs. For example, in Figure VI K-3, two lines are drawn on the basis of two data points for each. The information represented by a pair of data points was extrapolated to apply to particles of less than 60 microns in size, but the data are not really strong enough to reliably support this relationship.

Review of these data and data from other works such as "Radiological Dose Assessment and the Application and Effectiveness of Protective Actions for Major Property Types Contaminated by a Low-Level Radionuclide Deposition" (Julin et al. 1978) reveal that there are only a very few studies on the effectiveness of decontamination operations. These studies, done in the 1960s are cited repeatedly, and while they are based on actual field studies,

TABLE B.1. Summary and Comparison of Decontamination Data, Percent Decontamination of Various Surfaces by Method

Surface & Operation	Source: NARP	Source: Wallace & Romney	Source: Horan & Cunningham
Highway asphalt			
Vacuum	52	37-72	75-98
Sandblast	95	92-99	
Steam cleaning	33	22-44	
Water	93		96-98
High pressure water scrub	95	94-96	
High pressure water w/detergent	98	98-99	
Detergent & scrub	98	96-99	
High pressure water		92-99	93-98
Wood float concrete			
Vacuum	56	56	
Sandblasting	98	98-100	
Steam cleaning	67	65-85	
Water	96		
High pressure water scrub	94	92	
High pressure water w/detergent	98	98-100	
Detergent & scrub	98	97-98	
High pressure water		97-98	
Unpaved land areas			
Plowing	98	97.9	
Oiling & scraping	98	95.6	
0.3" water leach & scraping	93	92.7	
0.3" water-FeCl3 leaching	84	91.6	
Disking	76	89.2	
1.0" water leaching	85	87.4	
Scraping	95	86.0	98
Oiling	89	69.4	
0.3" water leaching		55.0	
0.3" water-Alconox		18.7	
Roofs: Asbestos shingles			
Vacuum	61	61	
Sandblast	100	100	
Steam cleaning	63	63	
Water	99		
High pressure water w/scrub	98	98	
High pressure water w/detergent	96	96	
Detergent & scrub	99	99	
High pressure water		99	90-97 ("composition" shingle)

TABLE B.1. (Continued)

Surface & Operation	Source: NARP	Wallace & Romney	Horan & Cunningham
Roofs: Tar paper			
Vacuum	55	55	
Sandblast	99	99	
Steam cleaning	52	52	
Water	98		
High pressure water w/scrub	95	95	
High pressure water w/detergent	95	95	
Detergent & scrub	96	96	
High pressure		98	87.5-99 (tar & gravel)

the quantitative results have not been confirmed in later studies. The frequently listed studies are by Dick and Baker (1961), and one by Langham (unreferenced 1968). The fact that studies of 14 to 20 years past are the prime data sources is indicative of the scarcity of information in this area.

In addition to the paucity of data sources for decontamination efficiencies, the sources that were available did not provide sufficient detailed information about the operations. For example, the amount of water used in high- and low-pressure hosing was not given. The implication of these data limitations, however, is not as great as it might seem. Since decontamination efficiencies for several methods were reported for each surface, certain judgments about the relative effectiveness of the methods can be made. Thus, it is fairly clear from the data given in Table B.1 that steam cleaning is a less effective method of decontaminating highway asphalt than high-pressure water with scrubbing. By focusing on the relative efficiency levels, efficiencies for the various operations were estimated. It should be clear from this discussion that these estimates should be interpreted more as indices of relative effectiveness rather than as highly accurate measures of the absolute effectiveness.

The efficiency issue becomes more obscured when various operations are combined. In this area information was even sparser, as most sources provided information only on a single decontamination treatment performed once. Clearly, the effect of performing one operation prior to another will be to reduce the effectiveness of the second. The actual reduction will depend on the specific nature of the two operations. Thus, vacuuming pavement before a low-pressure water wash will not greatly diminish the success of the second step. However, were the order of the operations to be reversed, the net outcome would be less effective. This is because any particles not removed by the water would tend to be driven into surface crevices by the water, making vacuum removal less effective.

TABLE VI K-2 HARD SURFACE DECONTAMINATION EFFICIENCIES IN PERCENT[a,b]

Material	Vacuum (D + 2)	High-Pressure Water (D + 3)	High-Pressure Water with Scrub (D + 12)	High-Pressure Water and Detergent (D + 4)	High-Pressure Water and Detergent with Scrub (D + 5)	Sandblasting (D + 9)	Steam Cleaning (D + 14)
Glass	98.95	98.85	97.79	100.00	99.76	100.00	97.86
Stucco	48.00	97.94	95.22	100.00	99.59	100.00	27.00
Painted wood	99.28	98.43	96.77	99.69	99.97	100.00	91.61
Unpainted wood	36.00	85.00	93.18	99.54	95.54	99.90	85.00
Aluminum	89.00	99.45	97.33	99.62	100.00	98.49	84.00
Plate Steel	93.04	97.26	94.19	100.00	93.83	99.72	91.46
Asbestos shingles	61.00	99.97	98.91	96.89	99.36	100.00	63.00
Unpainted wood shingles	61.00	97.16	90.49	95.01	57.93	99.82	71.00
Brick	29.00	99.46	99.32	99.14	99.56	99.92	97.50
Tarpaper	55.00	98.66	95.04	95.32	95.83	99.51	52.00
Galvanized roofing	89.00	99.36	97.19	99.73	99.86	100.00	85.00
Highway asphalt	32.00	99.90	96.25	90.82	99.48	99.90	44.00
Highway asphalt (10 x 10 ft)	72.00	92.45	94.95	98.85	96.34	92.73	22.00
Sealed Asphalt	71.00	98.67	90.00	100.00	99.72	99.61	84.00
Sealed asphalt (10 x 10 ft)	64.00	90.00	82.00	96.31	97.54	90.42	48.00
Steel trowel concrete	74.00	98.94	--	96.91	99.53	100.00	--
Steel trowel concrete (10 x 10 ft)	--	73.00	97.34	--	98.58	98.96	27.00
Wood float concrete	--	98.00	92.03	100.00	97.47	100.00	65.00
Wood float concrete (10 x 10 ft)	56.00	97.84	--	98.09	98.28	98.78	85.00
Average of all surfaces	65.40	96.12	94.59	98.61	98.64	98.83	67.80

(a) From Dick and Baker (1961)

(b) Decontamination factor (DF) = 100/[100 - decontamination efficiency (%)]; (D + n) = number of days between contamination and decontamination.

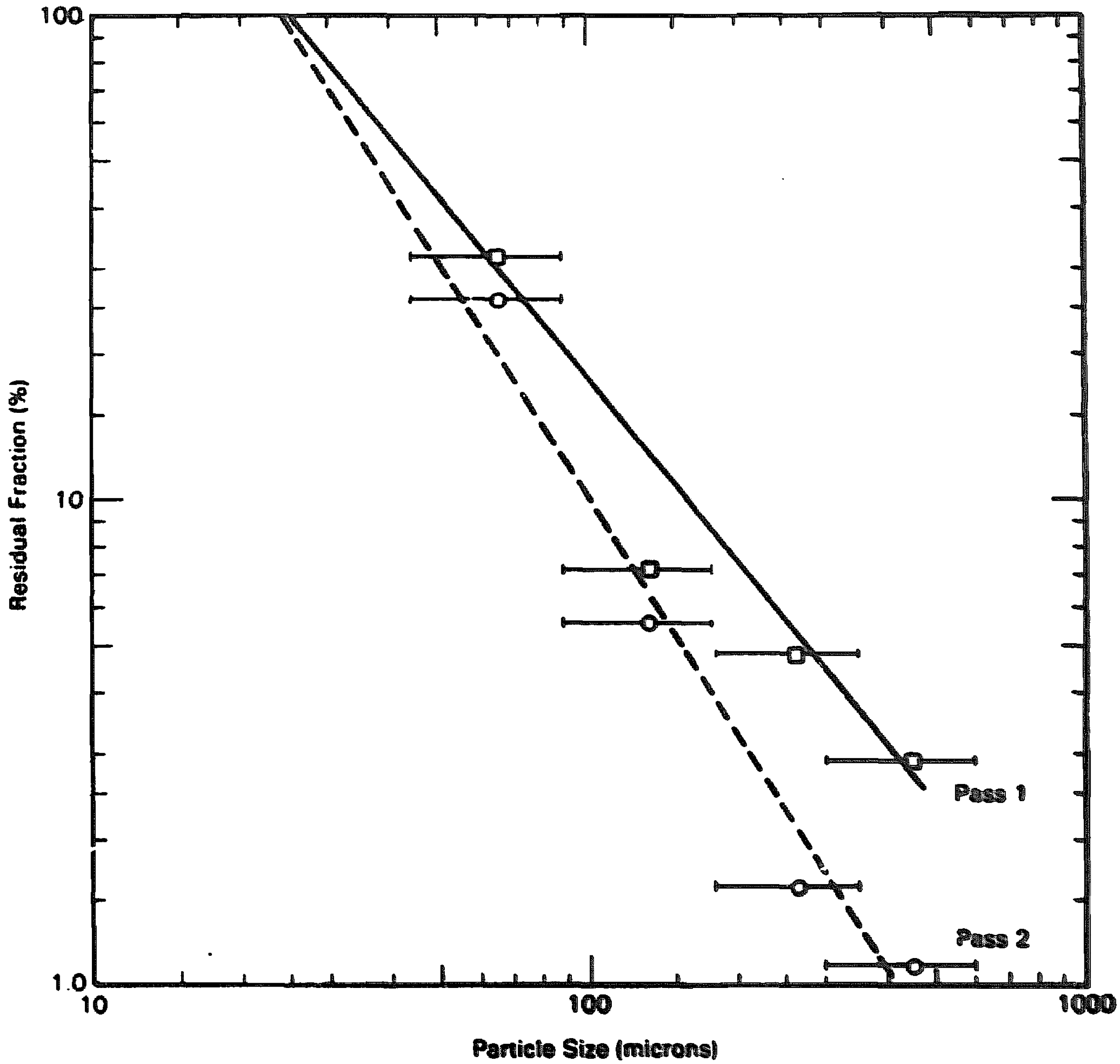


FIGURE VI K-1 Decontamination of roughly textured asphalt (or concrete) by firehosing (standard nozzle). Initial mass loading = 25 g/ft^2. [DF = 100/residual fraction (%).]

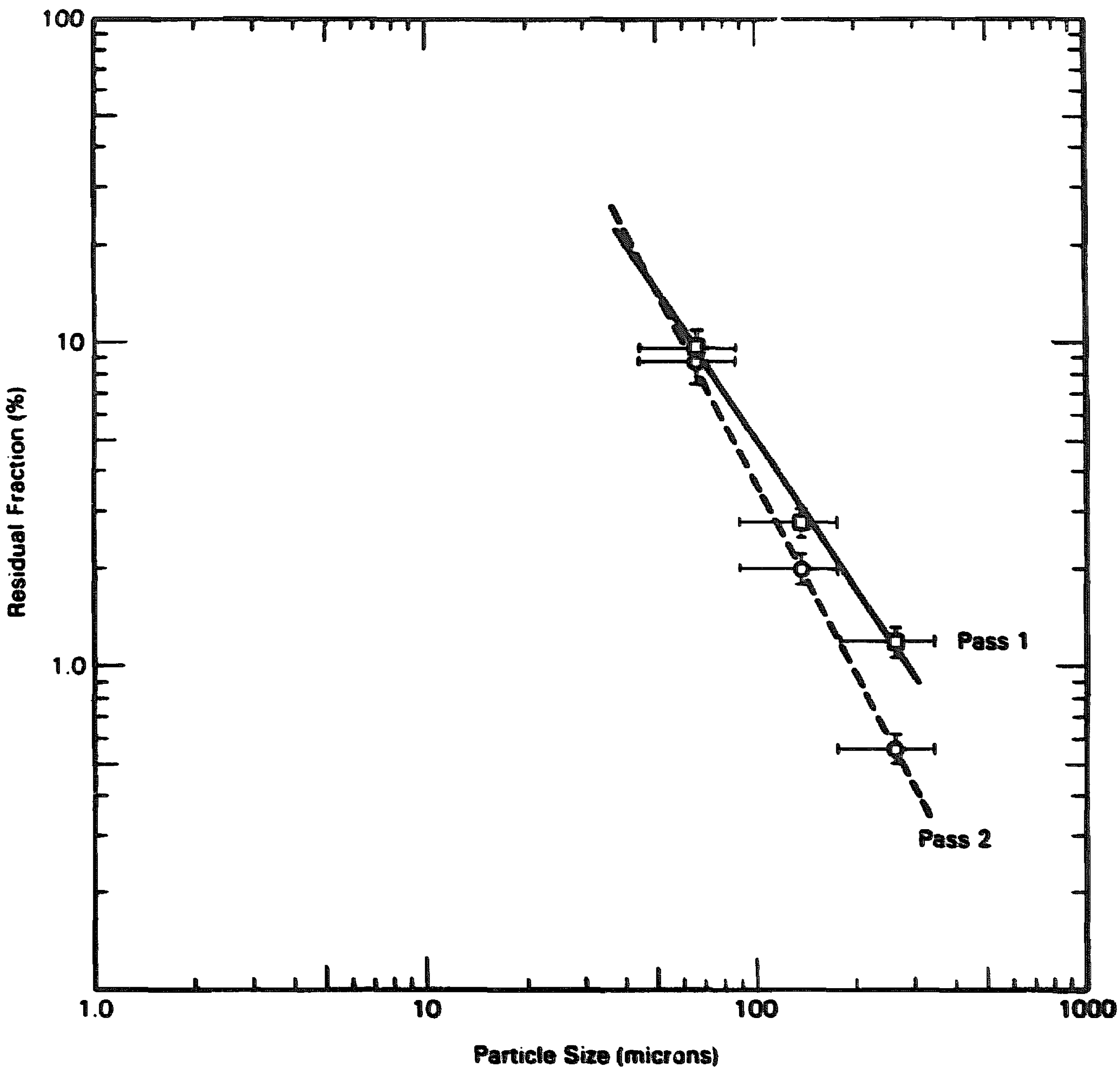


FIGURE VI K-2 Decontamination of smoothly textured asphalt (or concrete) by firehosing (standard nozzle). Initial mass loading = 25 g/ft^2. [DF = 100/residual fraction (%).]

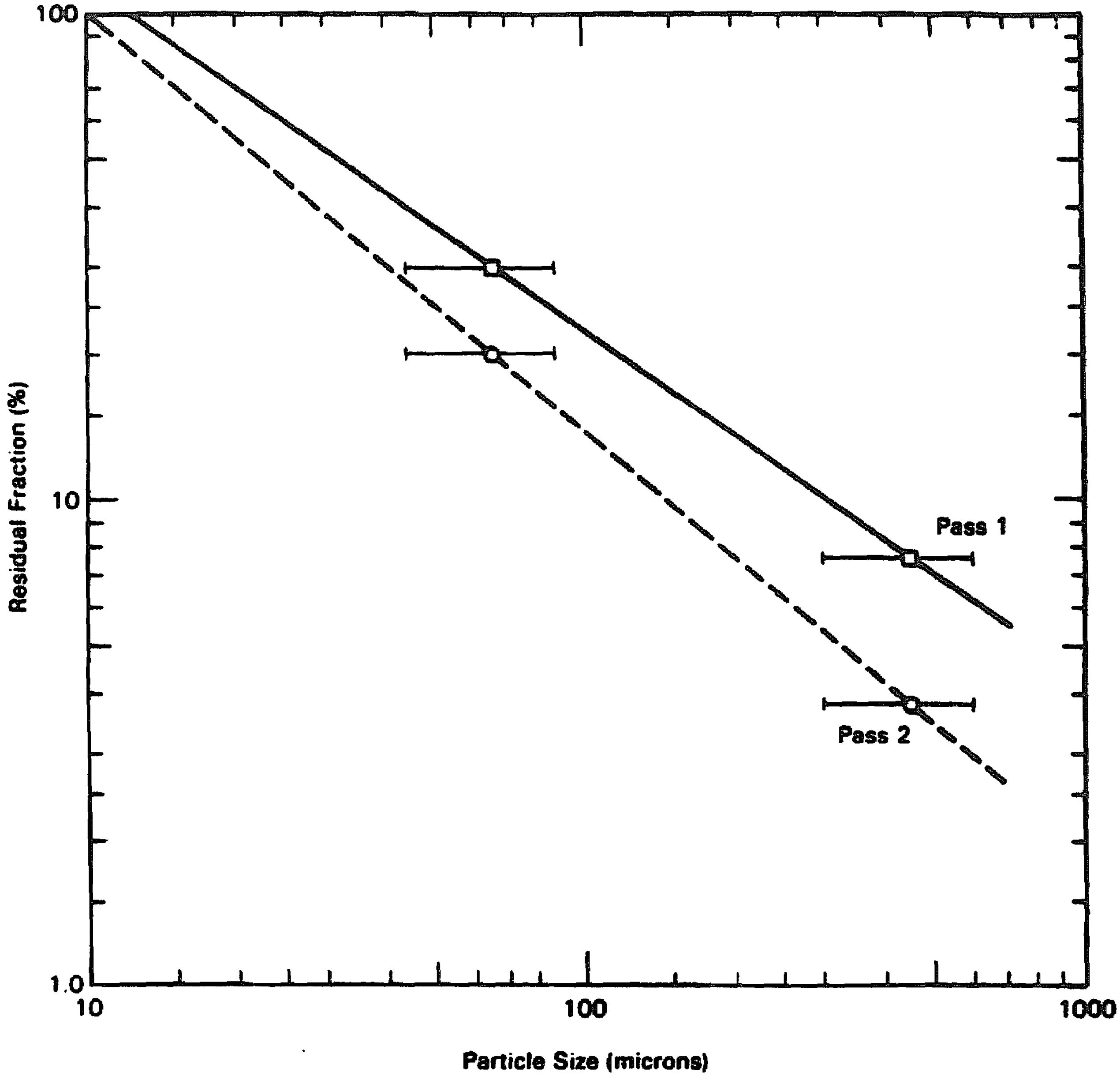


FIGURE VI K-3 Decontamination of roughly textured asphalt (or concrete) by firehosing (standard nozzle). Initial mass loading = 5 g/ft^2. [DF = 100/residual fraction (%).]

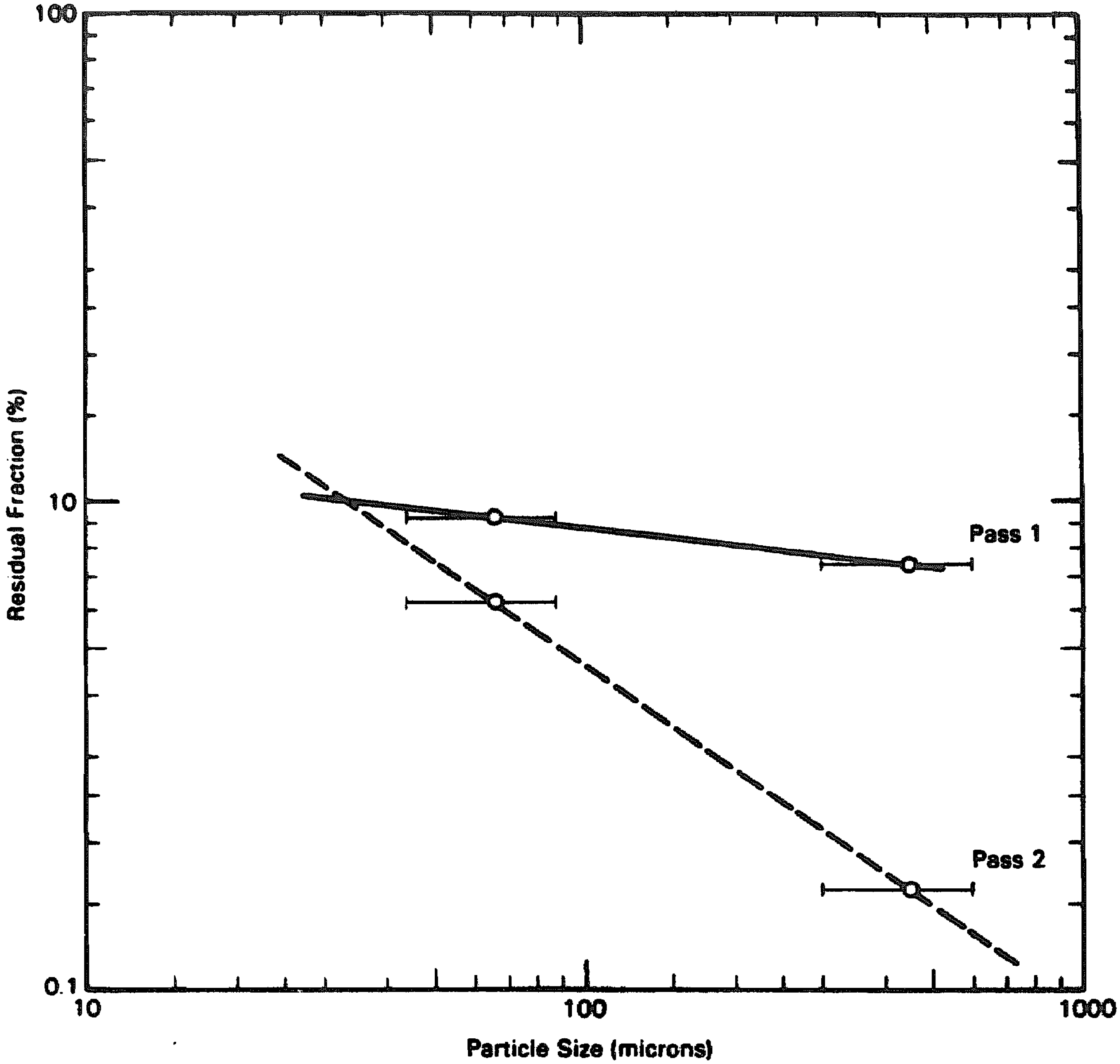


FIGURE VI K-4 Decontamination of smoothly textured asphalt (or concrete) by firehosing (standard nozzle). Initial mass loading = 5 g/ft^2. [DF = 100/residual fraction (%).]

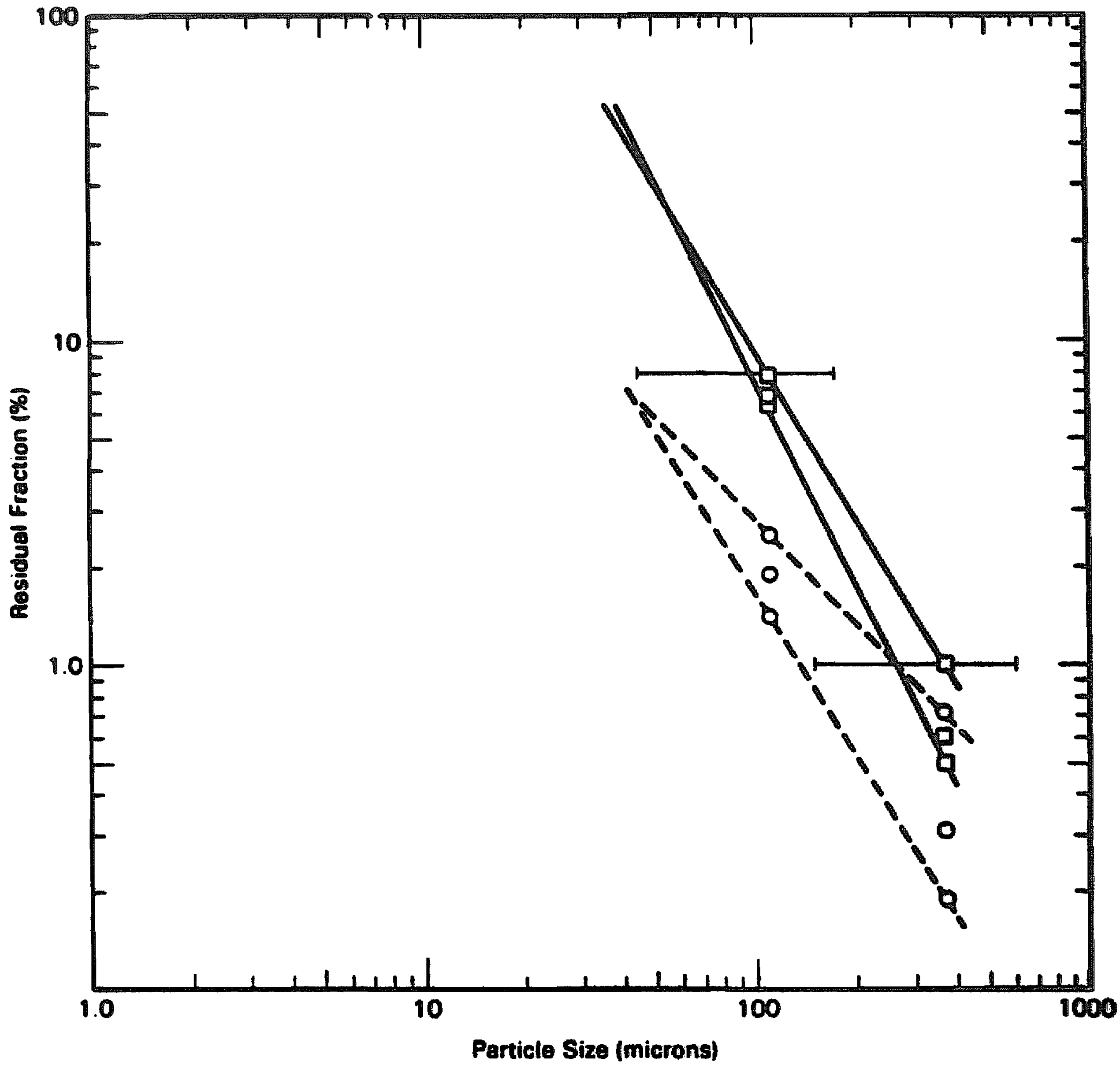


FIGURE VI E-6 Decontamination of roughly textured asphalt (or concrete) by mechanized flushing (three consecutive passes). Initial mass loading = 5 g/ft^2 (□) and 25 g/ft^2 (○). [DF = 100/ residual fraction (%).]

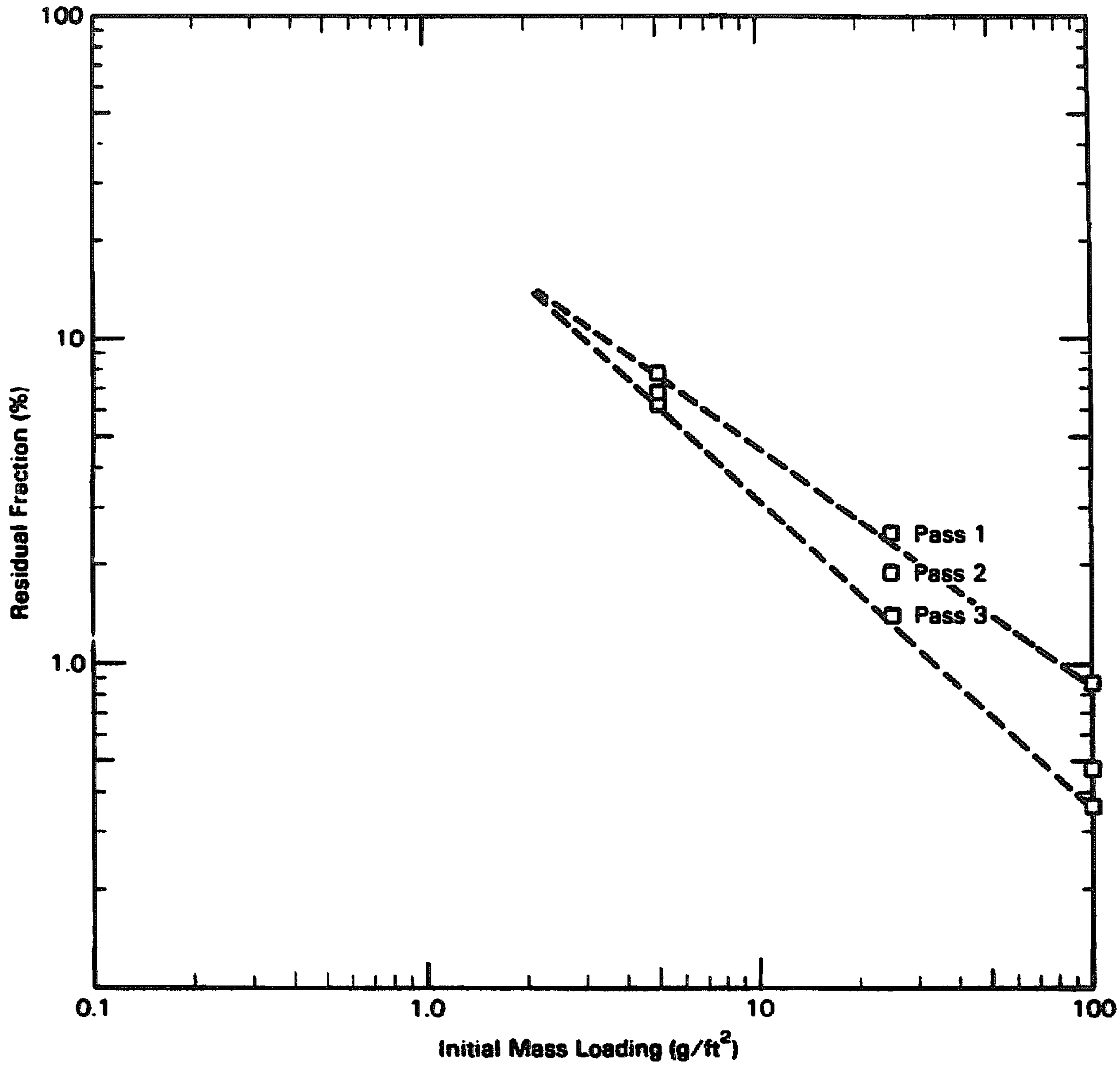


FIGURE VI K-6 Decontamination of roughly textured asphalt (or concrete) by mechanized flushing. Particle size = 44 to 100 microns. [DF = 100/residual fraction (%).]

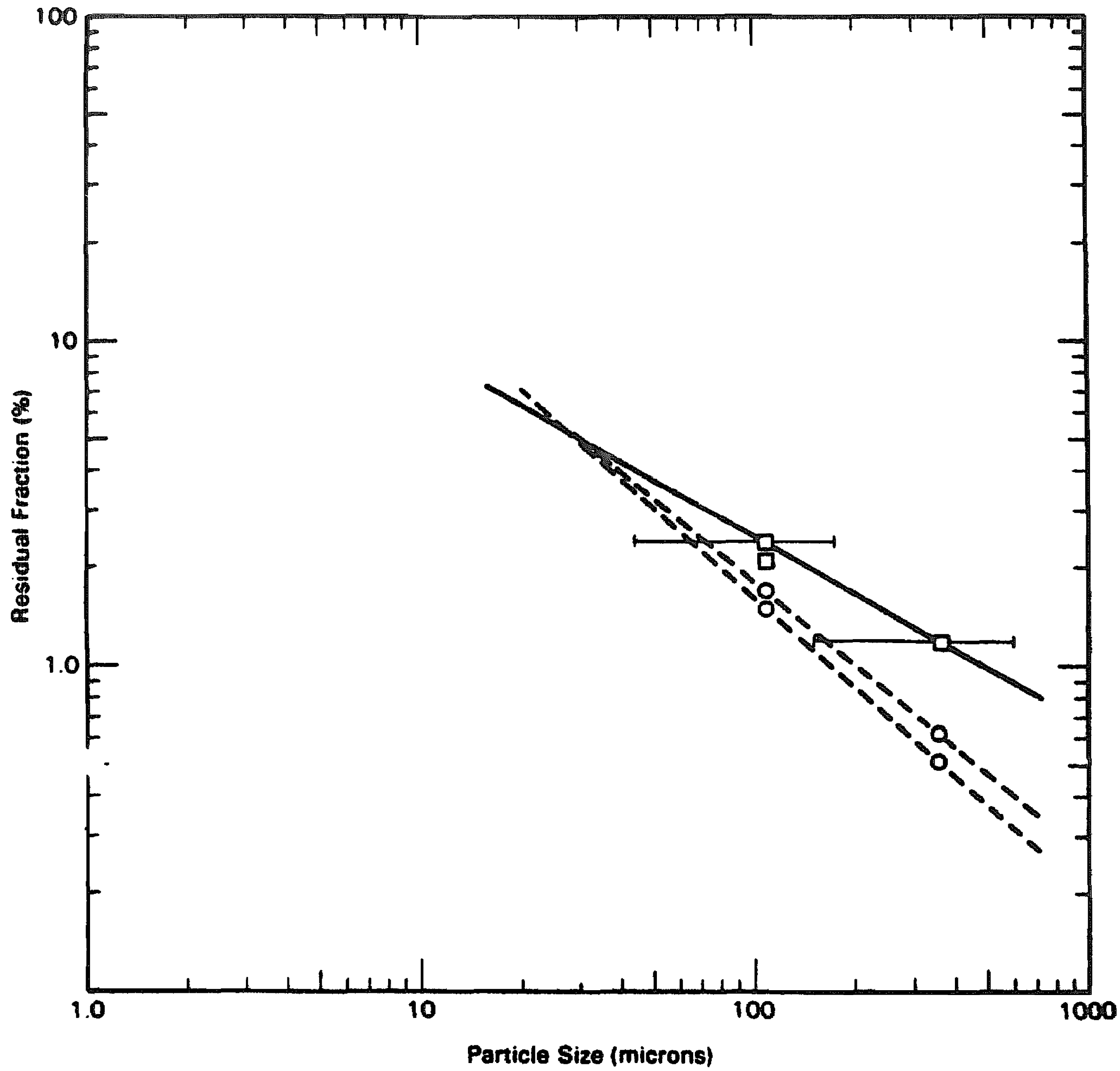


FIGURE VI K-7 Decontamination of smoothly textured asphalt (or concrete) by mechanized flushing (two consecutive passes). Initial mass loading = 5 g/ft² (□) and 12 g/ft² (○). [DF = 100/ residual fraction (%).]

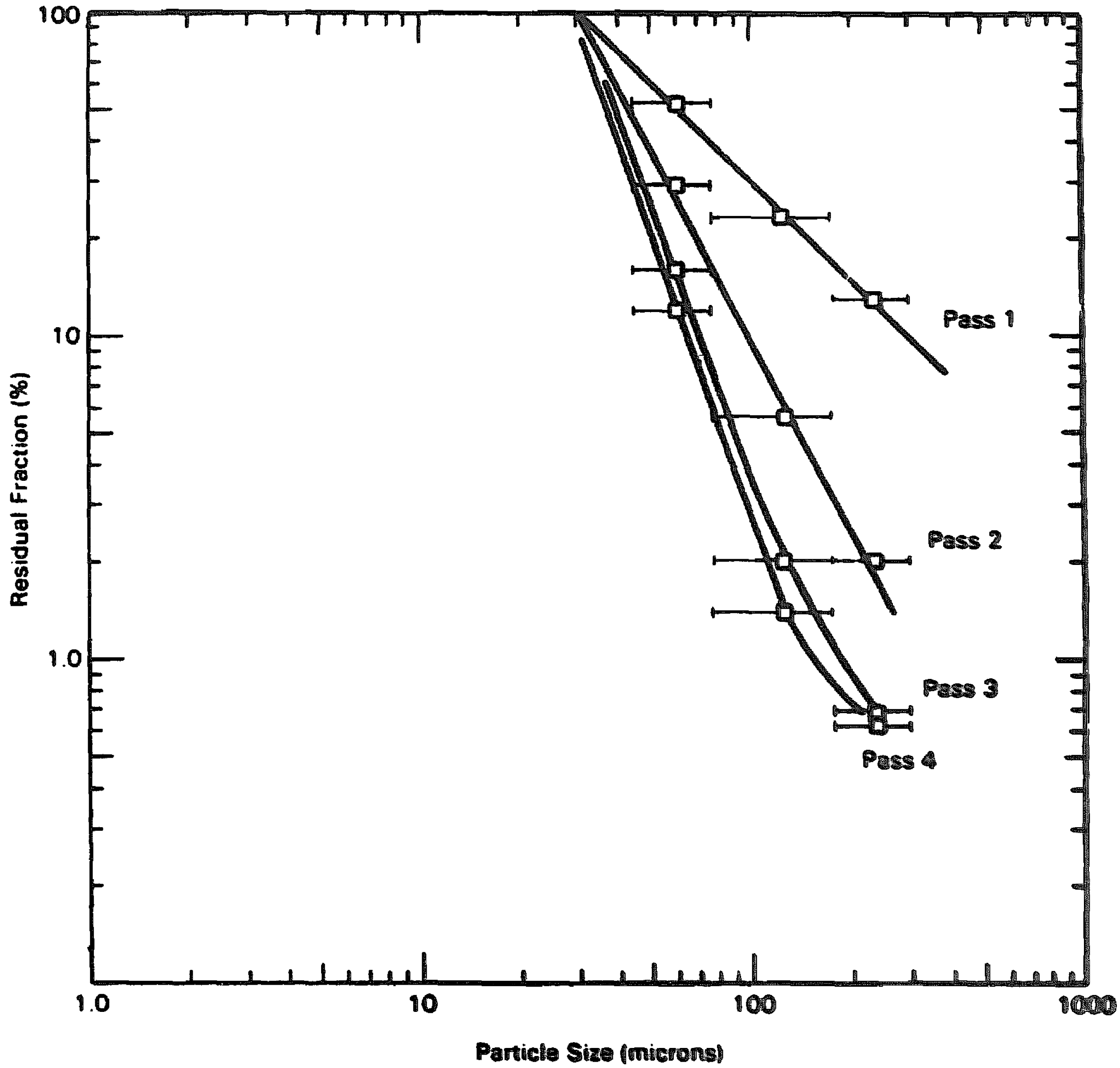


FIGURE VI K-8 Decontamination of roughly text. -d asphalt (or concrete) by "vacuumized" sweeper. Initial mass loading = 25 g/ft^2. [DF = 100/residual fraction (%).]

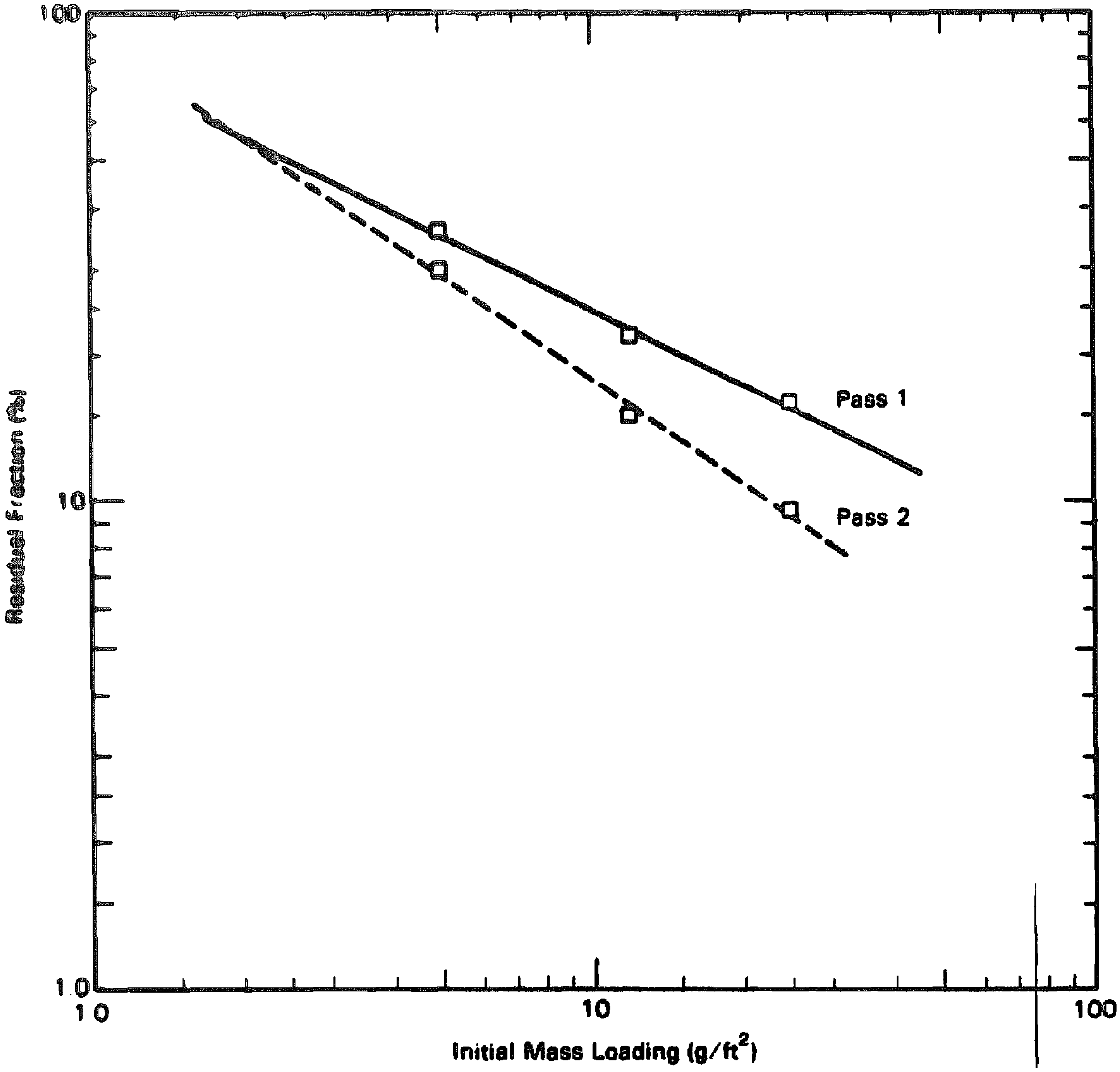
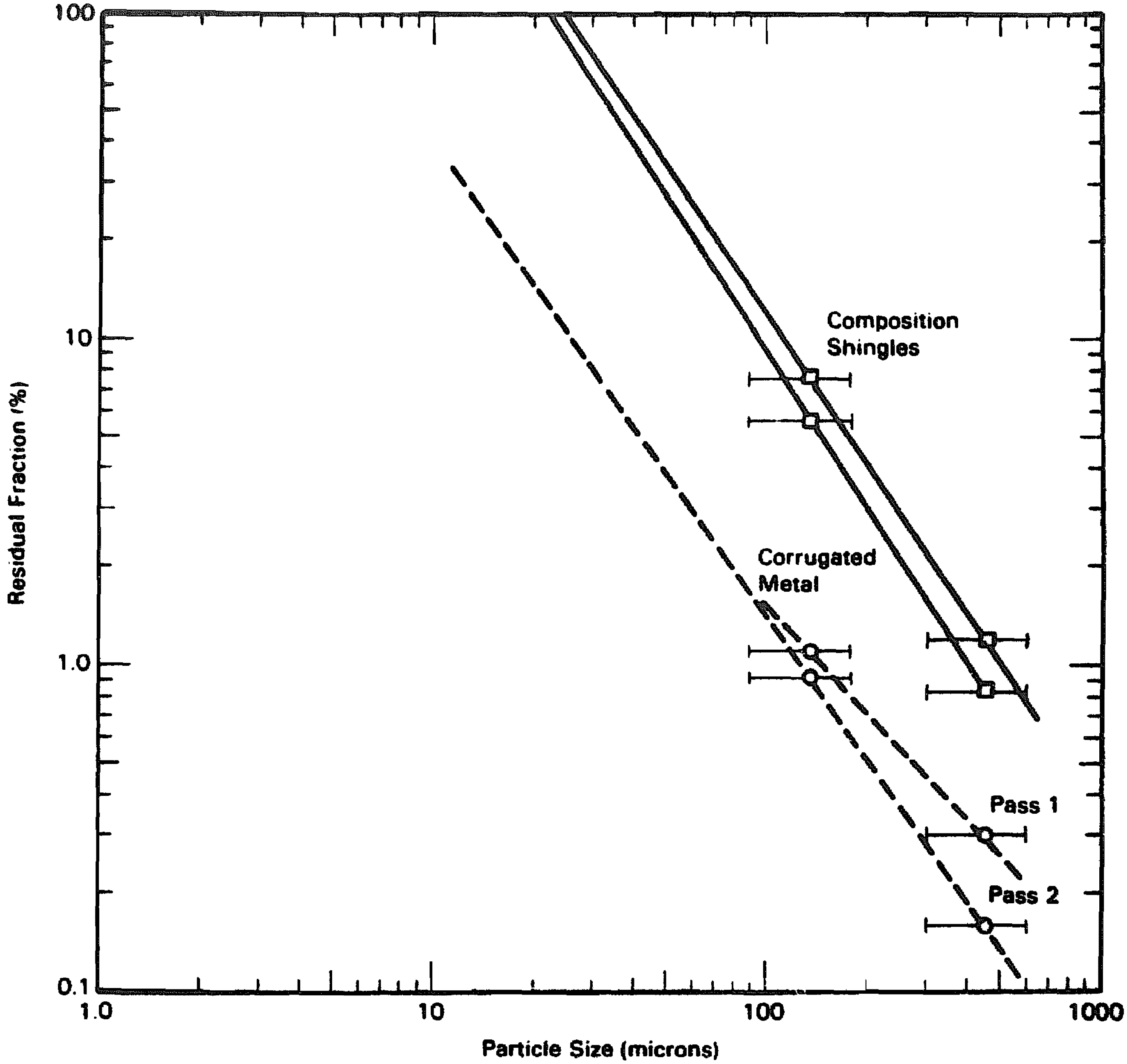


FIGURE VI K-8 Decontamination of roughly textured asphalt (or concrete) by "vacuumized" sweeper. Particle size = 44 to 74 microns. [DF = 100/residual fraction (%).]



[illegible]URE VI K-10 Decontamination of sloped roofs by firehosing. Ini[illegible] [illegible]se loading = 25 g/ft^2. [DF = 100/residual fraction

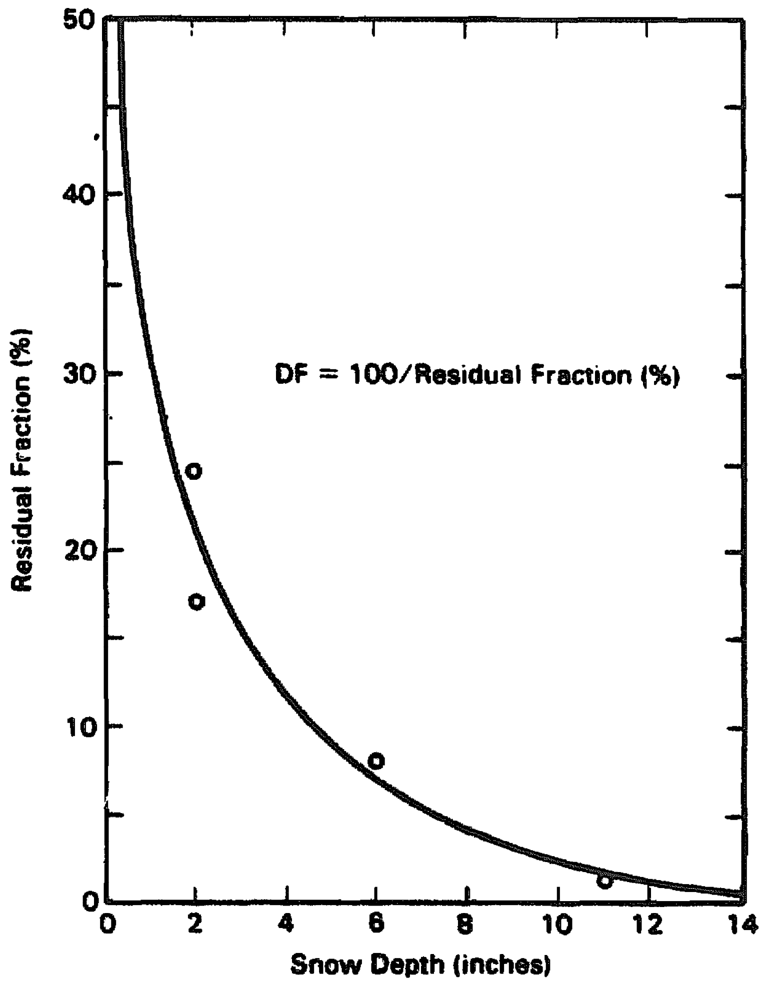


FIGURE VI K-11 Influence of snow depth on the decontamination effectiveness of the rotary snow blower. From Owen et al. (1967).

For convenience of reference, we have assigned numbers to each surface. The surfaces and their corresponding numbers are shown in Table B.2. Table B.3 shows for each surface the various decontamination methods that can be used on that surface and the estimated net inhalation and external exposure efficiencies for that method. The methods are described by a mnemonic code that defines the constituent operations of the method. Recall that a method is defined as consisting of one or more operations. The key to these mnemonic codes is given in Table B.4, which is reproduced from Table 1.1

TABLE B.2. Surfaces and Their Corresponding Numbers

Number	Surface
01	Agricultural fields
02	Orchards
03	Vacant land
04	Wooded land
05	Asphalt streets, roads and parking
06	Other asphalt surfaces
07	Concrete streets, roads and parking
08	Other concrete surfaces
09	Lawns
10	Reservoirs
11	Roofs
12	Exterior wood walls
13	Exterior brick walls
14	Exterior concrete walls
15	Exterior glass
16	Interior painted wood, plaster walls
17	Interior concrete walls
18	Interior glass
19	Carpeted floors
20	Linoleum floors
21	Wood floors
22	Concrete floors
23	Hard-surface furnishings
24	Soft-surface furnishings
25	Electronic equipment
26	Paper products
27	Auto exteriors
28	Auto interiors
29	Automobile tires
30	Automobile engine and drive train

TABLE B.3. Removal Efficiencies by Method (percent removed)

Method Code	Pathway Inhalation	Pathway External	Method Code	Pathway Inhalation	Pathway External
01 Agricultural Fields					
W	55.0000	25.0000	WG	84.7000	55.0000
WW	79.8000	43.7500	TG	89.5000	42.0000
WWW	90.9000	57.8000	LG	97.6000	70.0000
WWWW	95.9000	68.4000	XG	94.4000	91.6000
T	65.0000	.0000	AG	97.0000	91.0000
L	92.0000	35.0000	YG	99.4000	97.0000
N	30.0000	30.0000	NG	72.0000	58.0000
X	86.0000	86.0000	GG	88.0000	64.0000
A	90.0000	50.0000	GGG	96.4000	78.4000
Y	98.0000	60.0000	WWG	93.9000	66.3000
TN	40.0000	40.0000	TX	96.0000	96.0000
TNX	96.0000	96.0000	Tx	99.4400	99.4400
TNx	99.4400	99.4400	TxX	99.9200	99.9200
TNxX	99.9200	99.9200	TA	92.0000	55.0000
G	60.0000	40.0000	TY	98.5000	65.0000
02 Orchards					
W	33.0000	15.0000	TRX	93.6000	93.6000
WW	47.9000	26.3000	TO	72.5000	18.0000
WWW	54.5000	34.7000	TOA	93.3000	45.0000
WWWW	57.5000	41.0000	TRXG	95.0000	94.5600
X	48.0000	48.0000	g	30.0000	24.0000
A	51.0000	27.0000	Tg	33.0000	25.2000
TDX	80.0000	68.0000	Wg	47.9000	33.0000
TDx	90.3200	78.0000	TRXa	95.7000	95.1000
TX	75.0000	51.0000	T	50.0000	.0000
TDXW	77.3000	71.0000	TOA	93.3000	45.0000
03 Vacant Land					
N	30.0000	30.0000	WG	82.0000	55.0000
TN	40.0000	40.0000	NG	72.0000	58.0000
TNX	96.0000	96.0000	TNG	76.0000	64.0000
W	55.0000	25.0000	WWG	91.9000	66.3000
WW	79.8000	43.8000	WWWG	96.4000	74.7000
WWW	90.9000	57.8000	TAG	96.8000	73.0000
WWWW	95.9600	68.4000	TYG	99.4000	79.0000
TA	92.0000	55.0000	TNxG	99.7760	99.6640
TY	98.5000	65.0000	GG	84.0000	64.0000
TNx	99.4400	99.4400	T	65.0000	.0000
TNxX	99.9200	99.9200	A	98.0000	95.0000
G	60.0000	40.0000	TNxx	99.9890	99.9890
TG	86.0000	42.0000			

TABLE B.3. (Continued)

Method Code	Pathway: Inhalation	Pathway: External
04 Wooded Land		
TD	51.0000	.0000
TN	72.5000	42.5000
TNX	97.0000	95.0000
TNx	99.8600	99.7500
Th	70.0000	45.0000
TDh	87.6000	76.5000
TNG	89.0000	77.0000
ThG	73.0000	48.0000
T	50.0000	.0000
TDhG	89.6000	81.6000
TNXG	98.8500	98.0000
TNxG	99.9400	99.9000
TNXx	99.9930	99.9875
05 Asphalt Streets, Roads and Parking		
V	50.0000	45.0000
v	67.5000	61.5000
W	95.0000	85.0000
VW	95.5000	86.2500
VF	97.5000	91.7500
vF	98.0500	91.9150
vW	95.7750	86.5250
VR	99.5000	99.4500
vR	99.6750	99.6150
vFR	99.9805	99.9192
VK	99.2500	98.9000
vK	99.5125	99.2300
vFK	99.9708	99.8383
C	97.5000	93.0000
VP	99.0000	49.4000
vP	99.3500	64.5800
VG	99.2500	71.4000
vG	99.5125	79.9800
VC	98.0000	96.1500
T	97.7500	2.0000
vC	98.3750	93.4550
F	97.0000	90.0000
vCF	99.8375	98.3600
06 Other Asphalt Surfaces		
V	50.0000	45.0000
v	67.5000	6'.5000
W	95.0000	85.0000
VW	95.5000	86.2500
VF	97.5000	91.7500
vF	98.0500	91.9150
vW	95.7750	86.5250
VR	99.5000	99.4500
vR	99.6750	99.6150
vFR	99.9805	99.9192
VK	99.2500	98.9000
vK	99.5125	99.2300
vFK	99.9708	99.8383
C	97.5000	93.0000
VP	99.0000	49.4000
vP	99.3500	64.5800
VC	98.0000	96.1500
T	97.7500	2.0000
vC	98.3750	93.4550
F	97.0000	90.0000
vCF	99.8375	98.3600

TABLE B.3. (Continued)

Method Code	Pathway Inhalation	Pathway External	Method Code	Pathway Inhalation	Pathway External
07 Concrete Streets, Roads and Parking					
V	50.0000	45.0000	vFK	99.9708	99.8383
v	67.5000	61.5000	C	97.5000	93.0000
W	95.0000	85.0000	VP	99.0000	53.8000
VW	95.5000	86.2500	vP	99.3500	67.6600
VF	97.5000	91.7500	VG	99.2500	71.4000
vF	98.0500	91.9150	vG	99.5125	79.9800
vW	95.7750	86.5250	VC	98.0000	96.1500
VR	99.5000	99.4500	T	97.7500	2.0000
vR	99.6750	99.6150	vC	98.3750	93.4550
vFR	99.9805	99.9192	F	97.0000	90.0000
VK	99.2500	98.9000	vCF	99.8375	98.3600
vK	99.5125	99.2300			
08 Other Concrete Surfaces					
V	50.0000	45.0000	vK	99.5125	99.2300
v	67.5000	61.5000	vFK	99.9708	99.8383
W	95.0000	85.0000	C	97.5000	93.0000
VW	95.5000	86.2500	VP	99.0000	49.4000
VF	97.5000	91.7500	vP	99.3500	64.5800
vF	98.0500	91.9150	VC	98.0000	96.1500
vW	95.7750	86.5250	T	97.7500	2.0000
VR	99.5000	99.4500	vC	98.3750	93.4550
vR	99.6750	99.6150	F	97.0000	90.0000
vFR	99.9805	99.9192	vCF	99.8375	98.3600
VK	99.2500	98.9000			
09 Lawns					
V	30.0000	20.0000	R	98.0000	98.0000
W	85.0000	75.0000	L	85.0000	80.0000
WW	91.0000	84.0000	TRW	99.9000	99.7000
WWW	93.0000	86.8800	TRL	99.9200	99.9000
WWWW	94.0000	88.0600	TR	99.0000	99.0000
M	65.0000	65.0000			
10 Reservoirs					
r	99.9990	80.0000	rx	99.9990	96.5000
y	99.9990	5.0000	rxr	99.9990	98.4000
i	99.9990	67.0000	ii	99.9990	80.2000
rX	99.9990	95.0000	di	99.9990	92.0000

Method Code	Pathway Inhalation	Pathway External	Method Code	Pathway Inhalation	Pathway External
11 Roofs					
V	60.0000	50.0000	WW	98.0000	96.2500
S	99.0000	96.0000	R	99.9000	99.0000
H	97.0000	93.0000	VH	98.0000	95.0000
F	93.0000	90.0000	VW	92.0000	87.5000
C	85.0000	80.0000	TR	99.9400	99.8000
W	90.0000	85.0000			
12 Exterior Wood Walls					
W	90.0000	85.0000	vTR	99.9980	99.9980
J	95.0000	90.0000	VF	99.8000	98.5000
WJ	94.0000	90.2500	C	85.0000	84.0000
V	99.0000	94.0000	vF	99.8250	98.6500
VW	99.3000	94.0000	vFR	99.9400	99.6000
VJ	99.6000	95.5000	TZ	99.9990	99.9990
H	98.0000	93.0000	VC	99.6000	97.3000
VH	99.7000	97.9000	T	65.0000	.0000
TR	99.9000	99.9000	VT	99.5000	94.0000
VTR	99.9850	99.9850			
13 Exterior Brick Walls					
V	29.0000	25.0000	vFH	95.7800	92.7460
v	36.1000	30.2500	C	40.0000	35.0000
W	90.0000	85.0000	VU	96.4500	92.5000
VW	91.4800	86.5000	vU	96.4900	92.6700
VF	92.9000	88.7500	VJ	92.1900	88.3750
vF	92.9710	88.8400	vJ	92.3300	88.4900
vW	91.6930	86.7480	VO	99.2900	99.2500
VTR	99.7160	99.7000	vO	99.3000	99.2600
vTR	99.7440	99.7210	VTZ	99.7160	99.7000
vFR	99.8594	99.9280	T	65.0000	.0000
VH	91.4800	87.2500	F	92.0000	87.0000
vH	91.6900	87.4450			
14 Exterior Concrete Walls					
V	34.0000	30.0000	vH	93.8290	89.9200
v	43.9000	37.0000	vFH	97.0716	94.4434
W	92.0000	89.0000	C	45.0000	40.0000
VW	93.4000	88.8000	VU	98.0200	94.4000
VF	94.7200	90.9000	vU	97.7560	93.7000
vF	94.9510	91.1800	VJ	94.0600	90.2000
vW	93.8290	89.2900	vJ	93.8290	89.9200
VTR	99.4390	99.7200	VO	99.3400	99.3000
vTR	99.7756	99.7480	vO	99.3829	99.3070
vFR	99.8990	99.8236	VTZ	99.7360	99.7200
VH	93.4000	89.5000			

TABLE B.3. (Continued)

Method Code	Pathway Inhalation	Pathway External	Method Code	Pathway Inhalation	Pathway External
15 Exterior Glass					
V	98.0000	93.0000	C	86.2500	85.0000
v	98.8000	95.4500	VJ	99.9550	99.7550
VF	99.9000	99.4000	vJ	99.9670	99.8180
vF	99.9040	99.4540	J	99.0000	97.0000
VTR	99.9840	99.9440	W	98.0000	95.0000
vTR	99.9904	99.9636	VW	99.8400	99.3000
vFR	99.9981	99.9891	vW	99.8800	99.3175
16 Interior Wood/Plaster Walls					
V	99.0000	95.0000	VTR	99.9980	99.9900
v	99.3000	96.2500	vTR	99.9990	99.9910
J	97.0000	95.0000	vFTR	99.9991	99.9920
VJ	99.8500	99.0000	C	98.0000	97.0000
VF	99.9000	99.2500	VC	99.6000	97.8500
vF	99.8950	99.2500	T	80.0000	.0000
vJ	99.8600	99.0600			
17 Interior Concrete Walls					
V	70.0000	65.0000	vFTR	99.9580	99.9420
v	79.0000	74.1000	C	90.0000	85.0000
J	80.0000	75.0000	VH	94.0000	91.6000
VJ	92.5000	89.8500	vH	94.9600	93.0070
VF	95.5000	93.3500	VU	97.3000	95.4500
vF	95.8000	94.0400	vU	97.6900	95.6100
vJ	93.7000	91.4300	VC	91.3000	88.4500
VTR	99.7600	99.4120	vC	93.2800	90.6760
vTR	99.8320	99.7928			
18 Interior Glass					
V	98.0000	93.0000	vF	99.9040	99.4540
v	98.8000	95.4500	VTR	99.9840	99.9440
J	99.0000	97.0000	vTR	99.9904	99.9636
VJ	99.9550	99.7550	vFR	99.9981	99.9891
vJ	99.9670	99.8180	C	86.2500	85.0000
VF	99.9000	99.3000			
19 Carpeted Floors					
V	60.0000	55.0000	vTR	99.6360	99.5600
v	72.0000	66.2500	VI	72.8000	67.2000
VF	80.0000	75.2500	VJ	76.0000	70.8000
vF	83.2000	78.0625	vI	78.1600	72.0000
vFF	86.5600	81.3530	vJ	79.9000	73.0000
VTR	99.5200	99.4600			

TABLE B.3. (Continued)

Method Code	Pathway: Inhalation	Pathway: External	Method Code	Pathway: Inhalation	Pathway: External
20 Linoleum Floors					
V	99.0000	95.0000	VTR	99.9980	99.9900
v	99.3000	96.2500	vTR	99.9990	99.9910
J	97.0000	95.0000	vFTR	99.9991	99.9920
VJ	99.8500	99.0000	C	98.0000	97.0000
VF	99.9000	99.2500	VC	99.6000	97.8500
vF	99.8950	99.2500	T	80.0000	.0000
vJ	99.8600	99.0600			
21 Wood Floors					
V	90.0000	85.0000	vTR	99.9800	99.9730
v	94.5000	91.0000	vFTR	99.9940	99.9890
J	92.0000	87.0000	VTK	99.9600	99.9400
VJ	95.0000	91.0000	vTK	99.9760	99.9640
VF	97.5000	95.5000	vFTK	99.9916	99.9856
vF	98.0800	96.4000	C	80.0000	75.0000
vJ	95.9000	92.8000	VC	97.0000	94.5000
VTR	99.9700	99.9550	T	85.0000	.0000
22 Concrete Floors					
V	74.0000	69.0000	vFTK	99.9730	99.9606
v	83.1000	78.6100	C	95.0000	90.0000
J	85.0000	80.0000	VU	98.9600	97.5200
VJ	94.8000	92.5600	vU	98.9900	97.6470
VF	97.4000	95.6600	VH	96.1000	94.1100
vF	97.6300	96.1500	vH	96.7890	95.2942
vJ	95.7750	94.0108	VC	96.6200	94.4200
VTK	99.7920	99.7520	vC	97.2960	95.5080
vTK	99.8648	99.8289			
23 Hard-Surface Furnishings					
V	48.0000	42.0000	vbb	90.0000	83.5000
v	80.0000	70.0000	vvbb	91.5500	84.2500
vv	87.0000	77.5000	C	70.0000	65.0000
d	15.0000	12.0000	vC	92.0000	86.5000
dd	25.0000	20.0000	vvC	93.5000	87.6250
dddd	87.0000	77.5000	vddC	94.5000	90.4300
vdd	89.0000	82.6000	R	90.0000	90.0000
vvdd	90.9000	82.0000	vR	99.0000	97.0000
b	18.0000	15.0000	vvR	99.6100	99.3250
bb	30.0000	25.0000	vCR	99.2000	99.8650
bbbb	37.0000	31.0000			

TABLE B.3. (Continued)

Method Code	Pathway Inhalation	Pathway External	Method Code	Pathway Inhalation	Pathway External
24 Soft-Surface Furnishings					
V	36.0000	33.0000	vvF	83.2000	78.0625
v	60.0000	55.0000	vvFF	86.5600	81.3531
vv	72.0000	66.2500	K	75.0000	70.0000
s	65.0000	60.0000	vK	84.0000	84.2500
vs	82.0000	77.5000	vvK	87.4000	86.5000
vvss	83.3400	83.8000	R	95.0000	95.0000
vF	80.0000	75.2500	vR	98.8000	98.6500
25 Electronic Equipment					
V	60.0000	65.0000	Vn	80.0000	84.2500
v	72.0000	77.2500	vn	80.4000	85.2125
n	70.0000	75.0000	vnn	83.3400	88.1700
nn	79.0000	83.9500	VR	99.6000	99.8250
26 Paper Products					
o	30.0000	25.0000	q	60.0000	55.0000
oo	40.5000	32.5000	qq	70.0000	64.0000
p	50.0000	45.0000	k	98.0000	98.0000
pp	61.0000	53.2500	ok	98.6000	98.5000
27 Automobile Exteriors					
cW	85.0000	80.0000	TJJ	99.5000	99.2800
cWW	96.2500	93.0000	mK	99.9000	99.8000
TJ	95.0000	94.0000			
28 Automobile Interiors					
V	75.0000	70.0000	DD	96.0000	92.0000
v	92.5000	89.5000	R	99.0000	99.0000
D	95.0000	90.0000	Vz	98.0000	97.0000
29 Automobile Tires					
R	99.9000	99.9000	J	90.0000	85.0000
W	60.0000	55.0000	S	95.0000	88.0000
30 Automobile Engine/Drive Train					
I	75.0000	65.0000	IE	97.5000	94.7500
II	92.5000	86.0000	IEE	99.6250	98.9500
E	95.0000	90.0000			

TABLE B.4. Decontamination Operations and Associated Symbols

Symbol	Operation	Symbol	Operation
A	Plow	X	Scrape 10 to 15 cm and Remove
B	Vacuum Blast	Y	Deep Plow
C	Strippable Coating	Z	Remove Structure
D	Defoliate	a	15 cm Asphalt Layer; Add 30 cm Soil (No Trees)
E	Leaching, EDTA	b	Wash; Wipe
F	Foam	d	Dust
G	7.5 cm Asphalt Layer; Add 15 cm Soil (No Trees)	e	Tack Coat
H	High Pressure Water	f	Sealer Coat
I	Steam Clean	g	Add 15 cm Soil (Trees in Place)
J	Wash and Scrub; Shampoo Carpet	h	Hand Scrape
K	Resurface	i	Ion Exchange
L	Leaching, $FeCl_3$	k	Machine Copy Printed Matter
M	Close Mowing	n	Spray Solvent
N	Clear; Harvest	o	Vacuum Paper in Place
O	Plane, Scarify; Radical Prune	p	Vacuum Exposed Paper Surfaces
P	Thin Asphalt/Concrete Layer	q	Vacuum Individual Pages
Q	Very High Pressure Water	r	Drain Reservoir
R	Remove and Replace	s	Steam Clean Fabrics
S	Sandblasting	t	Fixative, Aerial Application
T	Surface Sealer; Fixative	v	Double Vacuum
U	Hydroblasting	x	Double Scrape
V	Vacuum	y	Dredge
W	Low Pressure Water	z	Remove Interior, Clean, Replace

Operations to Automobiles

D	Detailed Auto Cleaning	T	Tow
E	Clean Engine with Solvent	V	Vacuum
I	Steam Clean	W	Water
J	Wash and Scrub	c	Drive Auto Out
K	Repaint	m	Auto Transport Truck
R	Replace/Reupholster	v	Double Vacuum
S	Sandblasting	z	Remove Interior/Clean/Replace

APPENDIX C

SOURCES

The following list gives the names of people and organizations which generously supplied information or helped in the search for information used for the cost estimates of the decontamination operations.

AAA Spraying
Seattle, Washington
(206) 364-4283

AWC, Inc,
Las Vegas, Nevada
(702) 871-7733
William Ayers

Aaron Rents Furniture
Bellevue, Washington
(206) 746-4086

Agristruction
8135 E. Dinuba Ave.
Selma, California
(209) 896-7500
Paul Hinkle

American Building Maintenance
Seattle, Washington
(206) 325-8800

American Institute of Architects
Washington, D.C.
(202) 626-7494
Stephanie Byrnes

American La France
Elmira, New York
(607) 734-8181
Guy Dewey

American Maintenance Systems
Seattle, Washington
(206) 226-2340
Lisa Hurlocker

American Public Works Association
Chicago, Illinois
(312) 667-2200
William Forester
Robert Flemming
Mary Sasso

Agri-Till
Five Points, California
(209) 884-2471
Dave Jones

Allstate Insurance Company
Claims Department
(206) 361-1600
(206) 361-5621
Mark Nirschl

American Paper Institute, Inc.
New York, New York
(212) 340-0600
Mr. Slatin

American Road and Transportation Builders Association
Washington, D.C.
(202) 488-2722

Associated Landscape Contractors of America
McLean, Virginia
(703) 821-8611

Aquanetics, Inc.
Seattle, Washington
(206) 329-3090
Terry Ovstedal

Atlas Building Wreckers
Seattle, Washington
(206) 246-6336

A-Z Pest Control
Richland, Washington
(509) 783-3211
Jim Nichols

Battelle PNL
Computer Service Center
Richland, Washington
(509) 375-3674

J. T. Baker Chemical Co.
Phillipsburg, New Jersey
(201) 859-2151

Jerald K. Bell, Landscape Architect
Seattle, Washington
(206) 362-9137

City of Bellevue
Bellevue, Washington
(206) 455-7846
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Braden Farms
Hughston, California
(209) 883-4061
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Blue Grass Chemical Specialities
New Albany, Indiana
(812) 948-1115

Brick Institute of America
McLean, Virginia
(703) 893-4010
Norm Farley

Burris Oil
Las Vegas, Nevada
(702) 385-3263
Ed Bickman

Butler Aviation
Redoond, Oregon
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Leo Demers

C&M Landscaping
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(509) 946-0221
Jeff Markham

Cal-Trans
State of California
Sacramento, California
(916) 445-4300
Chet Fields
Kathy Peterson

Can-Do Custom Farming
Bakersfield, California
(805) 832-4389
Pete Andriotti

Oliver B. Cannon & Son
Richland, Washington
(509) 377-2327
Oscar Rickman

Carpet Manufacturers Marketing
Association
Dalton, Georgia
(404) 278-4101

Carpet and Rug Institute
Dalton, Georgia
(404) 278-3176

Carr Aviation
Pasco, Washington
(509) 547-5301

Chemfix Technologies, Inc.
Kenner, Louisiana
(304) 467-2800
P. Meehan

Chemwest Industries
San Francisco, California
(415) 421-8745
Kevin White
Kathy Hutchings
Chevron Asphalt Co.
Seattle, Washington
(206) 628-5207
Don Gunn
(206) 628-5281
Bob Shafer

Chevron USA, Inc.
Seattle, Washington
(206) 784-0171

Chicago Roofing Contractors Assoc.
Chicago, Illinois
(312) 887-9072

Cleaning Consultant Services
Seattle, Washingoon
(206) 682-9748
Bill Griffin

Cleveland Wrecking Co.
Los Angeles, California
1-800-421-6158

Columbia Aerial Ag. Service, Inc.
Pasco, Washington
(509) 545-8826
Richard Skupa

Computer and Business Equipment
Manufacturers Association
Washington, D.C.
(202) 737-8888

Concrete Coring Company
Seattle, Washington
(206) 246-2434

Conservation Chemical Co.
Kansas City, Missouri
(913) 262-3649
Norman Hjersted

Connors Publishing Co.
Building Supply News Div.
Des Plains, Iowa

Cooperative Extension Orchard
Farm Adviser
Butte County, California
Bill Olson
(916) 534-4400

Crowley Environmental Services
Seattle, Washington
(206) 682-4898
Ed Gillanders

Dave Price Contract Plowing
Stockton, California
(209) 465-3405
Dave Price

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Commission
Philadelphia, Pennsylvania
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Kent, Washington
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Carol Huerd

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(904) 222-3974
Jay Baker

Disaster Research Center
University of Delaware
Newark, Delaware
(302) 451-2000
(302) 451-6618

Doolittle Construction Company
(206) 455-1150
Ed Doolittle

Dow Chemical
Midland, Minnesota
(517) 636-1000
Gene Taylor
Seattle Sales Office
Bellevue, Washington
(206) 455-7250
Beverly Fletcher
Los Angeles Sales Office
Los Angeles, California
(213) 597-1515
Jenny Holland

The Drackett Products Company
Cincinnati, Ohio
(800) 632-1684

DuPont, E.I. DeNemours & Co.
Chemicals, Dyes and Pigments Dept.
Wilmington, Delaware
(800) 441-9475
(800) 441-9442

Economic Research Service
Stillwater, Oklahoma
FTS 728-4127
Gale Garst

Elan Construction Co.
Seattle, Washington
(206) 623-4245
Electronics Industries Association
Consumer Electronics Group
Washington, D.C.
(202) 457-4919
(202) 457-8709
Julie Quattro

Elite Sod Farm
Richland, Washington
(509) 627-3148
Dianne Enningham
Dale Kenyon

Emergency One, Inc.
Osala, Florida
(904) 237-1122
John Oakley

EROS Landsat Data Center
Sioux Falls, So. Dakota
FTS 784-7511

Evergreen Spray Service
Richland, Washington
(509) 943-4968

Federal Emergency Management Agency
Bothell, Washington
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Phil Coogan, Public Information Officer
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Florida Assocation of Independent Insurance Agents
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(904) 893-4155
Preston Matthews

Florida Disaster Preparedness Office
Tallahassee, Florida
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FMC Corporation
Pomona, California
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(206) 622-5138
Bellingham, Washington
(206) 733-4410
Jan Draut

Golf Course Superintendents Assoc.
Laurence, Kansas
(913) 841-2240

Grantree Furniture Rentals
Seattle, Washington
(206) 323-5913

C. P. Hall
Chicago, Illinois
(312) 767-4600

Hancock County Sheriff's Office
Hancock County, Mississippi
(601) 467-5101

Handy Andy Rent-A-Tool
Seattle, Washington
(206) 632-0404

Joseph M. Hans, Jr.
U.S. Environmental Protection Agency
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Home Builders Association
Washington, D.C.
(202) 822-0200

IBM
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(206) 587-4400
Larry Helms

Institute of Fire Restoration
Assocation of Specialists in Cleaning
Falls Church, Virginia
(703) 845-1400
Major Long

Insurance Information Institute
Austin, Texas
(512) 476-7025
Rick Gentry
Insurance Information Institute
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(206) 624-3330

Insurance Institute for Highway Safety
Washington, D.C.
(202) 333-0770

Insurance Services Offices
New York, New York
(212) 487-4691
(212) 487-5062
Don Yezzi

International Association of Fire Chiefs
Washington, D.C.
(202) 833-3420
Nowell Patten

Iowa State University Cooperative Extention
Ames, Iowa
(515) 294-4576
(515) 294-3000
Bob Jolly

Ivan's American Tire Service
Kennewick, Washington
(509) 582-2117

Jametsky Statewide Construction
Seattle, Washington
(206) 242-1228

Johnson March, Inc.
Philadelphia, Pennsylvania
(215) 668-2800
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K-Lines
Lake Oswego, Oregon
(800) 547-1256
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King County Surface Water Utility Study
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Les Schwab Tire Center
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Long's Installations
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City of Los Angeles
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Dusty Perkins, Public Information Officer

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APPENDIX D

This appendix provides the sources for the data used in the Indian Point case study discussed in Chapter 5. The case study required that 43 items of information be obtained for each of the 16 counties with land areas in the contamination zone. A brief description of each data item is given in Table D.1.

It is noted that several of the items in Table D.1 are repeated. The reason for this is that IR-GRID was designed to be used with township data. County data are used to impute township values when these data items are not available by township. For the Indian Point study, counties were used as the basic geographical unit, so identical values are entered where the same variable is called for.

In Table D.2, we present in compact form the information on the data sources and commentary on any adjustments that were made to the data. The headings at the top of this table refer to the data items listed in Table D.1. For each county indicated in the first column, there are two rows of information; the first row contains letters and the second row contains numbers. The letters refer to the sources of the data, the numbers refer to notes to the table. The notes appear at the bottom of Table D.2 and the sources are supplied as a reference list in Table D.3.

Table D.1. List of Data Items Used in Indian Point Study

1. Employment Data
2. Durable Manufacturing
3. Nondurable Manufacturing
4. Services
5. Wholesale Trade
6. Retail Trade
7. Finance, Insurance and Real Estate
8. Transportation and Utilities
9. Construction
10. Local Government
11. State Government
12. Assessed Value, All Property
13. Median Market Value, Single-Family House *@*
14. Average Market Value per Acre of Farmland
15. Total Acres, Residential Property
16. Total Acres, Commercial and Industrial Property
17. Total Acres, Agricultural Property
18. Total Acres, All Other Property
19. Fraction of Assessed Value in Residential Property
20. Fraction of Assessed Value in Commercial and Industrial Property
21. Fraction of Assessed Value in Agricultural Property
22. Total Number of Housing Units
23. Median Value of Housing Units
24. Median Ratio of Assessed Value to Sales Value, All Taxable Property
25. Median Ratio of Assessed Value to Sales Value, Residential Property
26. Number of Occupied Housing Units
27. Number of Vacant Housing Units
28. Median Number of Persons per Household
29. Median Value of Residential Units
30. Percent of Township within Grid Element
31. County to which Township Belongs
32. Total Acres in Township
33. Land Area Data
34. Acres of Single-Family Residential
35. Acres of Commercial
36. Acres of Industrial
37. Acres of Streets and Roads
38. Acres of Wooded Areas
39. Acres of Agricultural, Excluding Orchards
40. Acres of Orchards
41. Acres of Vacant Land
42. Acres of Multi-Family Residential
43. Acres of Rivers, Lakes and Reservoirs

Table D.2. Sources of and Notes to Data Used in Indian Point Study

County	Item 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Atlantic, NJ	A									B		C	C,D	E								F	C,D
		1	1	1	1	1	1	1	1		2		3		4	5	6	7	8	6	8		
Bergen, NJ	A									B		C	C,D	E								F	C,D
		1	1	1	1	1	1	1	1		2		3		4	5	6	7	8	8	8		
NYC Burroughs	J											C	C,D	E					C	C	C	[illegible]	C,D
		1	1	1	1	1	1	1	1	1	1	29	3		4	5	6	7					
Burlington, NJ	A									B		C	C,D	E								F	C,D
		1	1	1	1	1	1	1	1		2		3		4	5	6	7	[illegible]	[illegible]	8		
Essex, NJ	A									B		C	C,D	E					C	C	C	F	C,D
		1	1	1	1	1	1	1	.		2		3		4	5	6	7					
Fairfield, CT	N									B		C	C,D	E					C	C	C	F	C,D
		1	1	1	1	1	1	1	1		2		3		4	5	6	7					
Hudson, NJ	A									B		C	B,D	E					.	C	C	F	C,D
		1	1	1	1	1	1	1	1		2		3		4	.	6						
Middlesex, NJ	A									B		C	C,D	E					C	C	C	F	C,D
		1	1	1	1	1	1	1	1		2		3		4	5	6						
Monmouth, NJ	A									B		C	C,D	E					C	C	C	F	C,D
		1	1	1	1	1	1	1	1		2		3		4	5	6	7					
Nassau, NY	V											C	C,D	E					C	C	C	F	C,D
	27	1	1	1	1	1	1	1	1	1	1		3		4	5	6						
Ocean, NJ	A									B		C	C,D	E					C	C	C	F	C,D
		1	1	1	1	1	1	1	1		2		3		4	5	6	7					
Passaic, NJ	Y									B		C	C,D	E					C	C	C	F	C,D
		1	1	1	1	1	1	1	1		2		3		4*	5*	6*	7*					
Rockland, NY	AA									B		C	C,D	E					C	C	C	[illegible]	C,D
		1	1	1	1	1	1	1	1		2		3		4	5	6	7					
Suffolk, NY	V											C	C,D	E						C	C	[illegible]	C,D
	27	1	1	1	1	1	1	1	1	1	1		3		4	5	6	7					
Union, NJ	A									B		C	C,D	E					C	C	C	F	C,D
		1	1	1	1	1	1	1	1		2		3		4	5	6	7					
Westchester, NY	AA									B		C	C,D	E					C	C	C	[illegible]	C,D
		1	1	1	1	1	1	1	1		2		3		4	5	6	7					

Table D.2. Sources of and Notes to Data Used in Indian Point Study (Cont.)

County	Item 24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
Atlantic, NJ	8	8	9	9	9	10	11	12	9	G	13	13	13	14	H	E	E	15	13	13
Bergen, NJ	8	8	9	9	9	10	11	12	9	I	13	13	13	14	H	E	E	15	13	13
NYC Burroughs	C	C	9	9	9	10	11	12	9	L 30	13	13	13	13	M	E	E	15	13	13
Burlington, NJ	8	8	9	9	9	10	11	12	9	16	13	13	13	14	H	E	E	15	13	13
Essex, NJ	C	C	9	9	9	10	11	12	9	17	13	13	13	14	H	E	E	15	13	13
Fairfield, CT	C	C	9	9	9	10	11	12	9	21	21	21	Q	R	E	E	E	21	21	13
Hudson, NJ	C	C	9	9	9	10	11	12	9	S	13	13	13	13	H	E	E	15	13	13
Middlesex, NJ	C	C	9	9	9	10	11	12	9	T	13	13	13	14	H	E	E	15	13	13
Monmouth, NJ	8	8	9	9	9	10	11	12	9	U 23	13	13	13	14	H	E	E	15	13	13
Nassau, NY	C	C	9	9	9	10	11	12	9	W	13	13	13	14	M	E	E	15	13	13
Ocean, NJ	C	C	9	9	9	10	11	12	9	X	13	13	13	14	H	E	E	15	13	13
Passaic, NJ	C	C	24	24	9	10	11	12	9	Z 25	13	13	13	14	H	E	E	15	13	13
Rockland, NY	C	C	9	9	9	10	11	12	9	O	13	13	13	14	M	E	E	15	13	13
Suffolk, NY	C	C	9	9	9	10	11	12	9	W	13	13	13	13	M	E	E	15	13	13
Union, NJ	C	C	9	9	9	10	11	12	9	D	13	13	13	14	H	E	E	15	13	13
Westchester, NY	C	C	9	9	9	10	11	12	9	K 28	13	13	13	14	M	E	E	15	13	13

TABLE D.2. Sources of and Notes to Data Used in Indian Point Study (Cont.)

Notes to Table

1. See item 1 above
2. Not available
3. Adjusted to 1982
4. Summation of single-family and multi-family land use area. See land use sources.
5. Summation of commercial and industrial land use area. See land use sources.
6. Summation of land use area for agriculture and orchards. See land use sources.
7. Summation of the following land use areas: vacant land, water bodies, wood areas, and streets and roads. See land use sources.
8. Average of other New Jersey counties in study.
9. See item 22 above.
10. See item 23 above.
11. Derived from maps with grid element overlays using a planimeter.
12. County data are used in place of township data.
13. See item 33 above.
14. Area is assumed to be 3% of total land use area.
15. Balance of acreage is designated for this land use.
16. Based on land use data for Ocean and Atlantic counties.
17. Based on 1966 land use data from the Hudson County planning book and land use in adjacent counties.
18. Taken as an average of Greenwich Town and Stamford only.
19. From the Connecticut State Data Center (203-566-8285).
20. Adjusted to 1982 dollars.
21. Acreages for land use types other than agricultural, wooded areas and streets and roads for Fairfield county are distributed according to the percentages of these land use types in Westchester County.
22. Obtained from two 100-point random samples, one from the northern half of the county and the other from the southern half.
23. Obtained from two 100-point random samples taken in different parts of the county.
24. See Item 22 above. Data were apportioned to the southern part of the county using a multiplier of 0.66.
25. Obtained from a 100-point random sample taken from the southern part of Passaic County. (The plume covers only this portion of Passaic County.)
26. Obtained from a single 100-point random sample.
27. The original data were for Nassau and Suffolk counties combined. These were allocated to each county separately using populations as weights.
28. Land use data were developed from two 100-point random samples in the northern half of the county and from two 100-point random samples in the southern half of the county.
29. New York City data were distributed according to the percentage of New York City's population living within the county.
30. Derived from random samples taken from land use maps

* Based on data only in the southern part of the county.

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PREPARATION OF THE SITE DATA BASE

E.0 INTRODUCTION

Four programs have been developed to prepare the site data so that it can be used directly by DECON. These are 1) the dose model, 2) the grid model, and 3) two site data models. They have the following functions:

- The dose model transforms simulated or measured ground concentrations into dose rates and n-year dose commitments measured at specified distance intervals along the plume centerline.
- The grid model, using inputs from the dose model or measured ground concentrations, generates isopleths over the accident site. Once the grid elements have been defined, the grid model can also used to estimate exposure levels at the midpoint of each grid element.
- There are two site data models. Although either can be used, they have important differences that are discussed below. The site data models organize user-supplied, site-specific information for each grid element into a set of data records that are used directly by DECON.

E.1 THE DOSE PROGRAM

The dose program is called DOSES. It was designed to calculate dose rate and dose commitment information and produce an intermediate data file for use in the decontamination analysis. DOSES accepts either radiological data measured during a field survey or radiological data from a simulated reactor accident to develop a set of dose-related information. This information is used by DECON in: 1) selecting the appropriate decontamination method to apply to a contaminated surface, 2) estimating the dose avoided by relocating the resident population outside of the contaminated area until decontamination has been completed, 3) estimating dose to radiation workers, and 4) identifying the outer boundaries of the accident area within which monitoring and surveying activities need to be undertaken.

DOSES is based on mathematical models used in the CRAC2 computer code (Ritchie et al. 1983, 1984) and described in the Reactor Safety Study (USNRC 1975). The following terms and concepts are relevant:

1. Initial release time, also referred to as time zero. This time is used as the basis for the weathering calculations using the CRAC2 weathering model.
2. Monitoring time. The period of time--typically several days--over which monitoring data are gathered. This period is used as the basis for radionuclide inventory decay calculations.

3. Dose starting time. The time at which the dose period is to begin. It represents the time at which reoccupation of the site begins. This time may be varied in the analysis to determine the optimum time for reentry.

4. Dose period. The time period over which the dose is to be integrated. This period will normally be either one, 50 or 70 years.

The dose assessment models are described below.

E.1.1 Dose Assessment Models

Following an acute release of radioactivity to the atmosphere, individuals may receive radiation dose from exposure to the passing plume or from exposure to material deposited on the ground. The methods used to estimate radiation exposure from each of these pathways are described in this section. The plume exposure pathway includes external exposure from radiation emitted in the plume and from inhalation of radioactive particles contained in the plume. Additionally, deposited material causes external exposure to individuals standing on the contaminated ground.

The analysis of dose for this study is based on models contained in the CRAC2 computer program (Ritchie et al. 1983, 1984) with noted modifications. These calculations provide the basis for determining at a later stage of the analysis the doses to individuals within each grid element.

E.1.1.1 External Plume Exposure

The dose from submersion in the passing plume is calculated using the finite plume model of the CRAC2 computer program. This model calculates the dose based on a ground-level release and then makes a geometric correction for the actual plume height and plume dimensions. The equation for the calculation is:

$$D_p = \sum_{i=1}^{\text{Nuclides}} (E / Q) \cdot C_i \cdot DF_p \cdot CF \qquad (1)$$

where:

D_p = the total dose received from external exposure during the time of plume passage, (rem)

E/Q = the time-integrated ground-level dispersion factor, (sec/m^3)

C_i = the activity of radionuclide i released, corrected for decay during transit to the exposure location, (curies)

DF_p = the external plume dose conversion factor for radionuclide i, (rem per curie-sec/m^3)

CF = the finite plume correction factor for the current distance, release height, and plume dimensions (dimensionless)

The dose conversion factors, DF_p, used in the calculation are the original values given with the CRAC2 computer program. The finite plume correction factor is calculated from tabulated values based on plume dimension and height (USNRC 1975) using a modified interpolation method described by Strenge (1980). This method is summarized as follows:

$$CF = (CF_y \bullet CF_z)^{1/2} \tag{2}$$

where:

CF = the finite plume correction factor

CF_y = the tabulated correction value based on the horizontal plume dimension (sigma y) for a ground-level release

CF_z = the tabulated correction value based on the vertical plume dimension (sigma z) and the effective plume height

Tabulated values used in the interpolation are given in USNRC (1975) in Table 8-1 of Appendix VI.

E.1.1.2 Plume Inhalation Dose

Individuals exposed to the plume are assumed to remain in the plume during the total time of passage. The internal dose received from inhalation is calculated as follows:

$$D_i = \sum_{i=1}^{\text{Nuclides}} (E / Q) \bullet C_i \bullet B \bullet DF_i \tag{3}$$

where:

D_i = the effective inhalation dose equivalent for an individual, (rem)

B = the average individual breathing rate during the time of plume passage, (m^3/sec)

DF_i = the inhalation dose conversion factor for radionuclide i, (rem per curie inhaled)

and other terms are as previously defined.

The dose conversion factors are based on compilations presented in ICRP Publication 30 to calculate the effective committed whole-body dose equivalent for each radionuclide (ICRP 26, ICRP 30).

E.1.1.3 Exposure to Contaminated Ground

Following the accident, the deposited activity causes external exposure to individuals in the vicinity of the contamination. For the present analysis, the dose from this pathway is calculated only for the first four days following the accident. The dose is calculated as the time integral of the ground concentration over the four days. The ground concentration changes with time due to radiological decay and weathering. The weathering model of the CRAC2 program is used to describe the decrease in activity. At time t, the fraction of the initial activity remaining is given by the following equation:

$$f_w(t) = 0.63 \exp(-1.13\ t) + 0.37 \exp(-0.00748\ t) \qquad (4)$$

This equation is modified as follows to account for radiological decay.

$$f(t) = f_w(t) \bullet \exp(-0.693\ t/t_h) \qquad (5)$$

where:

$f(t)$ = the net fraction of activity remaining at time t

t_h = the radiological half-time, (y)

t = the time after the initial deposition, (y)

The time integral of f(t) over the four-day time period represents the effective exposure time for the dose calculation. The external whole-body dose is calculated by the following equation:

$$D_g = \sum_{i=1}^{\text{Nuclides}} (D / Q) \bullet C_i \bullet F(t) \bullet SF \bullet DF_{gi} \qquad (6)$$

where:

D_g = the external dose received in four days following the accident, (rem)

D/Q = the normalized deposition factor at the exposure location, (m^{-2})

C_i = the activity of radionuclide i released, corrected for decay in transit to the exposure location, (Ci)

$F(t)$ = the exposure time integral, (hr)

SF = the effective shielding factor for individuals for the four-day period following the release, (dimensionless)

DF_{gi} = the ground dose conversion factor for radionuclide i, (rem/hr per Ci/m^2)

For the present analysis, an effective shielding factor of 0.75 was used for the nonevacuating population (USNRC 1975). This represents normal occupancy in residential areas without any sheltering action taken as a result of the accident.

E.1.1.4 Summary

The total dose received by the nonevacuating individual is calculated as the sum of the doses for the three exposure pathways:

$$dc_k = D_p + D_i + D_g \qquad (7)$$

This dose is correctly termed the effective committed dose equivalent for individuals at the exposure location.

E.2 THE GRID PROGRAM

The grid program, called GRID, performs two primary functions. First, it is used to generate a set of isopleths, which can then be superimposed on a map of the accident site. This set of isopleths will often be used in determining the location, size and/or shape of each grid element. Secondly, GRID can be used to compute the dose or dose commitment at almost any point within the accident area. However, if the grid elements are determined largely by the boundaries of the isopleths, then this second function may not be used. The different approaches one can use to define the grid area are discussed in Chapter 3.0.

To produce a set of isopleths, the user informs GRID of the dose or dose commitment for which an isopleth is to be generated. The user then gives GRID a series of downwind centerline distances, and for each of these distances GRID returns the orthogonal distance to the outer boundary of the isopleth. This is shown in Figure E.1 below. The radionuclide release is at point O, and an isopleth for 100 rem is to be generated. The user enters the distances d_1, ..., d_6 into GRID, and GRID responds with the distances x_1, ..., x_6. The isopleth is then drawn through the endpoints of these latter distances.