A.12.3 Strippable Coating

See Section A.9.10.

A.12.4 Foam

See Section A.9.9.

A.12.5 Sand

This operation involves sanding and refinishing the wood floor. Data come from Means' Building Construction Cost Data 1982 (p. 231). For our purposes, we use the maximum refinishing cost.

The labor required is one carpenter at $24.35 per hour. The total hourly cost is equal to the rate times the cost per square foot:

$$130\ ft^2/day \div 8\ hrs/day \times \$1.99/ft^2 = \$32.34/hr$$

Material cost can be found by subtracting the labor cost:

$$\$32.34/hr - \$24.35/hr = \$7.99/hr$$

This can be converted to cost per square meter by the following:

$$\$7.99/hr \div 16.25\ ft^2/hr \div 0.0929\ m^2/ft^2 = \$5.29/m^2$$

The adjusted rate for this operation is

$$130\ ft^2/day \div 8\ hrs/day \times 0.0929\ m^2/ft^2 \times 7/8 = 1.32\ m^2/hr$$

Using this rate, the cost of labor per square meter can be found:

$$\$24.35/hr \div 1.32\ m^2/hr = \$18.45/m^2$$

Adding the labor and material costs gives the total cost:

$$\$18.45/m^2 + \$5.29/m^2 = \$23.74/m^2$$

A.12.6 Fixative

See Section A.9.3.

A.12.7 Remove and Replace

This operation has three distinct steps for which costs are calculated separately. They are removal, replacement, and finishing. The source for this operation is Means' Building Construction Cost Data 1982.

The removal crew specified (p. 371) includes one foreman at $22.25 per hour and four building laborers at $19.40 per hour each. The total labor cost comes to $99.85 per hour. The only equipment indicated would be small hand tools supplied by the workers themselves.

The adjusted rate is

$$1300\ ft^2/day \div 8\ hrs/day \times 0.0929\ m^2/ft^2 \times 7/8\ adj = 13.2\ m^2/hr$$

Dividing the hourly labor cost by the rate gives the labor (and total) cost as $7.50 per square meter.

For replacing a wood floor, Means advises a crew of one carpenter at $24.35 per hour. The total hourly cost is

$$170\ ft^2/day \div 8\ hrs/day \times \$3.37/ft^2 = \$71.61/hr$$

Subtracting the labor cost gives the hourly material cost:

$$\$71.61/hr - \$24.35/hr = \$47.26/hr$$

Converting this directly to cost per square meter is done as follows:

$$\frac{\$47.26/hr}{(170\ ft^2/day \div 8\ hrs/day \times 0.0929\ m^2/ft^2)} = \$23.94/m^2$$

The adjusted rate is

$$170\ ft^2/day \div 8\ hrs/day \times 0.0929\ m^2/ft^2 \times 7/8\ adj = 1.73\ m^2/hr$$

Dividing this figure into the hourly labor cost gives

$$\$24.35/hr \div 1.73\ m^2/hr = \$14.08/m^2$$

Adding labor and material cost yields total cost:

$$\$14.08/m^2 + \$23.94/m^2 = \$38.02/m^2$$

For finishing a new floor, Means (p. 231) specifies the total cost as $0.99 per square foot and the daily production rate as 295 square feet. From these figures the total hourly cost is easily calculated:

$$295\ ft^2/day \div 8\ hrs/day \times \$0.99/ft^2 = \$36.50/hr$$

The labor required is one carpenter at $24.35 per hour. Subtracting the hourly labor cost from the hourly total cost gives

$$\$36.50/hr - \$24.35/hr = \$12.15/hr$$

for materials. This can be converted to a cost per square meter with the following calculations:

$$\frac{\$12.15/hr}{(295\ ft^2/day \div 8\ hrs/day \times 0.0929\ m^2/ft^2)} = \$3.55/m^2$$

The adjusted rate is

$$295\ ft^2/day \div 8\ hrs/day \times 0.0929\ m^2/ft^2 \times 7/8 = 3\ m^2/hr$$

Dividing the hourly labor cost by this figure gives the labor cost in dollars per square meter:

$$\$24.35/hr \div 3\ m^2/hr = \$8.12/m^2$$

Adding the labor and equipment costs yields the total cost:

$$\$8.12/m^2 + \$3.55/m^2 = \$11.67/m^2$$

The foregoing calculations are summarized in Table A.12.7.1. In addition, the costs for the entire combined operation are presented. The rate for the whole operation is set equal to that of the most costly procedure, following

TABLE A.12.7.1. Summary of Data for Removal and Replacement of Wood Floors

Procedure	Rate (m^2/hr)	Cost (1982 \$/m^2) Total	Labor	Equipment	Material
Removal	13.2	7.50	7.50	--	--
Replacement	1.73	38.02	14.08	--	23.94
Finish	3.00	11.67	8.12	--	3.55
Total	1.73	57.19	29.70	--	27.49

the convention used in this report. Consequently, 1.73 ÷ 13.2 = 0.13 removal crews and 1.73 ÷ 3.00 = 0.58 finishing crews would be combined with one replacement crew to form one crew for the entire operation.

A.13 CARPETED FLOORS

See Section A.11.

A.13.1 Vacuum

See Sections A.9.4 and A.11.1.

A.13.2 Foam

See Section A.9.9.

A.13.3 Fixative

See Section A.9.3.

A.13.4 Remove and Replace

The primary source of information for removal and replacement of carpet comes from Means' Building Construction Cost Data 1982. The general range of these figures was confirmed by information from and conversation with sources

at Deluxe Carpet Company of Kent, Washington, and Long's Installations of Bellevue, Washington.

According to Means (p. 370), carpet removal requires one building laborer at $19.40 per hour. The rate given is 100 square yards per day. With adjustments this implies a rate of

$$100\ yd^2/day \div 8\ hrs/day \times 0.836\ m^2/yd^2 \times 7/8\ adj = 9\ m^2/hr$$

Dividing this figure into the hourly cost gives $2.12 per square meter.

According to the same source (p. 227), the total cost of carpet installation covers a range of from $7.80 per square yard for 15-ounce polypropylene carpet to $29.00 per square yard for 42-ounce sponge-backed wool carpet. The difference is due to different material costs. Here we assume a material cost of $11.70 per square yard, or

$$\$11.70/yd^2 \times 1.196\ m^2/yd^2 = \$14.00/m^2$$

The rate for installation, with adjustments, is

$$40\ yd^2 \div 8\ hrs/day \times 0.836\ m^2/yd^2 \times 7/8\ adj = 3.7\ m^2/hr$$

Dividing this rate into the hourly cost for the one "tile layer, floor" required for carpet installation gives the labor cost per square meter:

$$\$22.55/hr \div 3.7\ m^2/hr = \$6.09/m^2$$

Adding the labor and material cost gives the total cost:

$$\$6.09/m^2 + \$14.00/m^2 = \$20.09/m^2$$

The results of the preceding calculations are presented in Table A.13.4.1. Also shown are the totals for the entire operation. Note that 3.7 ÷ 9 = 0.41 removal crews per replacement crew would be used in making up a

TABLE A.13.4.1. Summary of Data for Removal and Replacement of Carpet

Procedure	Rate (m^2/hr)	Cost (1982-$/$m^2$) Total	Labor	Equipment	Material
Removal	9	2.12	2.12	--	--
Replacement	3.7	20.09	6.09	--	14.00
Total	3.7	22.21	8.21	--	14.00

single removal and replacement crew with a production rate of 3.7 square meters per hour.

A.13.5 Steam Clean

Data for steam cleaning carpets comes from Means' Building Construction Cost Data 1982 (p. 227). Two sets of costs and rates are given. The one with the slower rate and higher cost is used here. The total cost per hour can be found with the following calculations:

$$3250 \text{ ft}^2/\text{day} \div 8 \text{ hrs/day} \times \$0.06/\text{ft}^2 = \$24.38/\text{hr}$$

The specified labor is one building laborer at $19.40 per hour. Subtracting the labor cost from the total cost gives the equipment cost:

$$\$24.38/\text{hr} - \$19.40/\text{hr} = \$4.98/\text{hr}$$

With adjustments, the hourly rate is

$$3250 \text{ ft}^2/\text{day} \div 8 \text{ hrs/day} \times 0.0929 \text{ m}^2/\text{ft}^2 \times 7/8 = 33 \text{ m}^2/\text{hr}$$

Dividing this into the hourly input costs yields costs on a dollars per square meter basis:

Labor: $$\frac{\$19.40/\text{hr}}{33 \text{ m}^2/\text{hr}} = \$0.59/\text{m}^2$$

Equipment: $$\frac{\$4.98/\text{hr}}{33 \text{ m}^2/\text{hr}} = \$0.15/\text{m}^2$$

The total cost is the sum of the input costs, 0.74 per square meter.

A. 13.6 Shampoo

Carpet shampooing involves applying the shampoo with a power brush device and vacuuming when the resulting foam has dried. Northwest Janitorial Systems of Mercer Island, Washington, estimates the cost of this operation at from $0.10 to $0.20 per square foot. A lower, but overlapping, range was provided by American Building Maintenance of Seattle, Washington, with their estimate of $0.05 to $0.11 per square foot. This source added that the hourly production rate was about 370 square feet and that labor comprised 60% of their cost.

Based on these figures and an assumed cost of $16.00 per hour each for two cleaning workers, this operation is estimated to have a rate of 40 square meters per hour and a total cost of $1.25 per square meter. Labor costs $0.80 per square meter, and equipment costs come to $0.45 per square meter.

A. 14 CONCRETE FLOORS

See Section A.II.

A.14.1 Vacuum

See Sections A.9.4 and A.11.1.

A.14.2 Scrub and Wash

See Section A.9.2.

A.14.3 Strippable Coating

See Section A.9.10.

A.14.4 Foam

See Section A.9.9.

A.14.5 Scarify

In this report, scarification refers to any of a variety of methods to remove the surface of concrete floors, pavement, or walls. Information from three sources was combined to develop the cost and rate estimates of this operation. Two of these sources were associated with Concrete Coring Company. Their input specifications were combined with labor and equipment costs from Means' Building Construction Cost Data 1982.

Concrete Coring Company performs a wide range of jobs on concrete, including drilling, coring, flat sawing, flame cutting, grooving, and grinding. This company also has experience in working in radiation contaminated environments and in using remote-controlled equipment. According to a source in this company, the most effective means for treating concrete subjected to low contamination is with high-pressure water. For higher levels of contamination, the alternatives for surface treatment include grinding and saw cutting with chipping. The grinding procedure uses a rotating abrasive disk to grind away the surface. Water is used as a coolant and a dust suppressant. The other procedure has two basic steps. The first step is to cut grooves in the surface. In the second step, the high portions between the grooves are chipped away by hand. For both operations there are machines of various sizes, operating speeds, and operating costs. In general, grinding floors, roads, and other ground-cover surfaces is faster, easier, and less costly than grinding walls, ceilings, or sloped and irregular surfaces.

Based on input descriptions from Concrete Coring Company, costs are determined using data from Means, as shown in Table A.14.5.1.

To convert these hourly cost figures to a cost per square meter basis, it is necessary to estimate the production rate. Here, information is ambiguous. One source at Concrete Coring Company estimated a production rate of 2000 square feet per day. Another source with the same company estimated a rate of 96 square feet. The primary reason for this wide discrepancy is that the first source provided a rate estimate for normal operating conditions, while the second source adjusted the coverage rate to what it would be under severely contaminated conditions. The rate used here is between these two rates--800

TABLE A.14.5.1. Cost Data for Scarifying Concrete Surfaces

Labor	Cost (1982 $/hr)
1 Small-equipment operator @ $23.70/hr	23.70
2 Building laborers @ $19.40/hr	38.80
1 Foreman @ $22.25/hr	22.25
Total labor	84.75
Equipment	
1 Grinder	1.82
1 Wet vacuum	1.00
1 Pickup truck	5.42
Total equipment	8.24

square feet per day. Converted to square meters per hour and adjusted for one hour per shift lost to personnel and equipment decontamination, this comes to 8.1 square meters per hour.

Dividing the rate into the hourly costs gives $10.43 per square meter for labor and $1.01 per square meter for equipment. The total is $11.44 per square meter.

A.14.6 Resurface

This operation involves laying a thin layer of concrete over the existing concrete floor. The information for this operation comes from Means' Building Construction Cost Data 1982 (p. 83).

The labor designated includes one building laborer at $19.40 per hour and two cement finishers at $23.00 per hour each. The total hourly labor cost is $65.40. For equipment, two gas-powered cement finishing machines are specified for a total hourly charge of $6.85. The material cost comes to $8.88 per hour.

The coverage rate is 590 square feet per day. With adjustments, this comes to 6 square meters per hour. Dividing this into the hourly input costs yields:

Labor: $10.90/m^2

Equipment: $1.14/m^2

Materials: $1.30/m^2

Total: $13.34/m^2

A.14.7 High-Pressure Water

See Section A.9.6.

A.14.8 Hydroblast

See Section A.9.5.

A.14.9 Scarify and Resurface

This operation involves scarification as described in Section A.14.5, followed by resurfacing as described in Secton A.14.6. This information is summarized in Table A.14.9.1.

TABLE A.14.9.1. Summary of Data for Scarification and Resurfacing of Concrete Floors

Procedure	Rate (m^2/hr)	Cost (1982 \$/m^2) Total	Labor	Equipment	Materials
Scarification	8.1	11.44	10.43	1.01	--
Resurfacing	6	13.34	10.90	1.14	1.30
Total	6	24.78	21.33	2.15	1.30

A.14.10 Fixative

See Section A.9.3.

A.15 PAINTED WOOD, PLASTER INTERIOR WALLS

Many of the operations on interior walls are similar or identical, with respect to costs and rates, to analogous operations on other wall or floor surfaces. Where this is the case, reference is made to the section in which development of cost and rate estimates is discussed. While costs and rates for a particular operation on different surfaces may be the same, decontamination efficiencies in general will not be.

A. 15.1 Vacuum

See Section A.9.4.

A.15.2 Scrub and Wash

See Section A.9.2.

A.15.3 Strippable Coating

See Section A.9.10.

A.15.4 Foam

See Section A.9.9.

A.15.5 Fixative

See Section A.9.3.

A.15.6 Remove and Replace

The information for removal and replacement of interior painted wood, plaster walls comes from Means' Building Construction Cost Data 1982. This operation involves four separate steps: removal, replacement, tape and finishing, and painting.

According to this source (p. 371), removal requires one foreman at $22.25 per hour and two building laborers at $19.40 per hour each. The total hourly labor cost is $61.05. The rate given for this procedure is 520 square feet per day, which converts to 5.28 square meters per hour. Dividing the labor cost by the rate yields a labor cost of $11.56 per square meter.

Replacement (p. 219) requires two carpenters at $24.35 per hour each. The total hourly cost is found by multiplying one-eighth the daily rate by the cost per unit:

$$1800\ \text{ft}^2/\text{day} \div 8\ \text{hrs/day} \times \$0.37/\text{ft}^2 = \$83.25/\text{hr}$$

Subtracting the labor cost gives the material cost:

$$\$83.25/\text{hr} - (2 \times \$24.35/\text{hr}) = \$34.55/\text{hr}$$

At 1800 square feet per day, the cost of materials is

$$\frac{\$34.55/\text{hr}}{(1800\ \text{ft}^2/\text{day} \div 8\ \text{hrs/day} \times 0.0929\ \text{m}^2/\text{ft}^2)} = \$1.65/\text{m}^2$$

The adjusted rate is

$$1800\ \text{ft}^2/\text{day} \div 8\ \text{hrs/day} \times 0.0929\ \text{m}^2/\text{ft}^2 \times 7/8\ \text{adj} = 18\ \text{m}^2/\text{hr}$$

Dividing this into the hourly labor cost gives labor as $2.66 per square meter. The total cost per square meter is the sum of labor and material:

$$\$2.66/\text{m}^2 + \$1.65/\text{m}^2 = \$4.31/\text{m}^2$$

The taping and finishing crew is again two carpenters. The total cost per hour is

$$2000\ ft^2/day \div 8\ hrs/day \times \$0.21/ft^2 = \$52.50/hr$$

Subtracting the labor cost gives the hourly material cost:

$$\$52.50/hr - (2 \times \$24.35/hr) = \$3.80/hr$$

This converts to

$$\frac{\$3.80/hr}{(2000\ ft^2/day \div 8\ hrs/day \times 0.0929\ m^2/ft^2)} = \$0.16/m^2$$

The adjusted rate is

$$2000\ ft^2/day \div 8\ hrs/day \times 0.0929\ m^2/ft^2 \times 7/8 = 20\ m^2/hr$$

Dividing this into the hourly labor cost yields

$$\$48.70/hr \div 20\ m^2/hr = \$2.40/m^2$$

Adding the labor and materials cost gives the total cost:

$$\$2.40/m^2 + \$0.16/m^2 = \$2.56/m^2$$

According to Means (p. 232), an ordinary painter has an hourly billing cost of $22.55 and a daily production of 490 square feet. The total hourly cost is

$$490\ ft^2/hr \div 8\ hrs/day \times \$0.45/hr = \$27.56/hr$$

Subtracting the labor cost gives the hourly material cost:

$$\$27.56/hr - \$22.55/hr = \$5.01/hr$$

This converts to

$$\frac{\$5.01/hr}{(490\ ft^2/day \div 8\ hrs/day \times 0.0929\ m^2/ft^2)} = \$0.88/m^2$$

The adjusted hourly coverage rate is

$$490\ ft^2/day \div 8\ hrs/day \times 0.0929\ m^2/ft^2 \times 7/8\ adj = 4.98\ m^2/hr$$

Dividing this into the hourly labor cost gives the labor cost as

$$\$22.55/hr \div 4.98\ m^2/hr = \$4.53/m^2$$

Adding labor and material costs gives the total cost per square meter:

$$\$4.53/m^2 + \$0.88/m^2 = \$5.41/m^2$$

Table A.15.6.1 summarizes the foregoing and shows the totals. Note that for a rate of 5.28 square meters per hour, 5.28 ÷ 18 = 0.29 replacement

TABLE A.15.6.1. Summary of Data for Removal and Replacement of Painted Wood, Plaster Walls

Procedure	Rate (m^2/hr)	Cost (1982 $\$/m^2$) Total	Labor	Equipment	Material
Removal	5.28	11.58	11.56	--	--
Replacement	18.00	4.31	2.66	--	1.65
Taping and finishing	20	2.56	2.40	--	0.16
Painting	4.98	5.41	4.53	--	0.88
Total	5.28	23.84	21.15	--	2.69

crews, 5.28 ÷ 20 = 0.26 taping and finishing crews, and 5.28 a 4.98 = 1.06 painting crews would be required.

A.16 INTERIOR CONCRETE WALLS

See Section A.15.0.

A.16.1 Vacuum

See Section A.9.4.

A.16.2 Scrub and Wash

See Section A.9.2.

A.16.3 Strippable Coating

See Section A.9.10.

A.16.4 Foam

See Section A.9.9.

A.16.5 Fixative

See Section A.9.3.

A.16.6 Scarify

See Section A.14.5. Means lists a lower cost for wall grinders, making the total hourly equipment cost $7.42. More important, however, is the rate, which sources at Concrete Coring Company said would be lower for walls than for floors. Using a base rate of 50 square feet per hour, the adjusted rate comes to 4 square meters per hour. The total cost per square meter is $22.68, of which $20.85 is for labor and $1.83 is for equipment.

A.16.7 High-Pressure Water

See Section A.9.6.

A.16.8 Hydroblast

See Section A.9.5.

A.16.9 Remove and Replace

The source for information regarding costs, rates, and inputs for removal and replacement of interior concrete walls is Means' Building construction Cost Data 1982. Removal (p. 371) requires one foreman at $22.25 per hour and four building laborers at $19.40 per hour each. The total hourly labor cost comes to $99.85. Equipment is a 250 cubic feet per minute air compressor with air tools and accessories, costing $18.00 per hour.

The rate given by Means is 100 cubic feet per day. Assuming an average wall thickness of eight inches, the rate converts to

$$100\ ft^3/day \div 8\ hrs/day \times 1.5\ ft^2/ft^3 \times 0.0929\ m^2/ft^2$$
$$\times\ 7/8\ adj = 1.52\ m^2/hr$$

Dividing the rate into the hourly costs gives $65.51 per square meter for labor, $11.81 per square meter for equipment, and the total is $77.32 per square meter.

The labor specified for replacement (p. 82) includes two foremen at $27.85 each per hour and eight skilled workers at $25.00 per hour each. The total hourly labor cost is $255.70. The equipment specified include 0.125 80-ton cranes and power tools for an hourly cost of $14.93.

The listed rate is 9.6 cubic yards per day. For eight-inch thick walls this converts to 3.95 square meters per hour.

The hourly material cost is found by multiplying the hourly rate by the listed unit total cost and subtracting the other costs:

$$9.6\ yd^3/day \div 8\ hrs/day \times \$340/yd^3 = \$408/hr$$

$$\$408.00/hr - (\$255.70/hr + \$14.93/hr) = \$137.37/hr$$

The cost of material per square meter, assuming an average wall thickness of eight inches, is $34.77.

Dividing other input costs by the hourly coverage rate gives $64.72 per square meter for labor and $3.79 per square meter for equipment. The total cost per square meter is $103.27.

Table A.16.9.1 summarizes the foregoing information. Normalizing the total rate to that of the more costly procedure, replacement, requires 3.95 ÷ 1.52 = 2.60 removal crews for each replacement crew.

TABLE A.16.9.1. Summary of Data for Removal and Replacement of Interior Concrete Walls

Procedure	Rate (m^2/hr)	Cost (1982 $/$m^2$) Total	Labor	Equipment	Material
Removal	1.52	77.32	65.51	11.81	--
Replacement	3.95	103.27	64.72	3.79	34.77
Total	3.95	180.59	130.23	15.60	34.77

A.17 OTHER ASPHALT

Other asphalt refers to paved areas of smaller size than roads or large parking lots. Other asphalt surfaces are more likely to have restricted access than asphalt roads. Examples of other asphalt surfaces include driveways, sidewalks, and patios. Many of the operations described for asphalt roads are also applicable to other asphalt areas. However, because these other asphalt surfaces are smaller and have restricted access, production rates are likely to be slower. This could result from such things as the inability to use large-scale equipment. Therefore, where better data were lacking, costs for operations on other asphalt were estimated by doubling the costs per square meter and halving the production rate for the corresponding operation on asphalt roads. In some cases, independent cost and rate estimates for operations on other asphalt were developed in the corresponding sections on asphalt roads.

A.18 OTHER CONCRETE

The relationship between other concrete surfaces and concrete roads is the same as that between other asphalt and asphalt roads, as described in Section A.17. Moreover, cost estimates for other concrete surfaces are handled in the same manner as described in Section A.17.

A.19 VEHICLE TRANSPORT

Vehicles left in a contaminated area will need to be removed to a place where they can be decontaminated. Three ways to accomplish this are considered here. The first involves towing the vehicle out using a standard automobile tow truck. The cost of this procedure is estimated at $50 per hour, with $20 for labor, $25 for equipment, and $5 for fuel. The rate, in terms of vehicles removed per hour, is estimated at one. Therefore, costs per vehicle are the same as costs per hour. However, if the towing distance is particularly long, then the rate and costs per vehicle will have to be adjusted. Towing vehicles rather than driving them has the advantage of avoiding possible contamination of the interior of the engine, though it is not clear to what extent this poses a serious hazard.

The second means of vehicle transport involves using a vehicle transport truck such as is used to deliver new cars. The cost per vehicle is estimated at $40. Labor, comprising 40% of cost of the operation, costs $16 per vehicle. Equipment is estimated at $20 per vehicle, and fuel $4.00. The rate, in terms of vehicles per hour, is four.

The third means of vehicle transport is to drive the car out. This would involve transporting a driver to the vehicle using a van or bus. The driver would then drive the vehicle out. This method requires sufficient organizational coordination such that the driver will have the proper keys to operate the vehicle. Most of the cost of this operation is for labor. This accounts for $13.50 per vehicle, out of a total of $15.00. Fuel and equipment are for the bus or van and amount to $0.75 each per vehicle. The rate is two vehicles per hour.

A.20 AUTOMOBILE EXTERIORS

A.20.1 Ordinary Spray Wash

A standard spray wash of automobiles is a fairly effective technique for decontaminating the vehicle's exterior. Information for this operation was obtained from car wash businesses in the Richland, Washington area. These data are summarized in Table A.20.1.1. Also shown are the representative data.

TABLE A.20.1.1. Summary of Data for Ordinary Spray Wash of Automobiles

Source	Rate (autos/hr)	Cost (1982 $/auto) Total	Labor	Equipment	Materials
Columbia Industries	--	3.00	2.40	0.30	0.30
Walker's Hand Car Wash	--	--	(80%)	(10%)	(10%)
L.A. Hand Car Wash	--	6.00	--	--	--
Representative	4	5.00	4.00	1.00	1.00

A.20.2 Detailed Wash

This operation involves very thorough cleaning of the automobile's exterior. Also included is application of a protective coating. The information collected from businesses in the Richland, Washington area which perform this service is presented in Table A.20.2.1. Also shown are representative data.

A.20.3 Repainting

For severely contaminated automobiles, it may be necessary to repaint the exterior. This operation includes sanding the surface before painting. The collected and representative cost and rate data are presented in Table A.20.3.1.

TABLE A.20.2.1. Summary of Data for Detailed Washing of Automobile Exteriors

Source	Rate (autos/hr)	Cost (1982 $/auto) Total	Labor	Equipment	Materials
Tidy Car	--	100	--	--	--
Terry's Automotive Appearance	--	50	39	5	6
Representative	0.25	75	58.50	7.50	9.00

TABLE A.20.3.1. Summary of Data for Repainting Automobile Exteriors

Source	Rate (autos/hr)	Cost (1982 $/auto) Total	Labor	Equipment	Materials
Burkett's Auto Painting and Body Repair	--	300	--	--	--
Cascade Autobody and Paint, Inc.	--	950	600	114	236
Don's Auto Paint and Body	--	1500	900	75	525
Representative	0.083	900	558	72	270

A.21 AUTOMOBILE INTERIORS

A.21.1 Vacuum

Table A.21.1.1 presents data supplied by various businesses that perform vehicle vacuuming services. In addition, representative cost and rate data are also presented.

A.21.2 Detailed Vacuum and Clear

The data for detailed vacuuming and clearing of automobile interiors is shown in Table A.21.2.1. The crew includes two workers.

TABLE A.21.1.1. Summary of Data for Vacuuming of Automobile Interiors

Source	Rate (autos/hr)	Cost (1982 $/auto) Total	Labor	Equipment	Materials
Columbia Industries	--	2.00	1.70	0.20	0.10
Tidy Car	--	10.00	--	--	--
Walker's Hand Car Wash	--	--	85%	10%	5%
Representative	3	6.00	4.10	0.60	0.30

TABLE A.21.2.1. Summary of Data for Detailed Vacuuming and Cleaning of Automobile Interiors

Source	Rate (auto/hr)	Cost (1982 $/auto) Total	Labor	Equipment	Materials
Tidy Car	--	55.00	--	--	--
Terry's Automotive Appearance	--	40.00	28.00	4.00	8.00
VIP Car Wash	--	35.00	--	--	--
Representative	1	45.00	31.50	4.50	9.00

A.21.3 Remove Contents, Clean, and Replace

This extensive operation provides a more thorough cleaning than detailed cleaning. The costs and rate for this operation are based on data supplied by Terry's Automotive Appearance. This source charges about $300 for the service. Of this amount, $240 is for labor and $30 for equipment and the same amount for materials.

A.21.4 Re-Upholstery

Re-upholstery is the most effective and most costly operation for automobile interiors. Table A.21.4.1 summarizes the information on this operation and shows the representative costs and rates.

TABLE A.21.4.1. Summary of Data for Re-Upholstering Automobile Interiors

Source	Rate (autos/hr)	Cost (1982 $/auto) Total	Labor	Equipment	Materials
Crawford's Custom Upholstering	--	600	--	--	--
Dean's Upholstery and Glass	--	600	210	180	210
Representative	0.14	600	210	180	210

A.22 AUTOMOBILE TIRES

The operations for decontaminating tires are water wash, wash and scrub, sandblast, and remove and replace. The cost for washing is based on the hourly cost for a common laborer ($17.45) plus equipment ($1.00). The wash and scrub cost figures are based on the hourly wash and scrub cost figures used for walls and floors (see Section A.9.2). The sandblast cost is based on the hourly cost of roof sandblasting (see Section A.3.6). The data for removal and replacement are based on information supplied by Les Schwab Tire Center and Ivan's American Tire Service.

TABLE A.22.1. Summary of Data for Different Tire Decontamination Operations

Operation	Rate (autos/hr)	Cost (1982 $/auto) Total	Labor	Equipment	Materials
Wash	10	1.85	1.75	0.10	--
Wash and Scrub	3	5.83	3.83	2.00	--
Sandblast	8	12.71	5.54	7.17	--
Remove and Replace	1	225	22.50	24.75	177.75

A.23 AUTOMOBILE ENGINES AND DRIVE TRAINS

Two techniques for decontaminating automobile engines and drive trains are steam cleaning and cleaning with an organic solvent. The data for these operations are presented in Table A.23.1.

A.24 HAULING

Hauling is not specific to any particular surface; rather it is an activity which is associated with other operations that generate contaminated material to be removed from the decontamination site to some dump site. Alternatively, some operations, notably those involving covering land areas

TABLE A.23.1. Summary of Data for Decontaminating Automobile Engines and Drive Trains

Operation and Source	Rate (autos/hr)	Cost (1982 $/auto) Total	Labor	Equipment	Materials
Steam cleaning					
Terry's Automotive Appearance	--	24.00	17.28	2.40	4.32
L.A. Hand Car Wash	--	28.00	--	--	--
Representative	1	26.00	18.72	2.60	4.68
Clean with solvent					
U.S. Ecology	--	37.00	35.15	0.35	1.40
Representative	1	37.00	35.15	0.35	1.40

with uncontaminated soil, involve hauling to the decontamination site. Also, it is possible that hauling materials away from the area being decontaminated could be coordinated with hauling materials to the site.

There are two principal variables affecting the cost per square meter of hauling. One is the distance of the haul. The other is the volume of material per square meter to be hauled. This latter variable depends on the particular operation and surface. These two important cost variables are discussed below.

The primary source of information for estimating the relationship between cost and distance is Means' Building Construction Cost Data 1982. There are different options for hauling crews. For example, debris boxes could be used rather than dump trucks. Dump trucks, however, seem to offer the greatest flexibility and would be significantly more costly than debris boxes only when truck loading is very slow.

The inputs for hauling are one heavy-truck driver at $19.75 per hour and one 20-cubic-yard dump truck at $45.84 per hour. The total hourly cost is $65.59. According to this source, loading a dump truck with a front-end loader takes 0.3 hours. For off-road work and short hauls, Means assumes an average vehicle speed of ten miles per hour. For longer distances, we assume higher average speeds.

Table A.24.1 shows the calculation of the costs of hauling per cubic meter. Most of the table is self explanatory. The third column, showing the time required for the haul, includes the time for loading and dumping. The cost per load is calculated by multiplying the hourly cost by the time. The cost per cubic meter is calculated by dividing the cost per load by 15.292 cubic meters per load. The rate is calculated by dividing 15.292 cubic meters per load by the time. Note that labor comprises 30% of the costs.

Given the cost per cubic meter for hauling, it is next necessary to estimate the volume of material per square meter for each operation requiring hauling in order to get a hauling cost per square meter. Table A.24.2 shows the estimated volume of material per square meter for each operation requiring hauling.

TABLE A.24.1. Estimated Hauling Costs and Rates by Mileage

Round Trip Distance (miles)	Avg. Vehicle Speed (mph)	Time (hrs)	Cost (1982 $) Per Load	Cost (1982 $) Per m^3	Rate (m^3/hr)
1	10	0.4	26.24	1.72	38.23
2	10	0.5	32.80	2.14	30.6
3	10	0.6	39.35	2.57	25.5
4	10	0.7	45.91	3.00	21.8
5	10	0.8	52.47	3.43	19.1
10	15	0.9	63.43	4.15	15.8
20	25	1.1	72.15	4.72	13.9
30	30	1.3	85.27	5.58	11.8
50	40	1.55	101.66	6.65	9.9
100	40	2.80	183.65	12.00	5.5

TABLE A.24.2. Estimated Volume of Material Per Square Meter to be Hauled

Surface	Operation	Volume (m^3/m^2)
Agricultural fields	Scrape	0.15
	Clear	0.10
	Cover	0.15
Orchards	Scrape	0.12
	Remove and replace	0.10
	Cover - trees removed	0.15
	Cover - trees not removed	0.12
Vacant land	Clear	0.10
	Scrape	0.15
	Cover	0.15
Wooded land	Clear	0.22
	Grub and scrape	0.18
	Handscrape	0.15
	Cover, cleared land	0.15
	Cover, not cleared	0.15
Exterior wood walls	Remove and replace	0.08
	Remove structure	1.00
Exterior brick walls	Remove and replace	0.30
	Remove structure	1.00
Linoleum floors	Remove and replace	0.05
Wood floors	Remove and replace	0.20
Carpeted floors	Remove and replace	0.17
Painted interior wood, plaster walls	Remove and replace	0.20
Interior concrete walls	Scarify	0.025
	Remove and replace	0.30
Asphalt roads	Plane	0.083
	Resurface	0.083
	Remove and replace	0.33
Roofs	Remove and replace	0.20
Lawns	Close mow	0.04
	Remove and replace	0.11

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 Facilities 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 was on operations which are relatively inexpensive, which can be applied to large surface areas, dnd which require little or no special equipment or skills.

The hazard of radiation occurs through two distinct pathways. Inhalation and ingestion is one pathway, and external exposure is another. 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 nullify the danger of inhalation of radiation. However, the effect on reducing risk through exposure will be essentially nil. For this reason, each method has two efficiencies, one for each exposure pathwdy.

The radionuclide composition of the contamination will affect the initial relative hazards from the two pathways. Contamination due to a weapons accident would involve higher amounts of plutonium than would a nuclear reactor accident. The risk from plutonium is almost entirely through inhalation or ingestion.

In general, decontamination methods will be more effective against inhalation than exposure. Methods that involve fixing the contamination are effective in reducing exposure only to the extent that they also provide shielding. Methods that remove particles will reduce exposure risk for both pathways. However, the particles that remain after the 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 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, the efficiency tests performed by most sources apparently did not experience rain between the original deposition and the decontamination

activity. For methods in which the particles are removed, rain will generally lower the efficiency. On the other hand, since rain will tend to drive contamination into the surface, 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 amd Decontamination Techniques for Plutonium Fallout on Large-Area Surfaces" by Dick and Baker, the Nuclear Weapon Accident Response Procedures Manual (NARP), prepared by the Department of Defense, 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, and "Decontamination After Widespread Release to the Environment" by J.R. Horan and L. J. Cunningham (printed in Ayres, Decontamination of Nuclear Reactors) were particularly helpful. They provided decontamination effectiveness data for operations such as vacuuming, sandblasting, high pressure hosing, and others when used on different surfaces. This information is given in Table B.1.

Additional data came from a Product Information Network report on street sweepers. This report listed 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. Table VI K-2 presented decontamination efficiencies of seven operations on several surfaces. That table is reproduced here. There were also a number of graphs showing a negative relationship between particle size and decontamination efficiency. These graphs are also reproduced. Care should be taken against reading too much in 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 warrant great confidence in the validity of this relationship.

Review of these data and the data used in 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) reveals 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, the quantitative results have not been confirmed in later studies. The frequently listed studies are by Dick and Baker (Dick and Baker 1961), and one by Langham (unreferenced 1968). The fact that studies of 14 to

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

Surface & Operation	NARP	Wallace & Romney	Horan & Cunningham
	Source		
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-$FeCl_3$ 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	

TABLE B.1 (cont.)

Surface & Operation	NARP	Wallace & Romney	Horan & Cunningham
	Source		
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)
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)

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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.

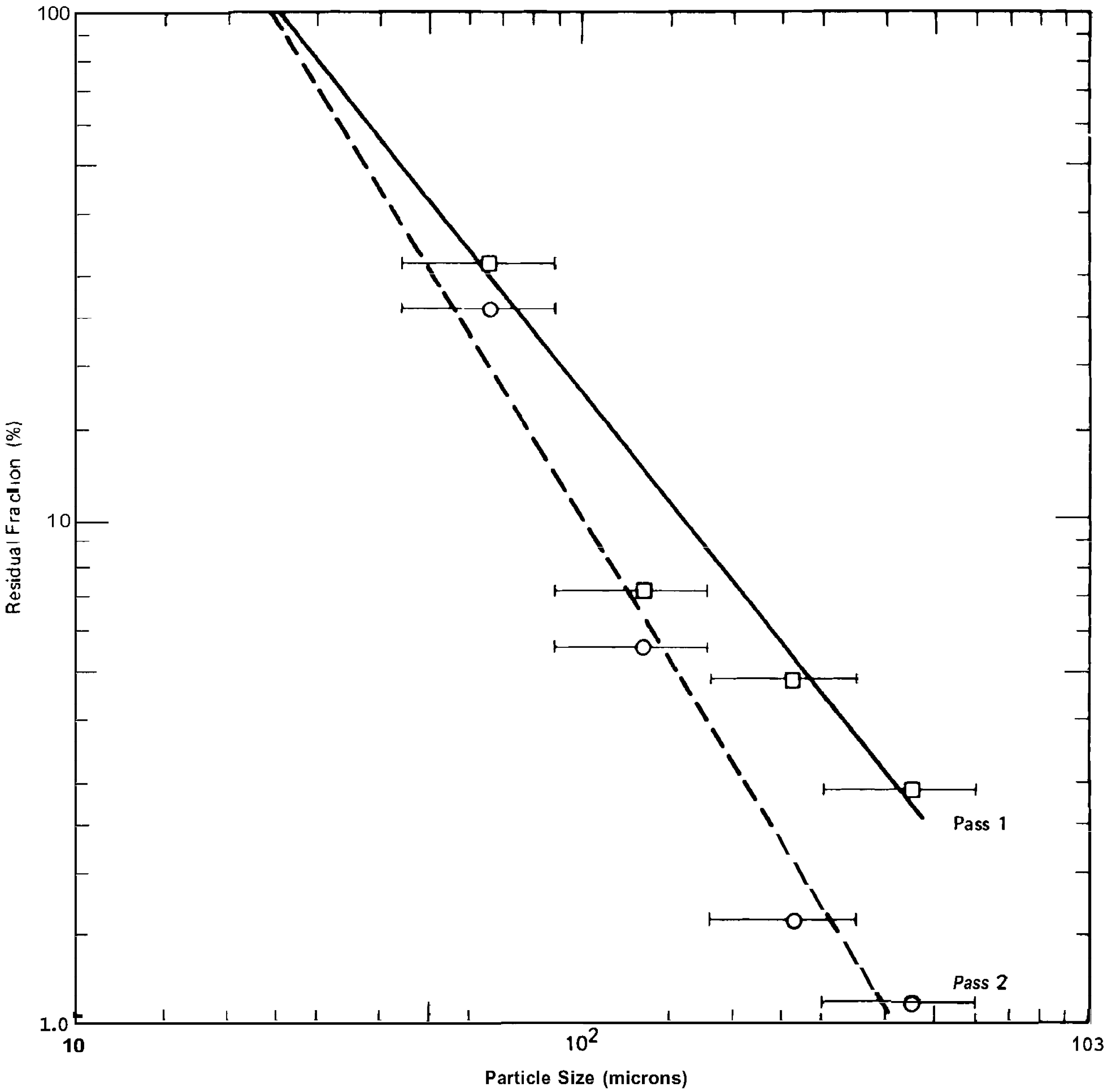


FIGURE VI K-1 Decontamination of roughly textured asphalt (or concrete) by firehosing (standard nozzle). Initial mass loading = 25 g/ft^2. [DF = 100/residual fraction (%).]

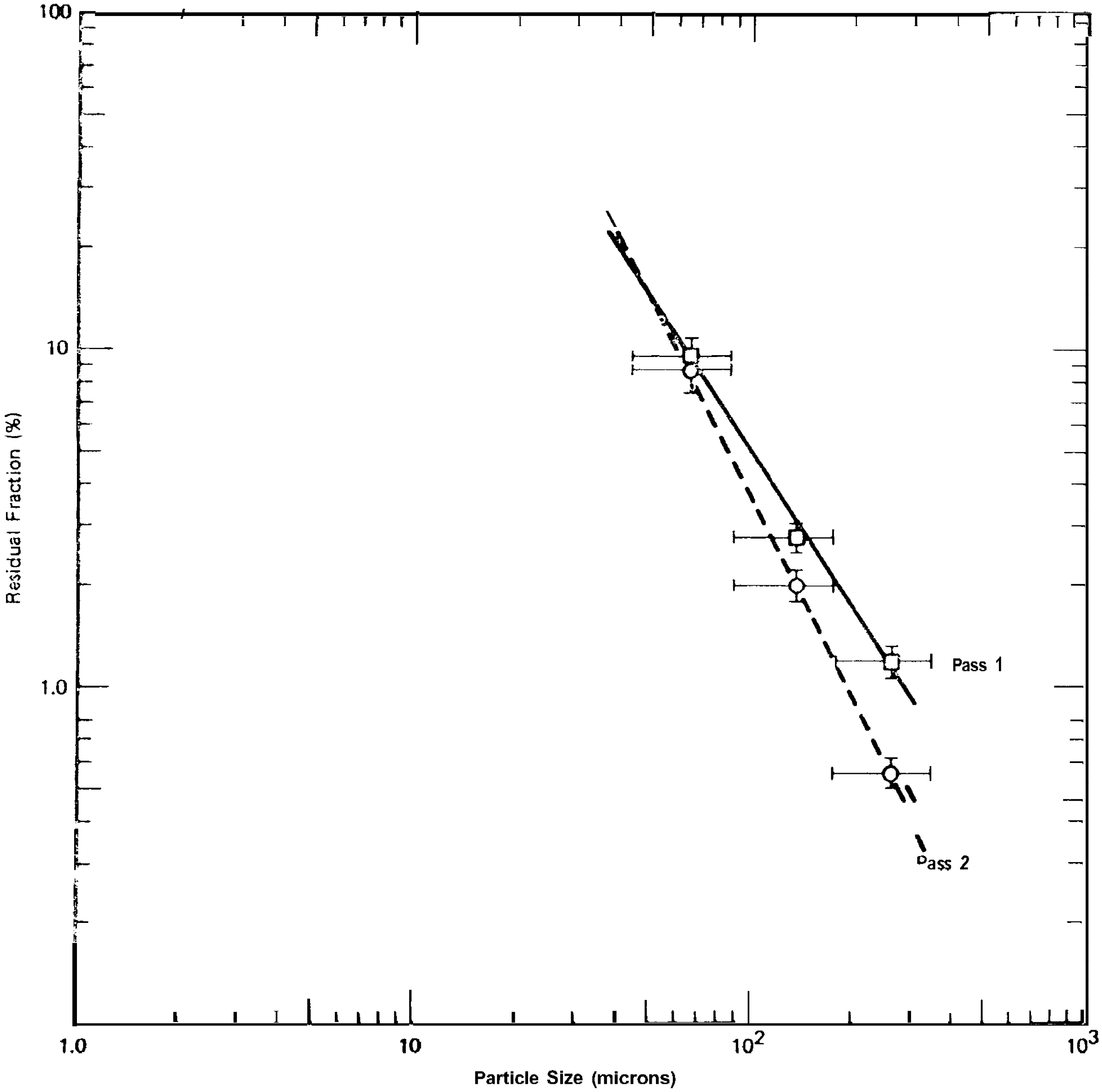
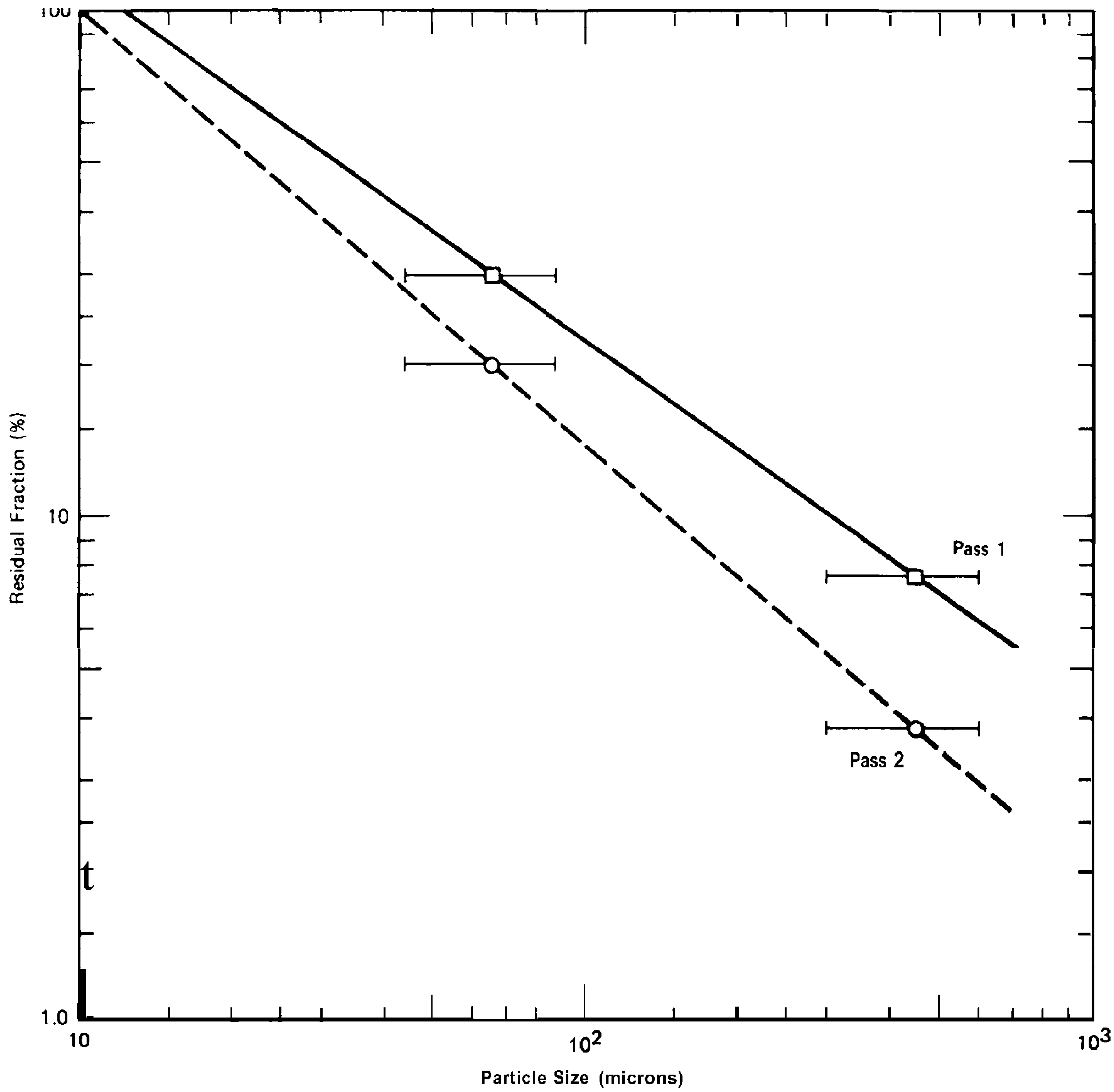


FIGURE VI K-2 Decontamination of smoothly textured asphalt (or concrete) by firehosing (standard nozzle). Initial mass loading = 25 g/ft^2. [DF = 100/residual fraction (%).]



FIQURE 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 (%).]

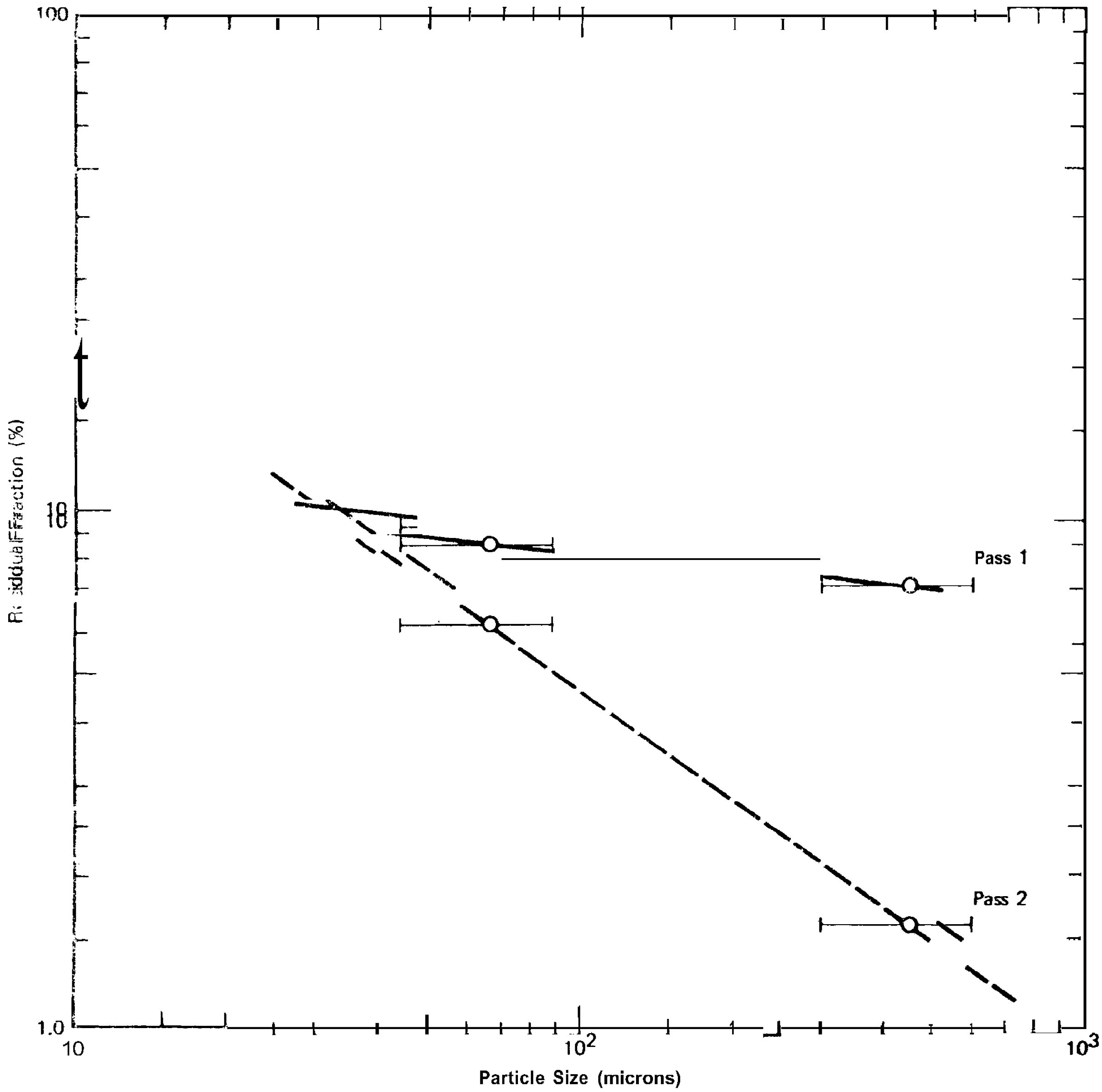


FIGURE VI K-4 Decontamination of smoothly textured asphalt (or concrete) by firehosing (standard nozzle). Initial mass loading = 5 g/ft^2. [DF = 100/residual fraction (%).]

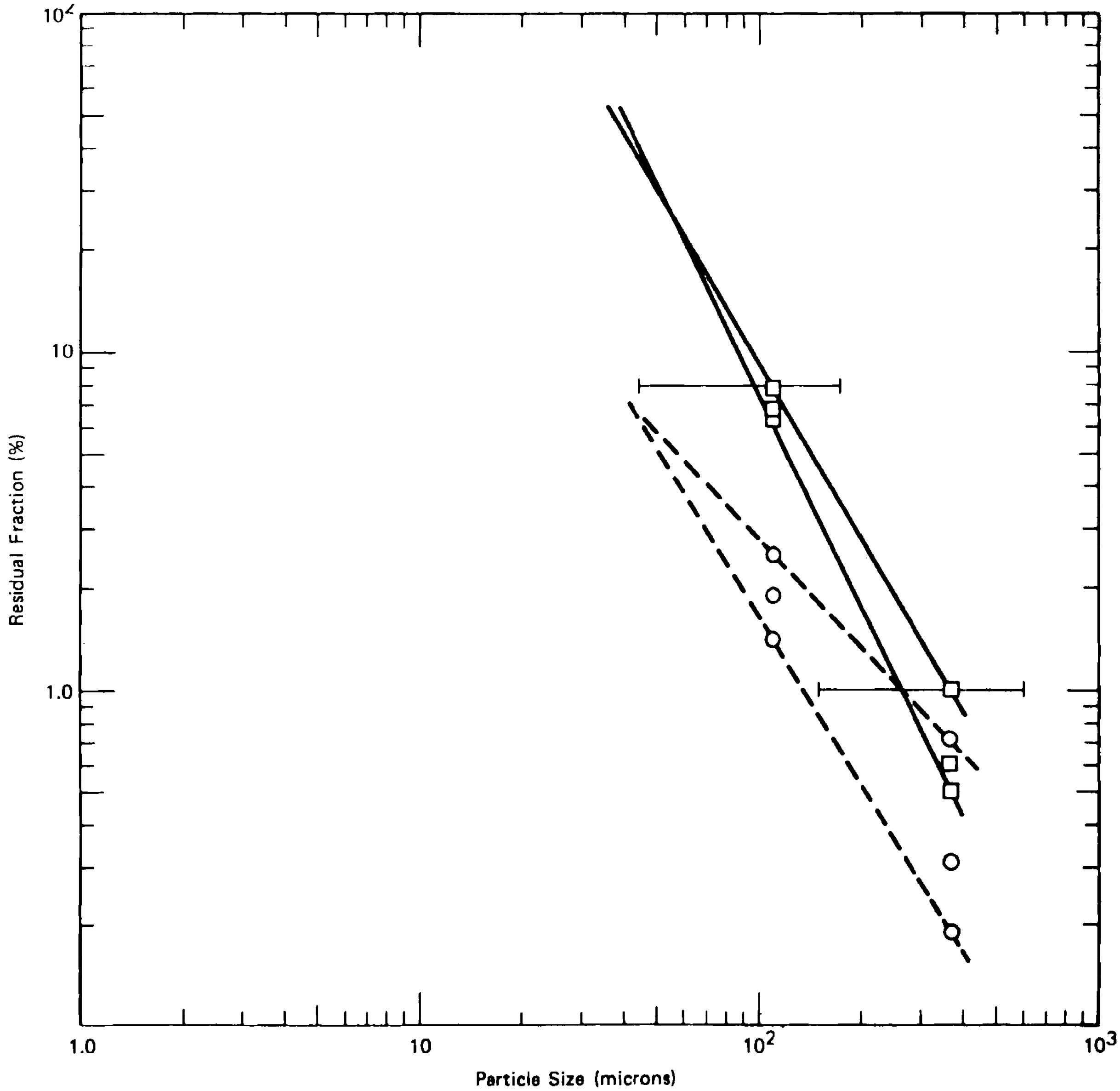


FIGURE VI K-6 Decontamination of roughly textured asphalt (or concrete) by mechanized flushing (three consecutive passes). Initial mass loading 5 g/ft^2 (□) and 25 g/ft^2 (○). [DF = 100/ residual fraction (%).]

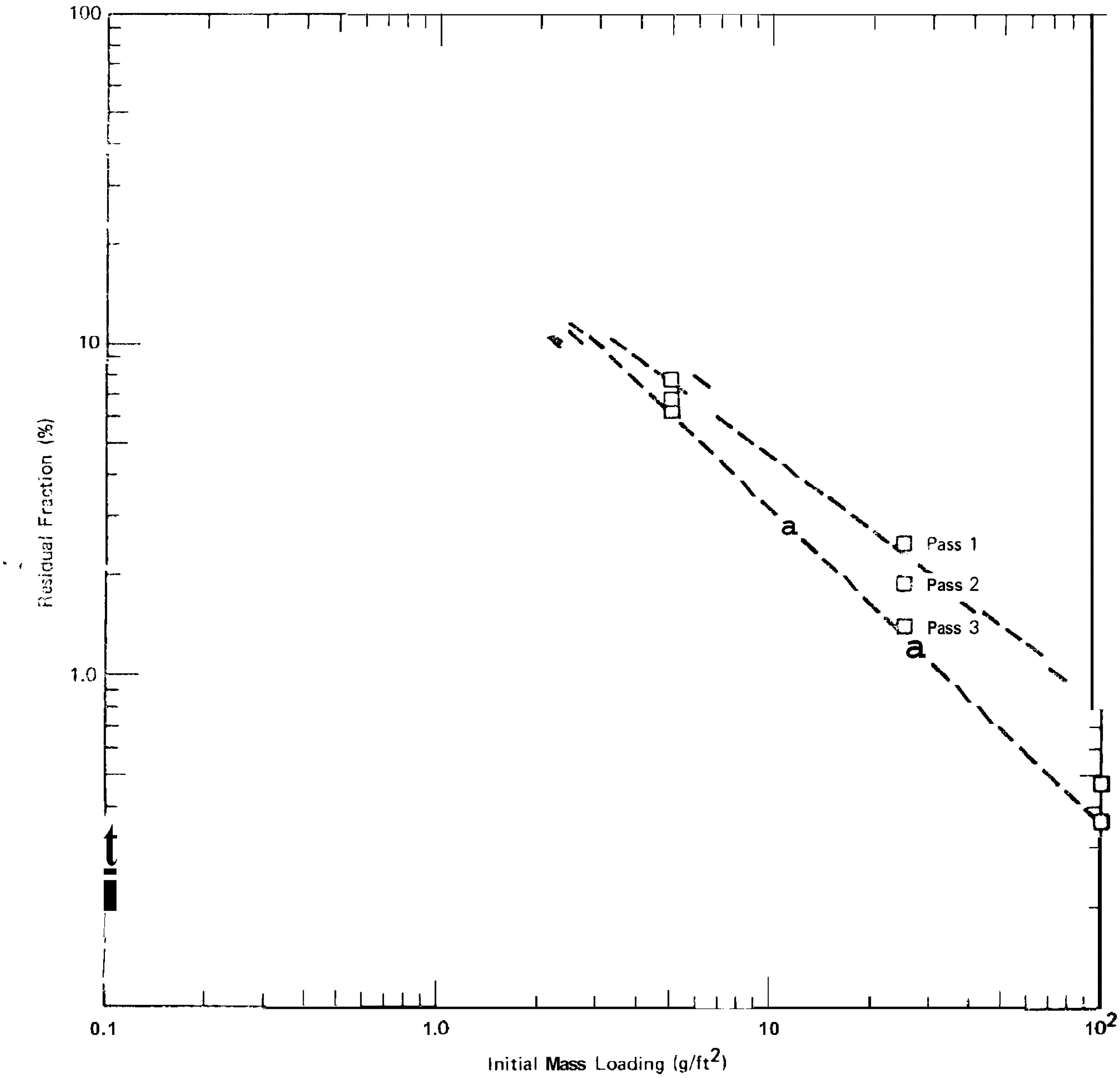


FIGURE VI K-6 Decontamination of roughly textured asphalt (or concrete) by mechanized flushing. Particle size = 44 to 100 microns. [DF = 100/residual fraction (%).]

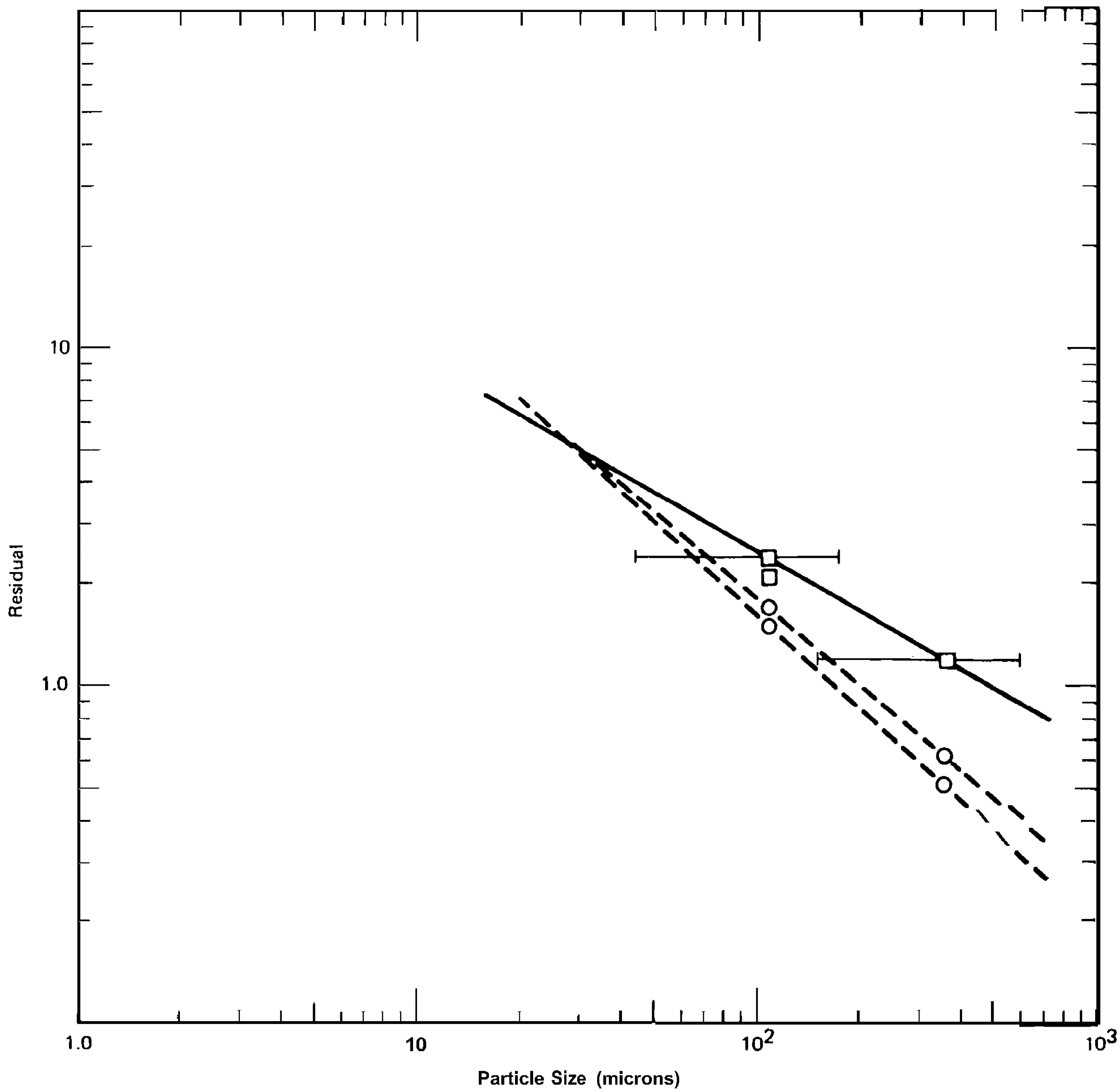


FIGURE VI K-7 Decontamination of smoothly textured asphalt (or concrete) by mechanized flushing (two consecutive passes). Initial mass loading = 5 g/ft^2 (O) and 12 g/f t^2 (O). [DF = 100/ residual fraction (%).]

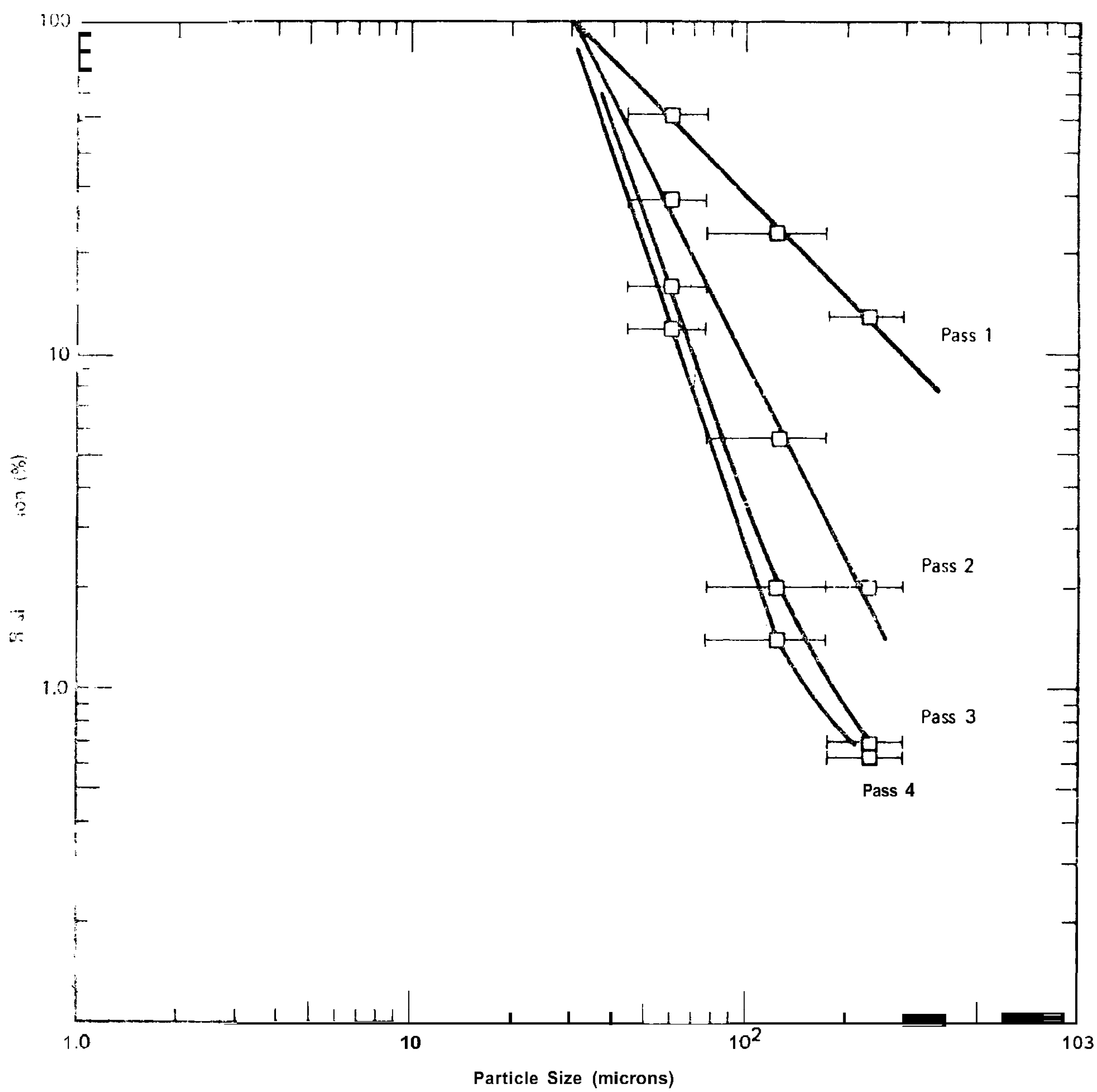


FIGURE VI K-8 Decontamination of roughly textured asphalt (or concrete) by "vacuumized" sweeper. Initial mass loading = 25 g/ft^2. [DF = 100/residual fraction (%).]

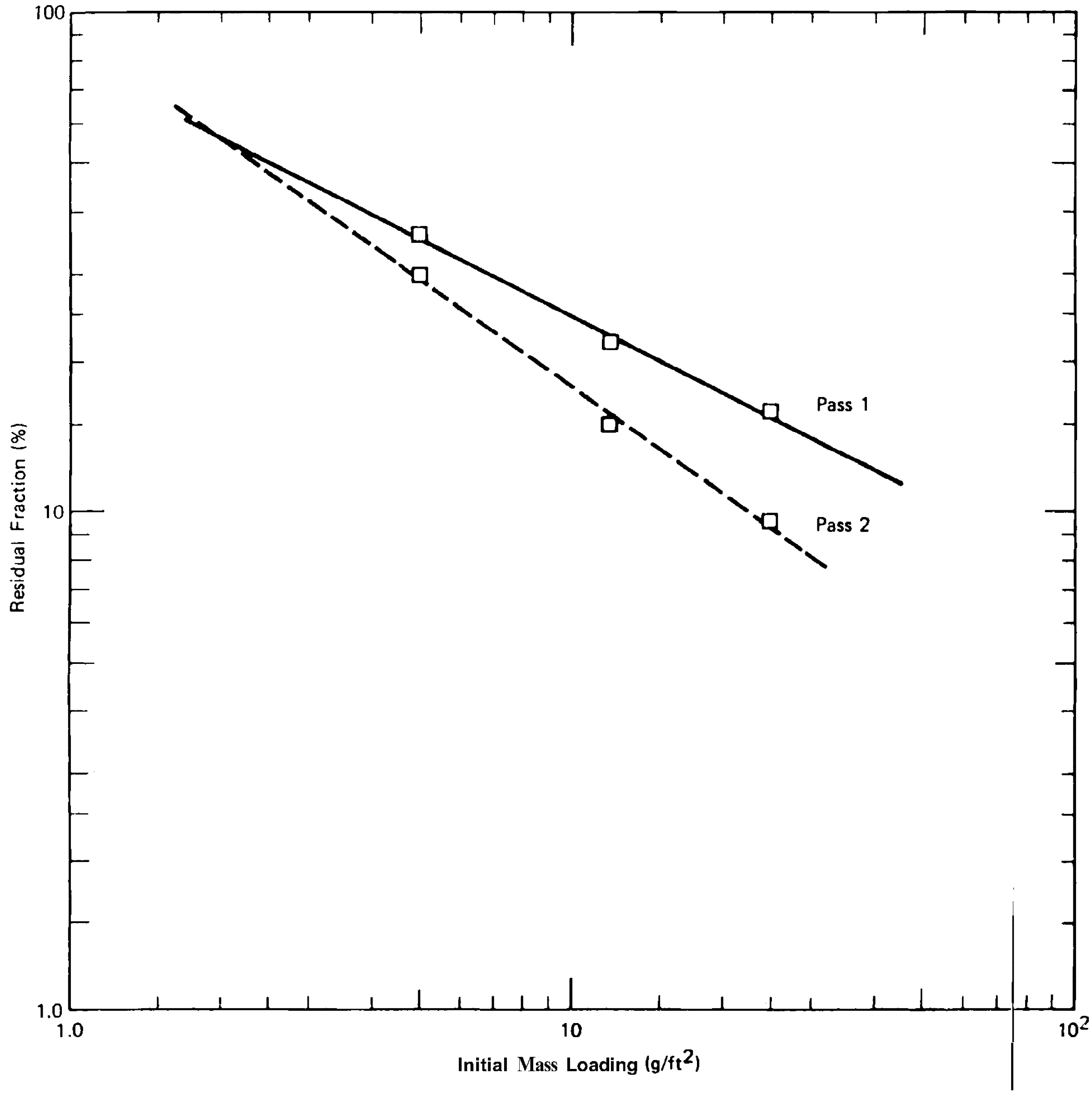


FIGURE VI K-9 Decontamination of roughly textured asphalt (or concrete) by "vacuumized" sweeper. Particle size = 44 to 74 microns. [DF = 100/residual fraction (%).]

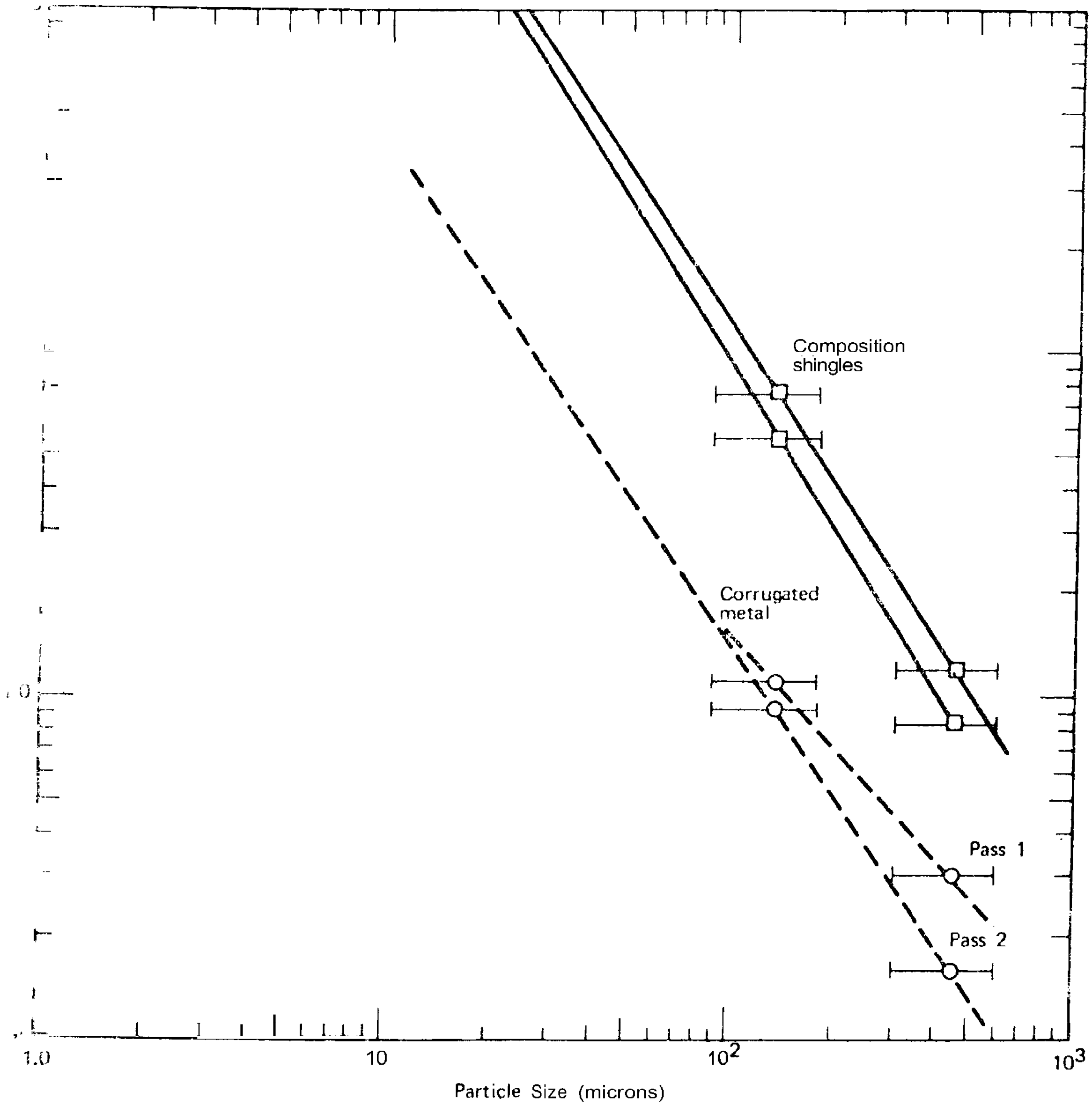


FIGURE VI K-10 Decontamination of sloped roofs by firehosing. Ini- ...ss loading = 25 g/ft^2. [DF = 100/residual fraction

K-32

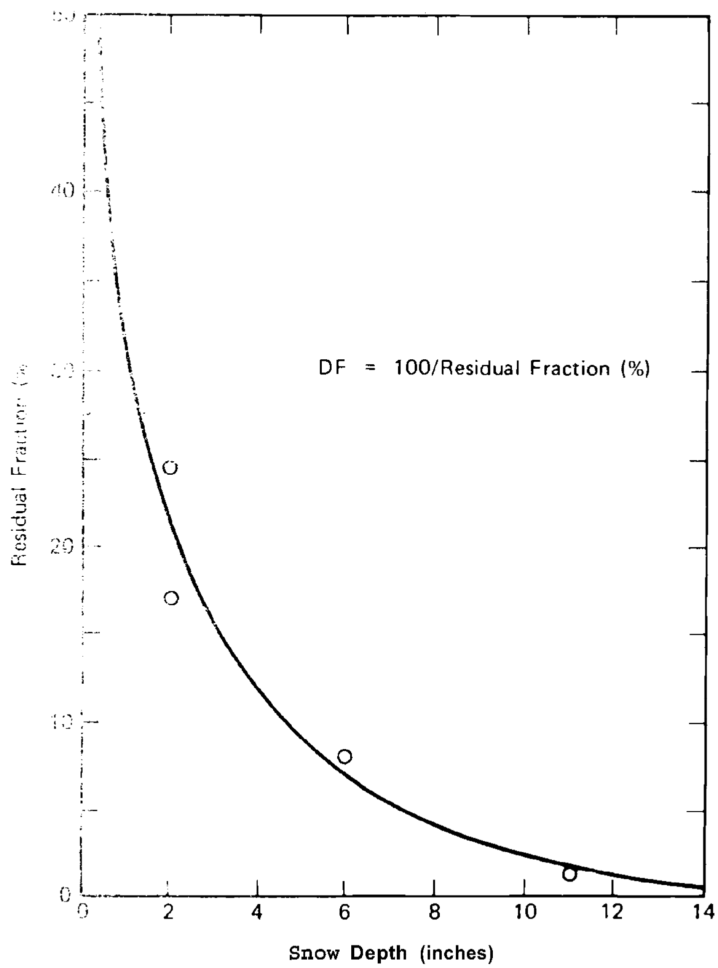


FIGURE VI K-11 Influence of snow depth on the decontamination effectiveness of the rotary snow blower. From Owen et al. (1967).

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20 years past are the prime data sources is indicative of the scarcity of information in this area.

In addition to the shortage of alternate data sources, 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 judgements about the relative effectiveness of the methods can be made. Thus, it is fairly clear from the data given in Table B.l that steam cleaning is a less effective method of decontaminating highway asphalt than high pressure water with scrubbing. Using 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 clouded when various operations are combined, and in this area information was even more sparse, as most sources provided information only on a single decontamination treatment done once. Clearly, the effect of performing one operation before 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 productive.

Provided in this Appendix is Table B.2, a listing that shows the various methods for each surface and each method's net inhalation and exposure efficiencies. In interpreting this table, the number in the first column to the left of the decimal point designates the surface. The surfaces and their numbers are shown in Table B.3. The number after the decimal point is simply a consecutive number of each method for that surface.

The next column shows the mnemonic code defining the operation. The key to these mnemonic codes is given in Table B.4, which is reproduced from Table 1.1.

The next two columns show the estimated net inhalation and exposure efficiencies for that method.

Table B.2. Removal Efficiencies for Decontamination Methods

AGRICULTURAL FIELDS

	Meth	Efficiency Inhal	Efficiency Exter
01.1	W	55.	25.
01.2	WW	79.8	43.75
01.3	WWW	90.9	57.8
01.4	WWWW	95.9	68.4
01.5	T	65.	0.
01.6	E	92.	35.
01.7	N	30.	30.
01.8	X	86.	86.
01.9	A	90.	50.
01.10	Y	98.	60.
01.11	TN	40.	40.
01.12	TNX	96.	96.
01.13	TNx	99.44	99.44
01.14	TNxX	99.92	99.92
01.15	G	60.	40.
01.16	WG	84.7	55.
01.17	TG	89.5	42.
01.18	LG	97.6	70.
01.19	XG	94.4	91.6
01.20	AG	97.	91.
01.21	YG	99.4	97.
01.22	NG	72.	58.
01.23	GG	88.	64.
01.24	GGG	96.4	78.4
01.25	WWG	93.9	66.3
01.26	TX	96.	96.
01.27	Tx	99.44	99.44
01.28	TxX	99.92	99.92
01.29	TA	92.	55.
01.30	TY	98.5	65.

ORCHARDS

	Meth	Efficiency Inhal	Efficiency Exter
02.1	W	33	15.
02.2	WW	47.9	26.3
02.3	WWW	54.5	34.7
02.4	WWWW	57.5	41.
02.5	X	48.	48.
02.6	A	51	27
02.7	TDX	130.	ht3.
02.8	TDx	90.32	'78
02.9	TX	75.	51.
02.10	TDXW	77.3	71.
02.11	TRX	93.6	98.6
02.12	TO	72.5	3.53.
02.13	TOA	93.3	45.
02.14	TRXG	95.	94.56
02.15	g	30.	24.
02.16	Tg	33.	25.2
02.17	Wg	47.9	33.
02.18	TRXa.	95.'7	95 1
02.19	T	50.	0.
02.20	TOA	23.3	45.

Table B.2. (continued)

VACANT LAND

	Meth	Efficiency Inhal	Exter
03.1	N	30.	30.
03.2	TN	40.	40.
03.3	TNX	96.	96.
03.4	W	55.	25.
03.5	WW	79.8	43.8
03.6	WWW	90.9	57.8
03.7	WWWW	95.96	68.4
03.8	TA	92.	55.
03.9	TY	98.5	65.
03.10	TNx	99.44	99.44
03.11	TNxX	99.92	99.92
03.12	G	60.	40.
03.13	TG	86.	42.
03.14	WG	82.	55.
03.15	NG	72.	58.
03.16	TNG	76.	64.
03.17	WWG	91.9	66.3
03.18	WWWG	96.4	74.7
03.19	TAG	96.8	73.
03.20	TYG	99.4	79.
03.21	TNxG	99.776	99.664
03.22	GG	84.	64.
03.23	T	65.	0.
03.24	A	98.	95.
03.25	TNxx	99.989	99.989

WOODED LAND

	Meth	Efficiency Inhal	Exter
04.1	TD	48.	00.
04.2	TN	65.	40.
04.3	TNX	85.	85.
04.4	TNx	89.25	89.25
04.5	TH	67.5	42.5
04.6	TDH	77.5	69.5
04.7	TNG	70.	60.
04.8	THG	72.	45.5
04.9	T	50.	0.
04.10	TX	67.5	42.5
04.11	TNH	85.	85.

EXTERIOR WOOD WALLS

	Meth	Efficiency Inhal	Exter
05.1	W	90.	85.
05.2	J	95.	90.
05.3	WJ	94.	90.25
05.4	V	99.	94.
05.5	VW	99.3	94.
05.6	VJ	99.6	95.5
05.7	H	98.	93.
05.8	VH	99.7	97.9
05.9	TR	99.9	99.9
05.10	VTR	99.985	99.985
05.11	vTR	99.998	99.998
05.12	VF	99.8	98.5
05.13	C	85.	84.
05.14	vF	99.825	98.65
05.15	vFR	99.94	99.6
05.16	TZ	99.999	99.999
05.17	VC	99.6	97.3
05.18	T	65.	0.
05.19	VT	99.5	94.

EXTERIOR BRICK WALLS

	Meth	Efficiency Inhal	Exter
06.1	V	29.	25.
06.2	v	36.1	30.25
06.3	W	90.	85.
06.4	VW	91.48	86.5
06.5	VF	92.9	88.75
06.6	vF	92.971	88.84
06.7	vW	91.693	86.748
06.8	VTR	99.716	99.7
06.9	vTR	99.744	99.721
06.10	vFR	99.8594	99.928
06.11	VH	91.48	87.25
06.12	vH	91.69	87.445
06.13	vFH	95.78	92.746
06.14	C	40.	35.
06.15	VU	96.45	92.5
06.16	vU	96.49	92.67
06.17	VJ	92.19	88.375
06.18	vJ	92.33	88.49
06.19	VO	99.29	99.25
06.20	vO	99.30	99.26
06.21	VTZ	99.716	99.7
06.22	T	65.	0.
06.23	F	92.	87.

Table B.2. (continued)

LINOLEUM FLOORS

	Meth	Efficiency Inhal	Exter
07.1	V	99.	95.
07.2	v	99.3	96.25
07.3	J	97.	95.
07.4	VJ	99.85	99.
07.5	VF	99.9	99.25
07.6	vF	99.895	99.25
07.7	vJ	99.86	99.06
07.8	VTR	99.998	99.99
07.9	vTR	99.999	99.991
07.10	vFTR	99.9991	99.992
07.11	C	98.	97.
07.12	VC	99.6	97.85
07.13	T	80.	0.

CARPETED FLOORS

	Meth	Efficiency Inhal	Exter
09.1	V	60.	55.
09.2	v	72.	66.25
09.3	VF	80.	75.25
09.4	vF	83.2	78.0625
09.5	vFF	86.56	81.353
09.6	VTR	99.52	99.46
09.7	vTR	99.636	99.56
09.8	VI	72.8	67.2
09.9	VJ	76.	70.8
09.10	vI	78.16	72.
09.11	vJ	79.9	73.

WOOD FLOORS

	Meth	Efficiency Inhal	Exter
08.1	V	90.	85.
08.2	v	94.5	91.
08.3	J	92.	87.
08.4	VJ	95.	91.
08.5	VF	97.5	95.5
08.6	vF	98.08	96.4
08.7	vJ	95.9	92.8
08.8	VTR	99.97	99.955
08.9	vTR	99.98	99.973
08.10	vFTR	99.994	99.989
08.11	VTK	99.96	99.94
08.12	vTK	99.976	99.964
08.13	vFTK	99.9916	99.9856
08.14	C	80.	75.
08.15	VC	97.0	94.5
08.16	T	85.	0.0
08.17	H	95.	90

CONCRETE FLOORS

	Meth	Efficiency Inhal	Exter
10.1	V	74.	69.
10.2	v	83.1	78.61
10.3	J	85.	80.
10.4	VJ	94.8	92.56
10.5	VF	97.4	95.66
10.6	vF	97.63	96.15
10.7	vJ	95.775	94.0108
10.8	VTK	99.792	99.752
10.9	vTK	99.8648	99.8289
10.10	vFTK	99.9730	99.9606
10.11	C	95.	90.
10.12	VU	98.96	97.52
10.13	vU	98.99	97.647
10.14	VH	96.1	94.11
10.15	vH	96.789	95.2942
10.16	VC	96.62	94.42
10.17	vC	97.296	95.508

Table B.2. (continued)

INTERIOR WOOD/PLASTER WALLS

	Meth	Efficiency Inhal	Efficiency Exter
11.1	V	99.	95.
11.2	v	99.3	96.25
11.3	J	97	95
11.4	VJ	99 85	99.
11.5	VF	99 9	99.25
11.6	vF	99 895	99.25
11.7	vJ	99.86	99.06
11.8	VTR	99.998	99 99
11.9	vTR	99.999	99.991
11.10	vFTR	99.9991	99.992
11.11	C	98.	97.
11.12	VC	99.6	97 85
11.13	T	80.	0.

INTERIOR CONCRETE WALLS

	Meth	Efficiency Inhal	Efficiency Exter
12..1	V	70.	65.
12.2	v	79.	74.1
12.3	J	80.	75.
12.4	VJ	92.5	89.85
12.5	VF	95.5	93.35
12.6	vF	95.8	94.04
12.7	vJ	93.7	91.43
12.13	VTR	99.76	99.412
12.9	vTR	99.832	99.7928
12.10	vFTR	99.958	99.942
12.11	C	90.	85.
12.12	VH	94.	91.6
12.13	vH	94.96	93.007
12.14	VU	97.3	95.45
12.15	vU	97.69	95.61
12.16	VC	91.3	88.45
12.17	vC	93.28	90.676

ASPHALT STREETS/PARKING

	Meth	Efficiency Inhal	Efficiency Exter
13.1	V	50.	45.
13.2	v	67.5	61.5
13.3	W	95.	85.
13.4	VW	95.5	86.25
13.5	VF	97.5	91.75
13.6	vF	98.05	91.915
13.7	vW	95.775	86.525
13.8	VR	99.5	99.45
13.9	vR	99.675	99.615
13.10	vFR	99.9805	99.9192
13.11	VK	99.25	98.9
13.12	vK	99.5125	99.23
13.13	vFK	99.9708	99.8383
13.14	C	97.5	93.
13.15	VP	99.	49.4
13.16	vP	99.35	64.58
13.17	VG	99.25	71.4
13.18	vG	99.5125	79.98
13.19	VC	98.	96.15
13.20	T	97.75	2.0
13.21	vC	98.375	93.455
13.22	F	97.	90.
13.23	vCF	99.8375	98.36

CONCRETE STREETS/PARKING

	Meth	Efficiency Inhal	Efficiency Exter
14.1	V	50.	45.
14.2	v	67.5	61.5
14.3	W	95.	85.
14.4	VW	95.5	86.25
14.5	VF	97.5	91.75
14.6	vF	98.05	91.915
14.7	vW	95.775	86.525
14.8	VR	99.5	99.45
14.9	vR	99.675	99.615
14.10	vFR	99.9805	99.9192
14.11	VK	99.25	98.9
14.12	vK	99.5125	99.23
14.13	vFK	99.9708	99.8383
14.14	C	97.5	93.
14.15	VP	99.	53.8
14.16	vP	99.35	67.66
14.17	VG	99.25	71.4
14.18	vG	99.5125	79.98
14.19	VC	98.	96.15
14.20	T	97.75	2.0
14.21	vC	98.375	93.455
14.22	F	97.	90.
14.23	vCF	99.8375	98.36

Table B.2. (continued)

ROOFS

	Meth	Efficiency Inhal	Efficiency Exter
15.1	V	60.	50.
15.2	S	99.	96.
15.3	H	97.	93.
15.4	F	93.	90.
15.5	C	85.	80.
15.6	W	90.	85.
15.7	WW	98.	96.25
15.8	R	99.9	99.
15.9	VH	98.	95.
15.10	VW	92.	87.5
15.11	TR	99.94	99.8

AUTO INTERIORS

	Meth	Efficiency Inhal	Efficiency Exter
19.1.	V	75.	70.
19.2	V	92.5	83.5
19.3	D	95.	90.
19.4	DD	96.	82.
19.S	R	99.	99
19.6	Vz	98	97.

LAWNS

	Meth	Efficiency Inhal	Efficiency Exter
16.1	V	30.	20.
16.2	W	85.	75.
16.3	WW	91.	84.
16.4	WWW	93.	86.88
16.5	WWWW	94.	88.06
16.6	M	65.	65.
16.7	R	98.	98.
16.8	L	85.	80.
16.9	TRW	99.9	99.7
16.10	TRL	99.92	99.9
16.11	TR	99.	99.

AUTO TIRES

	Meth	Efficiency Inhal	Efficiency Exter
20.1	R	99.9	99.9
20.2	W	60.	55.
20.3	J	90.	85.
20.4	S	95.	88.

AUTO EXTERIORS

	Meth	Efficiency Inhal	Efficiency Exter
1.13.1	W	85.	c30.
18.2	WW	96.	93.
18.3	J	98.	94.
18.4	JJ	99.5	99.28
18.5	K	99.9	99.8

AUTO ENGINE/DRIVE TRAIN

	Meth	Efficiency Inhal	Efficiency Exter
21.1	I	75.	65.
21.2	II	92.5	86.
21.3	E	95.	90.
21.4	IE	97.5	94.75
21.5	IEE	99.625	98.95

Table B.2. (continued)

	OTHER PAVED ASPHALT	Efficiency			OTHER PAVED CONCRETE	Efficiency	
	Meth	Inhal	Exter		Meth	Inhal	Exter
23.1	V	50.	45.	24.1	V	50.	45.
23.2	v	67.5	61.5	24.2	v	67.5	61.5
23.3	W	95.	85.	24.3	W	95.	85.
23.4	VW	95.5	86.25	24.4	VW	95.5	86.25
23.5	VF	97.5	91.75	24.5	VF	97.5	91.75
23.6	vF	98.05	91.915	24.6	vF	98.05	91.915
23.7	vW	95.775	86.525	24.7	vW	95.775	86.525
23.8	VR	99.5	99.45	24.8	VR	99.5	99.45
23.9	vR	99.675	99.615	24.9	vR	99.675	99.615
23.10	vFR	99.9805	99.9192	24.10	vFR	99.9805	99.9192
23.11	VK	99.25	98.9	24.11	VK	99.25	98.9
23.12	vK	99.5125	99.23	24.12	vK	99.5125	99.23
23.13	vFK	99.9708	99.8383	24.13	vFK	99.9708	99.8383
23.I4	C	97.5	93.	24.14	C	97.5	93.
23.15	VP	99.	49.4	24.15	VP	99.	49.4
23.1A	vP	99.35	64.58	24.16	vP	99.35	64.58
23.19	VC	98.	96.15	24.19	VC	98.	96.15
23.20	T	97.75	2.0	24.20	T	97.75	2.0
23.21	vC	98.375	93.455	24.21	vC	98.375	93.455
23.22	F	97.	90.	24.22	F	97.	90.
23.23	vCF	99.8375	98.36	24.23	vCF	99.8375	98.36

TABLE B.3. Surfaces and Their Corresponding Numbers

Number	Surface
01	Agricultural fields
02	Orchards
03	Vacant land
04	Wooded land
05	Exterior wood walls
06	Exterior brick walls
07	Linoleum floors
08	Wood floors
09	Carpeted floors
10	Concrete floors
11	Painted wood, plaster interior walls
12	Interior concrete walls
13	Asphalt roads
14	Concrete roads
15	Roofs
16	Lawns
18	Automobile exterior
19	Automobile interiors
20	Automobile tires
21	Automobile engine and drive train
23	Other asphalt surfaces
24	Other concrete surfaces

TABLE B.4.. Decontamination Operations

A	Plow	P	Thin Asphalt/Concrete Layer
B	Vacuum Blast	Q	Very High Pressure Water
C	Strippable Coating	R	Remove and Replace
D	Defoliate	S	Sandblasting
E	Leaching, EDTA	T	Surface Sealer/Fixative
F	Foam	U	Hydroblasting
G	Three-Inch Asphalt and	V	Vacuum
G	Cover with 6" Soil (No Trees)	W	Low Pressure Water
H	High Pressure Water	X	Scrape 4"-6"
I	Steam Clean	Y	Deep Plow
J	Wash and Scrub; Shampoo Carpet	Z	Remove Structure
K	Resurface	g	Cover with 6" Soil (Trees in Place)
L	Leaching, $FeCl_3$	h	Hand Scrape
M	Close Mowing	t	Fixative, Aerial Application
N	Clear; Harvest	v	Double Vacuum
O	Plane, Scarify; Radical Prune	x	Double Scrape

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

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.

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

AAA Spraying
Seattle, Washington
(206) 364-4283

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

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

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

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

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

Blue Grass Chemical Specialities
New Albany, Indiana
(812) 948-1115

Butler Aviation
Redmond, Oregon
(503) 548-8166
Leo Demers

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

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

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

Chemwest Industries
San Francisco, California
(415) 421-8745
Kevin White
Kathy Hutchings

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

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

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

Dow Chemical
Midland, Minnesota
(517) 636-1000

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

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

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

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

FMC Corporation
Pomona, California
(714) 629-4071
Rick Clayton

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

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

Home Builders Association
Washington, D.C.
(202) 822-0200

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

City of Kennewick
Street Department
Kennewick, Washington
(509) 586-4181
Earl Gavaert
Rick Olson

Lawn and Garden Manufacturers Association
Chicago, Illinois
(312) 644-6610

City of Los Angeles
Department of Public Works
Los Angeles, California
(213) 485-5691
Bill Harding

National Contract Sweepers Assoc.
Scotts Valley, California
(408) 438-5423
Jim Mills

Nurserymen's Association
Washington, D.C.
(202) 737-4060

Oakite Products
Richland, Washington
(509) 582-9079
Mike Denby

City of Pasco
Department of Public Works
Pasco, Washington
(509) 545-3463
(509) 545-3441
Jim Ajax
Jim Edwards

City of Portland
Department of Public Works
Portland, Oregon
(503) 248-5545
Jack Griffen

Power Master
Portland, Oregon
(503) 257-8801
Ken Crevier
Jerome Rushon
George Dodson

Public Technology
Washington, D.C
(202) 626-2400
Jeremy O'Brien

City of Richland
Fire Department
(509) 943-9161
Robert Panuccio, Chief

City of Richland
Street Department
(509) 943-9161
Dallas Phillips

Rockwell International
Richland, Washington
(509) 373-2102
Lester Bruns

City of San Francisco
Department of Public Works
San Francisco, California
(415) 558-4058
John Busher

Roger's Spray & Tree Service
Seattle, Washington
(206) 244-1717

City of Seattle
Fire Department
(206) 625-4073
Robert Hanson, Chief
Dave Lawson
Jack Seim
Richard Columbi

City of Seattle
Department of Maintenance
Seattle, Washington
(206) 625-4732
Morey Hilliard

Sherman Supply & Salvage Co.
Seattle, Washington
(206) 622-4801
Murray Federman

Sod-Growers Association of Mid-America
Palos Hills, Illinois
(312) 974-3419

City of Spokane
Department of Public Works
Spokane, Washington
(509) 456-4300
Warren Anington

Spokane Community College
Administrative Services
Spokane, Washington
(509) 456-3988
Don Kolb

True Value Hardware Store
Richland, Washington
(509) 946-5532

Turco Products
Carson, California
(213) 775-2111
Don Steiner
Bub Zaelke

U.S. Bureau of Land Management
Interagency Fire Center
Boise, Idaho
(208) 334-9421
Bob Weber
Bill Lyon

U.S. Department of Agriculture
Forest Service
Portland, Oregon
(503) 294-5393
Dick Pierce

U.S. Department of Agriculture
Forest Service
Seattle, Washington
(206) 442-5400
Jim Brain

U.S. Department of Agriculture
Forest Service
Fire Management Section
Wenatchee, Washington
(509) 662-4335
Ed Susich

U.S. Department of Transportation
Federal Highway Administration
Interstate Reports Branch
Washington, D.C.
FTS 426-0404
Mr. Shuffleburger

U.S. Department of Transportration
Federal Highway Administration
Policy Planning Branch
Washington, D.C.
FTS 426-0226
Bill Reulein

City of Walla Walla
Public Works Department
Walla Walla, Washington
(509) 527-4463
Max Graybeal

Wajax Firefighting Equipment
Seattle, Washington
(206) 243-4343
Ray Carr

State of Washington
Office of Emergency Services
Olympia, Washington
(206) 459-9191
Terry Simmons

State of Washington
Olympia, Washington
(206) 753-3605
Tom Brace, Fire Marshal

State of Washington
Department of Transportation
Maintenance Section
Olympia, Washington
Bob Lee

State of Washington
Department of Transportation
Olympia, Washington
(206) 753-2129
Dennis Jackson

Washington Tree Service
Seattle, Washington
(206) 362-9100

City of Yakima
Fire Department
Yakima, Washington
(509) 575-6060
Ed Carrol, Chief

APPENDIX D

This appendix describes the use of the DECON support programs. These programs include

- REFDATA - prepares reference database
- RADGRID - prepares site database for radial grid
- IRRGRID - prepares site database for irregular grid
- UNIGRID - prepares site database for uniform grid
- GETDOSE - determines dose at any map location given centerline dose
- RUNGRID - organizes radial grid pattern; determines isopleths for different exposure levels

The programs are described in the sections that follow.

D.1 REFDATA

REFDATA is a program for preparing the reference database. It consists of a main program and four subroutines. The input files for REFDATA are:

- COSTS.DAT - contains the costs and rates of each decontamination operation
- FACTOR.DAT - contains the factor inputs for each decontamination operation
- EFFNCS.DAT - contains the removal efficiencies of each decontamination method
- PARM.DAT - contains the program control parameters

REFDATA creates the following output files:

- CODEX.DAT - contains the codes for each decontamination method
- MTHDAT.DAT - a random access file containing the data for each decontamination method.

D.2 RADGRID

RADGRID is a program for preparing the site database for a radial grid. It consists of a main program and three subroutines, RADGRID, IMPUTE and XFORMA. The input files for REFDATA are:

- PARM.DAT - contains the program control parameters
- DOSEGE.DAT - contains the dose (commitment) at the midpoint of each grid element
- OFFSITE.DAT - contains site-specific data by political subdivision
- XFORM.DAT - contains the coefficients for subroutine XFORM

RADGRID creates the following output file:

- SITEDB.DAT - a random access file containing the site-specific data for each grid element.

D.3 IRRGRID

IRRGRID is a program for preparing the site database for a grid with irregular-shaped grid elements. It consists of a main program and two subroutines, IRRDATA and XFORM. The input files for IRRGRID are:

- PARM.DAT - contains the program control parameters
- DOSEXXX.DAT - contains the dose (commitment) at the midpoint of each grid element
- SITEXXX.DAT - contains site-specific data available by township
- XXXDATA.DAT - contains assorted site-specific data by county
- XFORM.DAT - contains the coefficients for subroutine XFORM

IRRGRID creates the following output file:

- SITEDB.DAT - a random access file containing the site-specific data for each grid element.

D.4 UNIGRID

UNIGRID is a program for preparing the site database for a grid with grid elements all of the same size. It is a special case of the more general program IRRGRID and has the same input and output files.

D.5 GETDOSE

GETDOSE is a program for computing the exposure level at any point on a map downwind from the point of radiological release. The point can be off the plume centerline. GETDOSE uses as inputs the doses or dose commitments at specified downwind distances and the plume width parameters. To find the dose at any point on the map, the user first enters the map scale--number of miles per inch. He then enters the distance (measured orthogonally) from the point of interest to the centerline, followed by the centerline distance from the point of release. The distances are entered in map-inches to simplify the process.

GETDOSE uses interpolative methods to compute the exposure levels. There will often be one or more points off of the centerline but close to the release point that must be computed. To compute these, the user will have to supply one or more exposure levels and distance intervals closer to the release point that the first distance interval of interest. For example, if the first distance interval of interest is 0.5 miles from the point of release, then the user may have to supply the exposure level along the centerline at 0.25 miles from the point of release. The number of these "extra" points will depend upon the accuracy required.

The user must respond to the following questions from the console:

- ENTER DATA NUMBER OF FIRST DISTANCE - This is equal to the number of "extra" data points plus one.
- ENTER NUMBER OF DISTANCE INTERVALS - This is equal to the number of data points, excluding the "extras".

ENTER NUMBER OF GRID SECTORS - This is equal to the number of radial sectors that divide the accidegt site; 16 sectors (each of 22-1/2) is common.

ENTER NAME OF INPUT FILE - Self-explanatory.

ENTER NAME OF OUTPUT FILE - Self-explanatory.

MAP SCALE—ENTER THE NUMBER OF MILES PER INCH - Enter the map scale.

ENTER ORTHOGONAL DISTANCE FROM LOOK-UP POINT - Draw a line from the look-up point to the centerline and at right angles to the centerline. Enter the length of this line in inches.

ENTER-CENTERLINE DISTANCE FROM ORIGIN - Measure the length, in inches, of the centerline from the release point to where it intersects the orthogonal line. Enter this distance.

GETDOSE will respond with "DOSE = ________". GETDOSE will then ask for the orthogonal distance from the next look-up point. To end the interactive session, enter a negative value for the orthogonal distance.

D.6 RUNGRID

RUNGRID is a program for organizing a radial grid. It will 1) produce a table showing the plume width, the incremental and the total areas covered by the plume for each downwind distance interval; 2) print out a map of the accident site, with a number for each grid element; and 3) print out a dose map of the accident site.

The user must respond to the following questions from the console:

ENTER DATA NUMBER OF FIRST DISTANCE - This is equal to the number of "extra" data points plus one. (See Section D.5.)

ENTER NUMBER OF DISTANCE INTERVALS - This is equal to the number of data points, excluding the "extras".

ENTER NUMBER OF GRID SECTORS - This is equal to the number of radial sectors that divide the accidegt site; 16 sectors (each of 22-1/2) is common.

ENTER NAME OF DOSE FILE - Name of file containing the dose data.

ENTER A VALUE FOR THE LOWEST RADIATION LIMIT TO BE CONSIDERED - This value is used to find the outer boundaries of the area covered by the plume.

RUNGRID will then print out a table showing the plume width, incremental area covered by the plume, and total area covered by the plume for each downwind

distance. Then, a grid map of the accident area will be printed. Finally, a map showing the dose (commitment) at the midpoint of each grid element will be printed. The user is then given an opportunity to 1) process a new dose file (enter '0'); repeat the process, but with a different radiation limit (enter '1'); exit from program (enter '-1').

D.7 FILES USED IN PRECEDING PROGRAMS

Codes for Decontamination Methods; CODEX.DAT - Unit 5

This file is prepared by the program REFDATA, which prepares the reference database (see Appendix D). CODEX.DAT must be on the default drive.

Labels for Surface Types; SRFLBL.DAT - Unit 6

This file is modified only when changing the number or types of surfaces supported by the reference database. SRFLBL.DAT must be on the default drive.

Labels for Factor Inputs; NPTLBL.DAT - Unit 7

This file is modified only when changing the number or types of factor inputs supported by the reference database. NPTLBL.DAT must be on the default drive.

Data from the Reference Database:, MTHDAT.DAT - Unit 8

This file is prepared by the program REFDATA. It is modified only when adding data to or changing data in the reference database. See Appendix D. MTHDAT.DAT must be on the default drive.

Parameter Values:, PARM.DAT - Unit 10

This file is prepared by the user and must reside on the default drive. The variables read and the format in which the variables must appear is described below.

The following 11 variables are read in Fortran format (918).

NGE - number of grid elements in the site database

NSURF - number of surface types in the reference database; current value is 24 (numbers 17 and 22 are not currently used).

NMAX - maximum number of decontamination methods available for any surface. The current value is 30.

LNDUSE - the number of land use categories. The current value is 11, and the categories are as follows: 1) residential, 2) commercial, 3) industrial, 4) streets and roads, 5) wooded areas, 6) parking lots, 7) grain crops, 8) vegetable crops, 9) orchards, 10) vacant land and 11) automobiles.

NPUTS - the number of factor inputs. The current value is 99.

NORGUS - the number of body organs to be processed. The maximum value for NORGUS is currently 1.

IJM - the number of decontamination methods in the reference database. The current value is 348.

IJS - the number of decontamination operations in the reference database. The current value is 186.

NTP - the number of time periods to be considered. Any value from 1 to 30, inclusive.

I20 - the number of exposure intervals to be used. Any value from 1 to 20, inclusive.

IACT - Set to 0 if batch processing mode is used; set to 1 if interactive mode at console is used. (Current implementation is only for IACT=1.)

The variable (NUMSRF(I),I=1,NSURF) is read in format (9I8). NUMSRF contains the number of decontamination methods available for each surface. The current values for NUMSRF are: 30, 20, 25, 13, 19, 23, 13, 16, 11, 17, 13, 17, 23, 23, 11, 11, 0, 5, 6, 4, 5, 0, 21, 21.

The variable (RADLIM(I),I=1,NORGUS) is read in format (9F8.2,F7.2). RADLIM contains the radiation limit, exposure limit, or cleanup criterion with respect to NORGUS body organs. RADLIM must be in the same units of measurement as GCE, which is read from the site database. The units of GCE are user-selectable. (The current implementation of DECON requires that NORGUS equal 1.)

The variable (XGCE(I),I=1,I20) is read in format (9F8.2,F7.2). XGCE contains the upper bound of each exposure (dose, dose commitment, or ground concentration) interval. The value of GCE is read for each grid element in the site database, and it is then determined in which of the XGCE exposure intervals GCE falls. The grid element is then processed as though GCE were equal to the value of XGCE for the interval in which it falls. For example, if XGCE(3)=7.8, XGCE(4)=9.2 and GCE=8.1, then GCE will fall in exposure interval 4 and the grid element will be processed as though GCE had equaled 9.2. In specifying the XGCE, the value for XGCE(1) should normally be set equal to zero, the value for XGCE(2) should be set equal to the minimum value for RADLIM, and the last nonzero value for XGCE should be equal to or slightly greater than the largest value of GCE in the site database.

The variable (DEPR(I),I=1,LNDUSE) is read in format (9F8.2,F7.2). DEPR contains the depreciation rates to be associated with each land use category. The values for the DEPR are expressed as the fraction of the property value lost from one year to the following year. For example, DEPR(3)=0.1 means that property in land use category 3 (industrial) loses 10 percent of its value every year due to depreciation.

The variable (DISC(I),I=1,LNDUSE) is read in format (9F8.2,F7.2). DISC contains the fraction of a property's pre-accident value that is lost because of residual contamination remaining after it has been decontaminated. For example, DISC(9)=0.2 means that property in land use category 9 (orchards) would lose 20 percent of its pre-accident value simply as a result of residual contamination.

The next set of variables read from PARM.DAT is P1, P2, P3, P4 and SCALE. The format is (9F8.2,F7.2). P1 through P4 are factors that can be used to adjust the costs of labor (P1), equipment (P2), materials (P3) and fuel (P4). These costs are actually adjusted in the program REFDATA, which also uses the file PARM.DAT.

For severe accidents, the costs, areas and hours of labor and equipment are large numbers and need to be scaled down if they are to be expressed in fixed decimal format. The variable SCALE permits the user to scale the output results. SCALE is usually expressed as some power of 10, and is entered in PARM.DAT in scientific notation. For example, the value 1.0E+03 would cause values expressed in dollars, areas, and hours of labor and equipment to be scaled down by a factor of 1000.

The last variable, (EXPOS(I),I=1,NSURF), is read in format (9F8.2,F7.2). EXPOS contains the exposure factors to be associated with each type of surface. Exposure factors are discussed in Section 4.3.5, page 4.19 and illustrated in Section 5.3.6, page 5.26. It is recommended that the values for EXPOS be set to 1.0 for base case evaluations.

Data Relating to Doses; DOSE.DAT - Unit 12

This file contains the decay factors (see DECAY in common block DOSE). It is prepared by the dose model. See Appendix D. DOSE.DAT must be on the default drive.

Data Relating to the Site Database; SITEDB.DAT - Unit 13

This file, which is prepared by the program SITEDATA, contains all of the information relating to the site database. One random access record is provided for each grid element. Each record contains 1) the pre-accident value of the property within the grid element; 2) the post-decontamination value of the property (as computed from the variable, DISC); 3) the exposure level (dose, dose commitment or ground concentration); 4) the population; 5) for each surface type, the ratio of the area for that surface type to the total geographic area of the grid element; and 6) the geographic area of the grid element. In the hard disk version of DECON, SITEDB.DAT is on the default drive. In the floppy disk version, the default drive is drive A: and SITEDB.DAT is read from drive B:.

APPENDIX E

PREPARATION OF THE SITE DATA BASE

Three programs are used in preparing the site data base so that the data can be used directly by DECON. These are 1) the dose model, 2) the grid model, and 3) the site data model. They have the following functions:

- The dose model transforms CRAC2 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, organizes the accident grid and generates dose rates and n-year dose commitments at the mid-point of each grid element that must be processed
- The site data model accepts data by political subdivision (township, county and/or state); it then 1) imputes corresponding values to the elements of the accident grid, and 2) tranforms areas by land use type into areas by surface type.

E.1 THE DOSE MODEL

The dose model is used to develop dose-related information that is used in DECON. Such information is required by DECON in 1) selecting the appropriate decontamination method to apply to a contaminated surface, 2) computing the dose avoided by relocating the resident population until decontamination has been completed, 3) computing dose to radiation workers, and 4) identifying the boundaries of the accident area within which monitoring and surveying activities need to be undertaken.

The dose model is based on mathematical models used in the CRAC2 computer program as defined in the Reactor Safety Study (USNRC 1975). Several time points and periods must be defined in carrying out the analysis. These include:

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. 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. The term "monitoring time" is used to represent this time period.
3. The time at which the dose period is to begin, and referred to as the "dose starting time." It represents a time at which reoccupation of the site begins. This time is varied in the analysis to determine the optimum time for re-entry.

4. The time period over which the dose is to be integrated, also known as the "dose period. This period will normally be either one or seventy years.

Daughter contributions are considered for inhalation and external dose calculations. The reader is referred to Appendix VI of the Reactor Safety Study (USNRC 1975) for details.

E.2 THE GRID MODEL

The grid model performs several functions relating to organizing the accident grid. First, it reads in the smallest value of dose or dose commitment that will be required in the site restoration analysis; this is the value of the strictest cleanup standard considered. Using this value, the grid model determines the maximum number of grid sectors that must be processed. This number will depend upon the width of the plume relative to its downwind distance and the number of degrees of arc per sector. The CRAC2 grid is divided into 16 sectors, each of $22\text{-}1/2^{0}$. Typically, the maximum number of sectors required with this grid is three or five for a wide range of cleanup standards.

The next step is to determine how many distance intervals must be processed; i.e., how far from the release point the analysis must extend. Having thus bounded the problem latitudinally and longitudinally, the grid model then numbers each grid element within the bounded area sequentially. The numbering scheme was illustrated in Figure 5.1. This numbering scheme will provide the order in which DECON processes the grid elements.

The final step is to compute doses or dose commitments for each grid element. To do this, the grid model must be able to estimate dose at any location downwind from the release point but off the plume centerline. This is accomplished as follows: CRAC2 is run to produce a file of ground concentrations along the plume centerline at each of several downwind distances. At each distance interval, the plume is assumed to have a Gaussian distribution taken orthogonally to the centerline. The mean of the distribution is, of course, at the centerline, and the standard deviation is denoted by σ_y. The dose model transforms this information on ground concentrations into corresponding information on dose or dose commitment. Using trigonometric relationships, the grid model computes the dose or dose commitment at the center of each numbered grid element based on the Gaussian distribution value, σ_y, and the dose or dose commitment at the corresponding point on the centerline.

E.3 SITE DATA MODEL

As already noted, the site data model performs two basic functions. First, it takes information based on political subdivisions and develops comparable information for each grid element. Secondly, it tranforms areas by land use type into areas by surface type. The techniques for accomplishing these functions are described in this section.

E.3.1 Imputing Data Values to Grid Elements

In this section we describe the methodology for mapping county-based data onto a radial grid. A typical CRAC2 accident grid was illustrated in Figure 3.1 on page 3.2. The first step in generating the data base for the accident grid is to superimpose the accident grid on a map showing the boundaries of the political subdivisions. Ideally, township data should be used within 40 to 50 miles of the release point. County and even state data can be used at points further away. Each area element of the grid is then associated with the political subdivisions included within its boundary lines; specifically, the proportion of the area element in each of the political subdivisions is estimated. Call these proportions w_{ij}, where there are i political subdivisions and j grid elements. It is clear that

$$\sum_{i=1}^{I} w_{ij} = 1.0 \quad \text{for all } j$$

Other data that are presumed to be available for the analysis are:

$A_{\cdot j}$ = the land area in grid element j
$A_{i\cdot}$ = the land area in political subdivision i
$P_{\cdot j}$ = the population in grid element j
$P_{i\cdot}$ = the population in political subdivision i
$d_{i\cdot l}$ = the fraction of area in political subdivision i that is in land use $l, =1,...,L$.

In $d_{i\cdot l}$, let the first r of the 1 land use categories represent residential uses. These may include single-family, multi-family, mobile homes, etc.

The land area, $A_{\cdot j}$, and the population, $P_{\cdot j}$, are the only accurate information that is available for grid elements. This information is to be used to adapt the political subdivision information to the accident grid.

In the next step, we determine how much land is used for residential purposes in each grid element. Acreage in residential use in political subdivision i is given by

$$\overline{RA}_{i\cdot} = A_{i\cdot} \sum_{l=1}^{r} d_{i\cdot l}$$

Using the weights w_{ij} defined earlier, we determine the <u>expected</u> residential acreage in grid element j from

$$RA_{\cdot j} = \sum_{i=1}^{I} w_{ij} RA_{i\cdot}$$

A more direct estimate of the residential acreage in grid element j can be obtained by using the actual population in grid element j, and assuming that the population density per residential acre is a weighted sum of the densities in the individual political subdivisions. That is,

$$RA^*_{\cdot j} = P_{\cdot j} \sum_{i=1}^{I} w_{ij} \frac{P_{i\cdot}}{RA_{i\cdot}}$$

This second estimate, $RA^*_{\cdot j}$, will usually be a more accurate estimate of the residential acreage in grid element j. Therefore, we will use this estimate to adjust the estimates of other land uses in grid element j.

Although it seems reasonable to assume that commercial and, to a lesser extent, industrial activity are positively correlated with residential density (except in very small area elements), we have assumed in the current version of the site data model that intercorrelations among land use types are zero. Therefore, the difference between the two estimates of residential acreage, $RA_{\cdot j}$ and $RA^*_{\cdot j}$, will be spread proportionately among the other land use categories as follows:

$$\text{Let } \Delta_{\cdot j} = \frac{A_{\cdot j} - RA^*_{\cdot j}}{A_{\cdot j} - RA_{\cdot j}}$$

$\Delta_{\cdot j}$ is the factor by which nonresidential land uses must be increased or decreased within political subdivision j to compensate for "unexpected" excesses or deficiences in residential land use within the grid element. The unadjusted, expected land use in nonresidential categories is

$$A_{\cdot j} \sum_{i=1}^{I} w_{ij} d_{i \cdot l} \qquad (l=r+1,\ldots,L)$$

The adjusted, expected land use is

$$L_{jl} = \Delta_{\cdot j} A_{\cdot j} \sum_{i=1}^{I} w_{ij} d_{i \cdot l} \qquad (l=r+1,\ldots,L)$$

The last step is to transform the land use information developed for each grid element j into surface type information, since only the latter are compatible with decontamination procedures. This is described in Section E.3.2.

The site data model must also transform property value information to the accident grid. The current version of this model requires only an estimate of the market value of taxable property within each political subdivision. Reasonably recent estimates are available from (Census of Governments, 1978).

If $V_{i\cdot}$ is the market value of taxable property within political subdivision **i**, then the market value of taxable property within grid element j can be estimated from

$$V_{\cdot j} = \sum_{i=1}^{I} w_{ij} V_{i\cdot}$$

(Census of Government, 1978) gives the ratio of the value of all property to taxable property as 1.95. Then the value of all property within grid element j is estimated by

$$\bar{V}_{\cdot j} = 1.95 V_{\cdot j}$$

Currently available data bases provide information from which it might be possible to develop stable relationships for relating property values directly to land use categories. This would allow the decision module within the program DECON to behave more realistically in making decontamination/interdiction decisions.

E.3.2 Transformation of Land Uses into Surface Types

In this section, we describe the basis for transforming land using data into data relating to surfaces. The approach that is used is to divide the area to be decontaminated into a number of surface types.

E.3.2.1 Land Use Categories Currently Implemented

Currently, ten different land use categories are implemented by DECON; they are reported in Table E.3.1. With the notable exception of wet areas, these land uses are expected to encompass all of the major land uses found around reactors. Wet areas have not been researched to determine what decontamination procedures are applicable and under what circumstances. In addition to these ten land use types, DECON also has the capability of addressing the decontamination of automobiles.

TABLE E.3.1. Land Uses Currently Implemented

1. Residential	6. Parking Lots
2. Commercial	7. Grain Crops
3. Industrial	8. Vegetable Crops
4. Streets and Roads	9. Orchards
5. Wooded Areas	10. Vacant Land

Another important category of property that has not been addressed is building contents. Thus, household furnishings and personal belongings in residences, and furnishings, fixtures, records, raw materials, inventory,

machinery and equipment in commercial and industrial buildings have not been treated in our analysis.

E.3.2.2 Relationship of Land Use to Surface Type

It is convenient to utilize land use information to characterize the areas that need to be decontaminated. Such information has the virtues 1) of being site-specific; 2) of being readily available from state and local government agencies in most areas; and, most importantly, 3) of being adaptable to a decontamination analysis framework.

With regard to the actual application of decontamination techniques to property, however, it is more precise to consider the treatment of specific physical surfaces rather than of land use types. The decontamination of plaster walls, linoleum floors and asphalt roofs lends an accuracy to the analysis that is lost in the more general concept of decontaminating residential property. To proceed along these lines, it is necessary to provide the linkage between land use types and surface types. The surface types currently implemented by DECON are presented in Table E.3.2.

The following discussion documents PNL's development of the relationship between land use types and surfaces. The estimates that have been developed are based on land use and surface relationships that are believed to be widely representative. The relationships have been incorporated within a subroutine used in the site data model, which prepares the site database used in DECON. This subroutine, called XFORM, has been structured so that it is a simple matter to alter these relationships either because better general information

TABLE E.3.2. Surface Types Currently Implemented by DECON

1. Agricultural Fields	12. Interior Walls, Brick
2. Orchards	13. Streets and Roads, Asphalt
3. Vacant Land	14. Streets and Roads, Concrete
4. Wooded Land	15. Roofs
5. Exterior Walls, Wood	16. Lawns
6. Exterior Walls, Brick	17. Auto Exteriors
7. Floors, Linoleum	18. Auto Interiors
8. Floors, Wood	19. Auto Tires
9. Floors, Carpeted	20. Auto Engine and Drive Train
10. Floors, Concrete	21. Other Paved Surfaces, Asphalt
11. Interior Walls, Painted	22. Other Paved Surfaces, Concrete

has become available or because the analyst wishes to exploit available information relating to a specific study area.

E.3.2.2.1 Methodology. For several of the land use types there is a one-to-one correspondence between land use type and surface type. For example, the orchard land use type is entirely equivalent to the orchard surface type. This equivalence relationship also exists for vacant land and wooded land.

Other land use types, such as streets and roads are broken down into just two surfaces: asphalt and concrete streets and roads. However, for some land uses, there are several different constituent surfaces. This is especially true for land use types which contain structures. These are residential, commercial and industrial areas. The presence of buildings means that not only are there more surface types, but because of vertical walls and multiple floors, total surface area is not equal to but greater than the area of the land use type.

Subroutine XFORM uses a similar methodology for residential, commercial and industrial areas. Conceptually, there are three basic steps in this methodology, though these are often combined in the actual calculation. The first step is to disaggregate the total land area into its horizontal components. For residential, commercial and industrial property these components generally include roofs, lawns, asphalt and concrete pavement and vacant land. Because roofs may overhang the structure, or because multi-layered open-air parking garages may be present, total horizontal exterior surface area may exceed the corresponding land area somewhat.

After estimating the relative areas of the horizontal exterior surfaces, the second step involves specifying the basic dimensions for a representative structure within that land use area. The most important of these dimensions is roof area since the other dimensions of the structure are specified as a proportion of the roof area. In this way, the surface area of interior walls, exterior walls, floors and basements are all derived.

In the third step, the percentage of wall and floor areas covered by different materials is specified. Thus, total floor area is apportioned among the various floor surface materials: linoleum, carpet, wood, or concrete. Due to resource constraints, not all types of surfaces have been addressed. For example, ceramic tile floors and exterior walls of aluminum siding are surfaces that have not been included.

This methodology and the factors to be estimated are described more explicitly by the equations in Table E.3.3. The term LUA denotes land use area and represents the area of residential, commercial, or industrial land under consideration. The upper case subscripted S's stand for the different surface types being estimated, while the lower case letters refer to factors that are to be estimated. These factors serve to define the relationships between surface areas and land use types. The definitions of these factors are given in Table E.3.4, and the specific estimates developed for these factors are shown in Table E.3.5. The discussion of how these estimates were developed is presented in Section E.3.2.2.2. The remainder of this section is devoted to explaining the medning of the equations in Table E.3.3.

The first seven equations in Table E.3.3 deal with horizontal, exterior surfaces. Factors a through g represent simple fractions of the total land use area. Note, however, that these factors do not necessarily sum to unity for any particular area. The reason is that such things as overhanging roof eaves and multi-storied open-air parking garages may make the total horizontal exterior surface area greater than the corresponding land area. Note also that not all land use types are comprised of all of the surface types. For example,

TABLE E. 3.3. General Methodology Used in Subroutine XFORM

Surface	Equation	
Roof	$S_{15} = a \times LUA$	1.1
Asphalt road	$S_{13} = b \times LUA$	1.2
Concrete road	$S_{14} = c \times LUA$	1.3
Other asphalt	$S_{23} = d \times LUA$	1.4
Other concrete	$S_{24} = e \times LUA$	1.5
Lawn	$S_{16} = f \times LUA$	1.6
Vacant	$S_{3} = g \times LUA$	1.7
Exterior concrete, brick wall	$S_{6} = i \times h \times S_{15}$	1.8
Exterior wood wall	$S_{5} = j \times h \times S_{15}$	1.9
Linoleum floor	$S_{7} = (n \times k + r \times m \times l)\ S_{15}$	1.10
Wood floor	$S_{8} = (o \times k + s \times m \times l)\ S_{15}$	1.11
Carpeted floor	$S_{9} = (p \times k + t \times m \times l)\ S_{15}$	1.12
Concrete floor	$S_{10} = (q \times k + u \times m \times l)\ S_{15}$	1.13
Painted wood, plaster interior wall	$S_{11} = (x \times v + z \times w \times 1)\ S_{15}$	1.14
Interior concrete wall	$S_{12} = (y \times v + a' \times w \times 1)\ S_{15}$	1.15

TABLE E.3.4. Factors and Definitions for Subroutine XFORM

Factor	Definition
a	ratio of roof area to land use area
b	ratio of asphalt road area to land use area
c	ratio of concrete road
d	ratio of other asphalt area to land use area
e	ratio of other concrete area to land use area
f	ratio of lawn area to land use area
g	ratio of vacant area to land use area
h	ratio of exterior wall area to roof area
i	fraction of exterior walls that are concrete or brick
j	fraction of exterior walls that are painted wood
k	ratio of floor area to roof area
l	fraction of buildings with basements
m	ratio of basement floor area to roof area
n	fraction of floor area that is linoleum
o	fraction of floor area that is wood
p	fraction of floor area that is carpeted
q	fraction of floor area that is concrete
r	fraction of basement floor area that is linoleum
s	fraction of basement floor area that is wood
t	fraction of basement floor area that is carpeted
u	fraction of basement floor area that is concrete
v	ratio of interior wall area to roof area
w	ratio of basement wall area to roof area
x	fraction of interior wall area that is painted wood or plaster
y	fraction of interior wall area that is concrete
z	fraction of basement wall area that is painted wood or plaster
a'	fraction of basement wall area that is concrete

by definition residential areas exclude roads since that is a separate land use type. However, commercial and industrial areas contain large paved areas such as parking lots. These large paved areas are treated in the same way as either concrete or asphalt roads. The categories "other paved surfaces, asphalt" and "other paved surfaces, concrete" refer to smaller exterior paved areas, such as patios, driveways and car port floors, which are not generally amenable to the high production rate decontamination techniques that can be applied to roadways.

As we have already noted, the estimation of roof area is especially important because it is used in essentially all of the remaining equations. Equations 1.8 and 1.9 are an example. They generate exterior concrete and painted wood wall surface areas. Factor h represents the ratio of total exterior wall area to roof area, and factors i and j further break down exterior wall area into concrete and painted wood surfaces.

Equations 1.10 through 1.13 deal with floor surfaces. These equations are not quite as simple as the exterior-wall equations. The primary reason for

TABLE E.3.5. Factor Estimates by Land Use Type

Factor	Residential	Commercial	Industrial
a	0.26	0.70	0.27
b	0.00	0.20	0.25
c	0.00	0.13	0.13
d	0.01	0.00	0.00
e	0.04	0.00	0.00
f	0.70	0.00	0.02
g	0.00	0.00	0.33
h	1.58	1.20	1.14
i	0.15	1.00	1.00
j	0.85	0.00	0.00
k	1.33	1.80	1.60
l	0.48	0.40	0.00
m	0.70	0.90	0.00
n	0.20	0.54	0.15
o	0.25	0.00	0.00
p	0.55	0.24	0.05
q	0.00	0.22	0.80
r	0.17	0.20	0.00
s	0.01	0.00	0.00
t	0.02	0.00	0.00
u	0.80	0.80	0.00
v	2.40	2.22	2.00
w	0.96	1.10	0.00
x	1.00	1.00	0.45
y	0.00	0.00	0.55
z	0.05	0.20	0.00
a'	0.95	0.80	0.00

this is that two types of floors are explicitly estimated: nonbasement floors and basement floors. Factor k represents the ratio of nonbasement floor area to roof area. In other words, k is approximately the average number of floors per structure. The factor preceding k in the equations is the proportion of nonbasement floor that is comprised of linoleum (n), wood (o), carpet (p), or concrete (q). The nonbasement floor surfaces are added to the basement floor surfaces as indicated by the addition within the parentheses. The three terms on the right side of the plus sign refer to basement floor surfaces. The factor l represents the proportion of homes that have basements. The factor m is the ratio of basement floor area to roof area. The factors r, s, t, and u are the fractions of basement floors that are covered with the four materials listed.

Equations 1.14 and 1.15 estimate the area of concrete and painted wood or plaster interior wall surfaces. The structure of these equations is analogous to the floor equations. Factor v is the ratio of interior wall area to roof area, and factor w is the ratio of basement wall area to roof area. Factors x, y, z, and a' indicate the proportions of wall area constructed of concrete or painted wood and plaster.

The methodology embodied in these equations is intended to be general. That is, should the user wish to add other land use types, these equations may be directly applicable for generating surface area estimates, once the factor values for the new land use type have been determined.

E.3.2.2.2 Estimation of Factors. In this section the derivation of the factor estimates is described and principle information sources are provided. The discussion of the factor estimates generally follows the surface area estimating methodology. That is, the first step is to determine the exterior, horizontal surface factors. Then, based on the dimensions of a representative structure for that land use type, the exterior wall area, interior wall area, and floor areas are estimated as proportions of the roof area. These surfaces are then subdivided into the specific materials with which they are constructed or covered. For example, once the floor area factor is estimated it is necessary to estimate the proportion which is linoleum, wood, concrete, or carpeted. Finally, the factors for surfaces associated with basements are estimated.

It is important to note two important facts regarding the residential area factor estimates. First, data for estimating the factors are extremely limited, and much of the data which are available provide only indirect information about the factors. Second, the intent of these estimates is to characterize the surface makeup of representative residential, commercial, and industrial areas. For each of these land use categories there is a very wide variance in construction techniques, land cover, materials, and so forth. Therefore, true factor values for any particular area could differ greatly from the estimates developed here. This suggests that where such differences are large it may be desirable to specify alternate values for these factors.

Both of these difficulties could be addressed at least to the extent of identifying exterior surfaces for any particular area by the use of high-quality aerial photos combined with standard manual or automated aerial reconnaissance techniques. By determining building dimensions and density, it may also be possible to refine estimates of factors for interior surfaces. Such photos are sometimes available from the United States Geological Survey or from local municipalities, where they are used for zoning, planning, and mapping purposes. In fact, the NRC already has a set of high-quality aerial photos (transparencies and prints) covering the vicinity around approximately 60 reactor sites. There is one photo per site, and each covers a square area about 11.5 miles on a side. With good equipment, the transparencies can be used to identify features less than one square meter in size. Also, they could be scanned and digitized for computer storage and analysis. A major reactor accident, however, could affect areas significantly further away than 11.5 miles from the reactor site.

Residential Areas. Residential land use areas in this work refer to areas comprised of single-family detached homes and excluding public roads, vacant land and wooded areas. Apartments are included in commercial land use areas. Other residential types, such as single-family attached and mobile homes, have not yet been addressed.

To be considered first are the factors defining the exterior horizontal surface areas (roof, lawn, other concrete, and other asphalt). A guide for determining the share of residential land covered by lawn lies in several studies prepared for various locations concerned with rain water runoff. In analyzing the amount, rate, and pollution of runoff, these studies generally estimate the percentage of land cover which is "impervious". Impervious cover includes houses, sidewalks, roads, parking lots, and other surfaces which prevent rainfall from penetrating into the soil. The principal surface not included in this group is lawn. Thus, we can assume that, after some adjustments to the data, any residential surface that is not impervious is lawn.

The United States Geological Survey provided sections of a number of these runoff studies, each of which deals with several drainage areas within a specific city or urban area. There is no study that identifies the percentage of impervious cover for all residential areas in the United States. Further, the locales for these investigations were not selected with any intent to be representative of any particular land use type. This means that these data can only give an indication of the range and variability of *f*, the ratio of lawn area to total area.

Table E.3.6 presents data from these reports that are relevant for estimating lawn cover in residential areas. Note that the drainage areas in the runoff reports are not strictly residential according to the designations used in this work. In particular, impervious area in the runoff reports includes road surfaces, and some reports noted proportions of the drainage area that are commercial, industrial, or other use type.

The Pompano Beach, Florida, site characteristics provide sufficient information to make a rough estimate of how much the given impervious percentage should be adjusted to remove road surface area. Assuming a street width of 25 feet, which appears reasonable from the aerial photo in the report, then each lot, including its share of the street, measures about 92.5 feet by 100 feet, making a total of 9250 square feet per lot. Since 43.9 percent is designated impervious, that is equivalent to about 4060 square feet. Of this area, the street comprises an area of about 12.5 by 80 feet, an area of 1000 square feet. Thus, the impervious nonstreet area per parcel is about 3060 square feet, or 33 percent of the nonstreet residential area. Another way of looking at this is that about 10 percent of the land (or 25 percent of the reported impervious area) is road pavement. The impervious cover estimate is adjusted for road surfaces by subtracting 10 percent from the figure given.

In addition, some site descriptions include information on the amount of vacant land and other characteristics. Assuming that open land, parks, public land, conservational land, agricultural land, and so forth are all pervious surfaces, the pervious-impervious estimate for residential areas can be further improved. The fifth column of Table E.3.6 shows the impervious area percentage after taking into account the adjustment for road surface and this last adjustment for vacant land. However, no adjustment was made for industrial and commercial areas since their surface composition (pervious or impervious) was not known. By subtracting these adjusted impervious area figures from 100, an estimate of lawn area was obtained. These estimates are listed in the last

TABLE E.3.6 Selected Data from Runoff Reports

Source	Site	Site Characteristics		Impervious Area (%)	Adjusted Impervious Area (%)	Estimated Lawn Area (%)
"Effects of Storm Runoff on Water Quality in the Mill Creek Drainage basin, Willingboro, New Jersey"	W1, W2, W4, W5, W9	Single-family residential	= 56.25%	24.70	25.0	75.0
		Multi-family residential	= 0.0%			
		Commercial	= 0.50%			
		Industrial	= 12.10%			
		Public, conservational, recreational	= 31.15%			
"Quantity and Quality of Urban Runoff from the Denver Metropolitan Area, Colorado"	Littleton	Single-family residential	= 75%	25	23.1	76.9
		Parks and open space	= 25%			
	Lakewood	Multi-family residential	= 30%	40	75.0	25.0
		Commercial	= 20%			
		Undeveloped	= 50%			
	Denver	Mixed single- multi-family res	= 37%	65	65.5	34.5
		Multi-family	= 37%			
		Commercial	= 20%			
		Parks	= 6%			
"Urban Storm-Water-Quality Data Portland, Oregon, and Vicinity"	Fanno Creek	Single-family residential	= 76%	32	28.2	71.8
		Multi-family residential	= 6%			
		Commercial	= 6%			
		Rural	= 12%			
	Willamette R. tributary in Oak Grove	Single-family residential	= 73%	36	34.7	65.3
		Multi-family residential	= 4%			
		Commercial	= 8%			
		Rural	= 15%			

Source	Site	Site Characteristics							Impervious Area (%)	Adjusted Impervious Area (%)	Estimated Lawn Area (%)
	Tyron Creek	Single-family residential = 72% Multi-family residential = 10% Commercial = 5% Rural = 13%							32	28.6	71.4
"Storm Runoff As Related to Urbanization in the Portland, Oregon-Vancouver, Washington Area"		A	B	C	D	E	F	*			
	Vancouver sewer outfall	25	0	13	36	21	5		49	60.0	40.0
	Beaverton Creek	25	3	51	4	13	4		23	21.0	79.0
	Fanno Creek	13	0	7 5	6	6	0		32	28.6	71.4
	Singer Creek	18	0	77	4	1	0		28	25.0	75.0
	Willamette River Tributary (Oak Grove)	14	0	74	4	8	0		36	34.2	65.8
	Tyron Creek Tributary	12	0	72	11	5	0		32	28.2	71.8
	NE Hancock-Flint sewer	2	0	0	91	5	2		43	37.5	62.5

Source	Site	Site Characteristics						Impervious Area (%)	Adjusted Impervious Area (%)	Estimated Lawn Area (%)
		A	B	C	D	E	F *			
	N Albina-Kilpatrick sewer	6	0	1	75	18	0	44	40.5	59.5
	N Vancouver-OWR&N sewer	2	0	0	81	17	0	46	40.9	59.1
"Characteristics of Four Urbanized Basins in South Florida"	Pompano Beach, Broward Co., FL	Land use: single-family residential Average lot size: 80' x 100' Average house size: 40' x 60'						43.9	32.9	67.1
	Kings Creek Apts., So. Miami, FL	Land use: apartments						70.7	53.0	47.0
"Bellevue Urban Runoff Project and Bellevue Street Sweeping Demonstration Project"	Surrey Downs	Single-family homes and a senior high school						35.0	26.3	73.7
	Lake Hills	Single-family homes and church						43.1	32.3	67.7

Source	Site	Site Characteristics	Impervious Area (%)	Adjusted Impervious Area (%)	Estimated Lawn Area (%)
"Quality of Runoff From Small Watersheds in the Twin Cities Metropolitan Area, Minnesota--Hydrologic Data for 1980	80th St. storm sewer	Fully developed medium-density residential	16.0	7.6	92.4
	Estates Drive	Medium- to high-density single-family residential	29.0	21.8	78.2
	Highway 100	High-density single-family with intersection commercial	35.0	26.3	73.7
	Valley View Road	Medium-density single- and multi-family	11.0	8.3	91.7

*A = Parks, forests, vacant
B = Agricultural
C = Light to normal residential
D = Dense residential
E = Apartments and commercial
F = Downtown and industrial