The coverage rate per lance for this system is reported at about 20 feet by 20 feet in two hours. This comes to about 11 sq meters per hour with adjustment for personnel and equipment decontamination.

The labor cost is $16.50 per hour, and the equipment cost (per lance) is $53.50. Dividing by the hourly coverage rate gives the labor cost as $1.55 per sq meter and the equipment cost as $5.00 per sq meter.

To this we add the cost of one common laborer at $17.45 per hour with a wet vacuum costing $1.00 per hour. The resulting total cost is $8.50 per sq meter, of which $3.39 is for labor and $5.11 is for equipment.

A.3.2.6 High-Pressure Water

This operation uses equipment frequently employed to strip old paint from wood walls. A small portable pump is used to raise the water pressure. In addition, there is a spray wand with special nozzle for directing the water to the surface. The cost for this equipment, based on rental information supplied by Handy Andy Rent-A-Tool in Seattle, Washington, is $600 per month. This comes to about $2.00 per hour.

The labor required is one common laborer at $17.45 per hour.

The coverage rate for this equipment was observed at about 90 sq feet per hour for a thorough job of paint removal. With adjustment for one hour per shift for personnel and equipment decontamination, this is equivalent to 8 sq meters per hour.

Dividing the coverage rate into the hourly costs gives $2.18 per sq meter for labor, $0.25 for equipment, and $2.43 for the total.

A.3.2.7 Remove and Replace

For severely contaminated exterior painted wood walls, it may be necessary to remove and replace the entire surface. Normally this would be preceded by vacuuming and application of a fixative.

Removal and replacement involves three distinct steps for which costs and rates are estimated separately. These are removal of existing wall surfaces, replacement with new siding, and painting of new siding. The primary source for this operation is Means' Building Construction Cost Data 1982. This source provides mutually consistent data for all three procedures.

Exterior wood wall removal, according to Means (p. 371), requires one foreman at $22.25 per hour and two building laborers at $19.40 per hour each, for a total hourly labor cost of $61.05. Equipment would be those tools normally supplied by the workers themselves.

The production rate given is 700 sq feet per day. After adjusting for one hour per shift for personnel decontamination, this rate converts to 7 sq meters per hour. Dividing this into the hourly cost gives $8.60 per sq meter, all of which is for labor.

According to Means (p. 162), replacement requires two carpenters at $24.35 per hour each. The total hourly labor cost is, therefore, $48.70. The hourly cost for power tools is given as $1.73. The total labor and equipment cost comes to $50.43.

The total hourly cost can be found by multiplying the hourly rate

$$750\ ft^2/day \div 8\ hr/day = 93.75\ ft^2/hr$$

by the cost per sq foot

$$93.75\ ft^2/hr \times \$0.89/ft^2 = \$83.43/hr$$

Subtracting the hourly labor and equipment charge from this total gives the hourly cost of materials:

$$\$83.43 - \$50.43 = \$33.00$$

The cost of materials is calculated as the difference between total and the sum of labor and equipment because Means reports total, labor, and equipment costs with markups for overhead. While overhead is implicitly added to material cost, the source does not provide information for direct calculation of the markup to be applied to materials. This calculation method yields the appropriate cost for materials with markup. The Means data requires this method be used in most every instance in which materials are part of the cost.

The hourly rate is

$$750\ ft^2/day \div 8\ hr/day \times 0.0929\ m^2/ft^2 \times 7/8\ adj = 7.6\ m^2/hr$$

Dividing this rate into the hourly input costs yields costs on a sq-meter basis:

$$\text{Labor:}\quad \frac{\$48.70/hr}{7.6\ m^2/hr} = \$6.41/m^2$$

$$\text{Equipment: } \frac{\$1.73/\text{hr}}{7.6\ \text{m}^2/\text{hr}} = \$0.23/\text{m}^2$$

$$\text{Materials: } \frac{\$33.00/\text{hr}}{7.6\ \text{m}^2/\text{hr}} = \$4.34/\text{m}^2$$

The sum of these gives the total cost per sq meter as $10.98.

Means (p. 231) indicates that painting wood siding with primer and one coat, including puttying, requires one ordinary painter at $22.55 per hour. The total cost per hour is found by multiplying the hourly rate

$$665\ \text{ft}^2/\text{day} \div 8\ \text{hr/day} = 83.125\ \text{ft}^2/\text{hr}$$

by the cost per sq foot

$$83.125\ \text{ft}^2 \times \$0.39/\text{ft}^2 = \$32.42/\text{hr}$$

The material cost is found by subtracting the labor cost from this total:

$$\$32.42/\text{hr} - \$22.55/\text{hr} = \$9.87/\text{hr}$$

The adjusted hourly coverage rate in metric units is

$$83.125\ \text{ft}^2/\text{hr} \times 0.0929\ \text{m}^2/\text{ft}^2 \times 7/8\ \text{adj} = 6.8\ \text{m}^2/\text{hr}$$

Dividing the hourly costs by the hourly production yields the costs in terms of dollars per sq meter:

$$\text{Labor: } \frac{\$22.55/\text{hr}}{6.8\ \text{m}^2/\text{hr}} = \$3.32/\text{m}^2$$

$$\text{Material: } \frac{\$9.87/\text{hr}}{6.8\ \text{m}^2/\text{hr}} = \$1.45/\text{m}^2$$

The total is the sum of the input costs, or $4.77 per sq meter.

Table A.3.2.7.1 summarizes the foregoing calculations and shows the total costs for the entire operation combining the three steps. Using the convention employed throughout this report, the most costly procedure determines the overall rate. Therefore, the rate for the entire operation is 7.6 sq meters per hour. This means that 7.6 ÷ 7.1 = 1.07 removal crews and 7.6 ÷ 6.8 = 1.12 painting crews would be used for every replacement crew. Together, in these ratios, they comprise an entire removal and replacement crew.

TABLE A.3.2.7.1. Summary of Data for Removal and Replacement of Painted Exterior Wood Walls

Procedure	Rate (m^2/hr)	Cost (1982 $/$m^2$) Total	Labor	Equipment	Material
Removal	7.1	8.60	8.60	--	--
Replacement	7.6	10.98	6.41	0.23	4.34
Painting	6.8	4.77	3.32	--	1.45
Total	7.6	24.35	18.33	0.23	5.79

A.3.2.8 Foam

The use of acidic foam as a decontamination operation is described in Section A.1.5.5. Also, the material cost is calculated there as $0.0753 per sq meter for application and $0.0074 for removal, for a total material cost of $0.0827 per sq meter.

Since the foam is applied with aspirated spray equipment as is paint, the application cost is taken as equal to the cost of applying a fixative to walls, which was estimated in Section A.3.2.3. Similarly, removal of the foam would be accomplished by vacuuming, the cost of which was developed in Section A.3.2.4.

Table A.3.2.8.1 summarizes these data and calculates the total costs for a foam treatment. Note that since the most costly procedure by convention determines the rate, 40 ÷ 69 = 0.58 removal crews would be combined with each application crew to make one foam treatment crew. The rate for the whole operation is 40 sq meters per hour.

TABLE A.3.2.8.1. Summary of Data for Foam Treatment of Painted Exterior Wood Walls

Procedure	Rate (m^2/hr)	Cost (1982 $/m^2) Total	Labor	Equipment	Materials
Application	40	0.6793	0.555	0.049	0.0753
Removal	69	0.1894	0.16	0.22	0.0074
Total	40	0.8687	0.715	0.071	0.0827

A.3.2.9 Strippable Coating

The basic functioning of strippable coating as a decontamination technique is described in Section A.1.5.6. In addition, the material cost is also calculated there at $1.77 per sq meter.

Like fixative and foam application to exterior painted wood walls (see Sections A.3.2.3 and A.3.2.8), strippable coating would be sprayed on. However, this material requires an airless sprayer. Here, as in the previous section, we use cost figures developed in Section A.3.2.3 for the application cost.

Removal costs and rates require extensive estimation since this is not an activity for which there is much data. Removal would involve one common laborer at $17.45 per hour, equipped with incidental hand tools. We estimate the removal rate at 35 sq meters per hour. The cost per sq meter, therefore, is

$$\$17.45/\text{hr} \div 35\ \text{m}^2/\text{hr} = \$0.50/\text{m}^2$$

In addition to application and removal, there is also the cost of disposal of the removed coating. This is discussed in Section A.3.1.7, and the cost estimates used there for centralized collection of the coating are used here. Ultimate disposal costs are calculated as separate hauling costs.

The costs and rates are presented and summarized in Table A.3.2.9.1. The overall rate is set equal to that of the most costly step, application. This means that $40 \div 35 = 1.14$ removal crews and $40 \div 488 = 0.08$ collection crews would be combined with one application crew to form a complete crew for a strippable coating treatment.

A.3.3 Exterior Brick Walls

Many decontamination operations for painted wood exterior walls are identical to operations applicable to brick walls. However, while operation costs and rates may be the same, the rougher texture and porosity of brick result in lower decontamination efficiencies.

TABLE A.3.2.9.1. Summary of Data for Strippable Coating Treatment of Painted Exterior Wood Walls

Procedure	Rate (m^2/hr)	Cost (1982 \$/m^2) Total	Labor	Equipment	Material
Application	40	2.37	0.55	0.05	1.77
Removal	35	0.50	0.50		
Collection	488	0.05	0.04	0.01	
Total	40	2.92	1.09	0.06	1.77

A.3.3.1 Water Wash

See Section A.3.2.1.

A.3.3.2 Wash and Scrub

See Section A.3.2.2.

A.3.3.3 Fixative

See Section A.3.2.3.

A.3.3.4 Vacuum

See Section A.3.2.4.

A.3.3.5 Hydroblast

See Section A.3.2.5. Note that higher water pressures could be used on brick than on wood.

A.3.3.6 High-Pressure Water

See Section A.3.2.6.

A.3.3.7 Scarify

See Sections A.3.7.6 and A.3.12.5.

A.3.3.8 Remove and Replace

The general aspects of removing and replacing exterior walls are discussed in Section A.3.2.7. As in the case of removing and replacing exterior wood walls, Means Building Construction Cost Data 1982 is the primary source of information.

Costs for the first step, wall removal, are estimated using Means data for concrete wall removal (p. 371) since no data are supplied for removal of brick walls. The labor specified is 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.

For equipment, Means calls for an air compressor with air tools and accessories. These cost $18.00 per hour.

The rate for removing walls four to twelve inches thick is 220 cubic feet per day. Assuming an average wall thickness of eight inches, converting to metric units per hour and adjusting for one hour per shift for personnel and equipment decontamination yields a rate of 3.35 sq meters per hour.

Dividing the hourly rate into the hourly costs results in costs per sq meter:

$$\text{Labor: } \frac{\$99.85/\text{hr}}{3.35\ \text{m}^2/\text{hr}} = \$29.81/\text{m}^2$$

$$\text{Equipment: } \frac{\$18.00/\text{hr}}{3.35\ \text{m}^2/\text{hr}} = \$5.37/\text{m}^2$$

Total removal cost is

$$\$29.81/\text{m}^2 + \$5.37/\text{m}^2 = \$35.18/\text{m}^2$$

According to Means (pp. 114, 123), installing an eight-inch thick brick wall requires three bricklayers at $24.85 per hour each, two bricklayer helpers at $19.65 per hour each, and 0.25 carpenters for scaffolding construction at $24.35 per hour each. The total hourly labor cost totals $119.94.

The hourly material cost is found by subtracting the hourly labor cost from the hourly total cost:

$$\$176.62/\text{hr} - \$119.94/\text{hr} = \$56.68/\text{hr}$$

The rate in terms of sq meters per hour is calculated in a straightforward manner based on 13.50 bricks per sq foot. Along with adjustments, the rate is

$$0.225\ \text{M br/hr} \times 1000\ \text{br/M} \div 13.50\ \text{br/ft}^2 \times 0.0929\ \text{m}^2/\text{ft}^2$$

$$\times\ 7/8\ \text{adj} = 1.35\ \text{m}^2/\text{hr}$$

Means' total cost per hour can be found by multiplying the number of thousand bricks (M) per hour by the total cost per thousand bricks laid. The daily output is listed at 1.8 thousand bricks. This comes to 0.225 thousand bricks per hour. The total cost per thousand bricks laid is $785. Therefore, the cost per hour is

$$0.225 \text{ M/hr} \times \$785/\text{M} = \$176.62/\text{hr}$$

Dividing the hourly production rate into the hourly costs converts the costs to a dollars-per-sq-meter basis:

$$\text{Labor: } \frac{\$119.94/\text{hr}}{1.35 \text{ m}^2/\text{hr}} = \$88.84/\text{m}^2$$

$$\text{Materials: } \frac{\$56.68/\text{hr}}{1.35 \text{ m}^2/\text{hr}} = \$41.99/\text{m}^2$$

The total cost per sq meter is the sum of these two costs, $130.83 per sq meter.

Table A.3.3.8.1 summarizes the preceding calculations and shows total costs per sq meter for removal plus replacement. Since replacement is the more costly of the two constituent steps, its rate determines the rate of the overall combined operation. This means that 1.35 ÷ 3.35 = 0.40 removal crews would be used with one replacement crew to form the crew for the entire operation.

TABLE A.3.3.8.1. Summary of Data for Removal and Replacement of Exterior Brick Walls

Procedure	Rate (m^2/hr)	Cost (1982 $\$/m^2$) Total	Labor	Equipment	Materials
Removal	3.35	35.18	29.81	5.37	--
Replacement	1.35	130.83	88.84	--	41.99
Total	1.35	166.01	118.65	5.37	41.99

A.3.3.9 Foam

See Section A.3.2.8.

A.3.3.10 Strippable Coating

See Section A.3.2.9.

A.3.4 Exterior Reinforced Concrete Walls

Most decontamination operations for exterior reinforced concrete walls are identical to operations described earlier for exterior painted wood walls and exterior brick walls. However, because concrete walls are generally a little smoother and less porous than brick walls, the decontamination efficiencies for concrete are expected to be slightly higher.

A.3.4.1 Water Wash

See Section A.3.2.1.

A.3.4.2 Wash and Scrub

See Section A.3.2.2.

A.3.4.3 Fixative

See Section A.3.2.3.

A.3.4.4 Vacuum

See Section A.3.2.4.

A.3.4.5 Hydroblast

See Section A.3.2.5. Note that higher water pressures could be used on concrete than on wood.

A.3.4.6 High-Pressure Water

See Section A.3.2.6.

A.3.4.7 Scarify

See Sections A.3.7.6 and A.3.12.5.

A.3.4.8 Remove and Replace

The calculations for removing and replacing exterior concrete walls follow those for brick walls. Again, the primary source is Means' Building Construction Cost Data 1982. On page 371, data are given separately for removal of concrete block walls at thicknesses of four, six, and eight inches, plain concrete walls, and reinforced concrete walls. This list of concrete wall types is in order of increasing cost. Here we assume the wall type to be removed and replaced is reinforced concrete, eight inches thick. For information regarding concrete walls without reinforcement see Section A.3.7.9.

Removal (p. 371) requires the same crew and equipment as used in the removal of brick walls (see Section A.3.3.8). The rate for removing reinforced concrete walls is given as 70 cubic feet per day. Converting to metric units per hour and adjusting for one hour per shift for personnel and equipment decontamination, the rate works out to 1.07 sq meters per hour for eight inch thick walls.

The costs per sq meter are:

$$\text{Labor: } \frac{\$99.85/\text{hr}}{1.07\ \text{m}^2/\text{hr}} = \$93.32/\text{m}^2$$

$$\text{Equipment: } \frac{\$18.00/\text{hr}}{1.07\ \text{m}^2/\text{hr}} = \$16.82/\text{m}^2$$

Total removal costs are:

$$\$93.32 + \$16.82 = \$110.14$$

According to Means (p. 82) installing eight inch thick reinforced concrete walls eight to 14 feet high requires a crew consisting of two outside foremen at \$27.85 per hour each, eight skilled workers at \$25 per hour each, and equipment consisting of an 80-ton crane plus power tools. The hourly equipment cost is \$14.93.

The rate given for wall placement is 7.40 cubic yards per day. After adjustments this is equal to a wall area of 1.02 sq meters per hour.

The total cost per hour may be calculated from the figure of \$435 per cubic yard given in Means (p. 82).

$$\frac{\$435/\text{yd}^3 \times 7.40\ \text{yd}^3/\text{day}}{8\ \text{hr/day}} = \$402.38/\text{hr}$$

This can easily be converted to a cost-per-sq-meter basis.

$$\$402.38/\text{hr} \div 1.02\ \text{m}^2/\text{hr} = \$394.49/\text{m}^2$$

Labor and equipment costs per sq meter are:

$$\text{Labor: } \frac{(2 \times \$27.85 + 8 \times \$25.00)/\text{hr}}{1.02\ \text{m}^2/\text{hr}} = \$250.69/\text{m}^2$$

$$\text{Equipment: } \frac{\$14.93/hr}{1.02\ m^2/hr} = \$14.64\ m^2$$

Material cost per sq meter can be calculated by subtracting labor and equipment costs from the total cost:

$$\text{Material: } \$394.49 - \$250.69 - \$14.64 = \$129.16/m^2$$

Table A.3.4.8.1 summarizes the results of the preceding calculations and shows the total costs per sq meter for removal and replacement. Note that the rate for the entire operation is equal to that of the most costly step, replacement. This means that 1.02 ÷ 1.07 = 0.95 removal crews would be used for each replacement crew.

TABLE A.3.4.8.1. Summary of Data for Removal and Replacement of Exterior Reinforced Concrete Walls

Procedure	Rate (m^2/hr)	Cost (1982 \$/m^2) Total	Labor	Equipment	Materials
Removal	1.07	$110.14	93.32	16.82	--
Replacement	1.02	394.49	250.69	14.64	129.16
Total	1.02	504.63	344.01	31.46	129.16

A.3.4.9 Remove Structure

See Section A.3.13.

A.3.4.10 Foam

See Section A.3.2.8.

A.3.4.11 Strippable Coating

See Section A.3.2.9.

A.3.5 Exterior Glass

For a number of reasons, windows represent a special case as a distinct surface type when considered in the context of a radiation contamination cleanup effort. Because of their placement with respect to walls, it is appropriate that there be some coordination in the selection and application of a decontamination method for the two surfaces. Two special characteristics of windows are noteworthy: 1) As a result of the hardness and smoothness of glass surfaces, methods applied to windows will generally have higher efficiencies than they will on wall surfaces; and 2) they are more susceptible to damage than walls. Therefore, certain operations such as vacuum blasting or hydroblasting would not be appropriate for windows.

Another reason windows require special consideration is that removal and replacement necessarily affects both interior and exterior surfaces. Thus, not only is method selection dependent on the adjacent wall surface, but, in this case, it is also dependent on the method selected for the opposite window surface.

The consequence of these facts is that the procedure for selecting the decontamination method for windows will differ from that used for other surfaces. The first step in identifying the optimal decontamination method for a window surface is to see if the method selected for use on the adjacent wall can be used effectively. If it can be used without damaging the windows and its efficiency is adequate, then that method is selected provided that another method is not required and the selected method does not contain a restricted operation. The reasoning behind this approach to method selection is, first, that it would be impractical and therefore costly not to use the same method on the windows as on the walls. This is because, in most cases, extra cost and effort would be necessary to shield the windows from the wall decontamination procedure or to otherwise work around the windows. Also, doing the windows in conjunction with the walls avoids duplication of set-up costs and effort.

Second, we assume that such methods would be more effective on windows than on wall surfaces and, third, except for removal and replacement, the cost per sq meter would be the same on windows as on walls. For example, if the indicated method on the adjacent wall was a water wash, it would be inconvenient not to use the same procedure on windows. Further, since the method chosen for walls should result in adequate decontamination, the higher efficiencies on windows means that the same method would also produce adequate decontamination of windows. In effect, this means simply increasing the wall area by the window area. Therefore, except for removal and replacement, the costs and rates of these operations on windows are listed as equal to these on walls.

In instances in which the method used on the wall includes an operation which could not be used on windows, the method selection process used to tentatively select a method is the same as is used on other surfaces. The costs and rates of these operations applied to windows are estimated as equal to the cost of performing the operation on the wall plus a cost and rate adjustment associated with moving and setting up equipment and materials.

There is a final step in this method selection process when the method selected for the walls cannot be used on windows. This concerns whether the method involving window removal and replacement should be selected. Separate treatment of this question is required because this single procedure necessarily affects both interior and exterior window surfaces. Therefore, it is necessary to compare the cost of removal and replacement with the sum of the costs of methods tentatively selected for decontaminating the inside and outside window surfaces. If the cost of removal and replacement is less than the sum of the costs of the methods (tentatively) selected for interior and exterior window surface decontamination, and if window removal and replacement provides adequate decontamination, then window removal and replacement is the indicated procedure.

A.3.5.1 Water Wash

See Section A.3.2.1.

A.3.5.2 Wash and Scrub

See Section A.3.2.2.

A.3.5.3 Fixative

See Section A.3.2.3.

A.3.5.4 Vacuum

See Section A.3.2.4.

A.3.5.5 Foam

See Section A.3.2.8.

A.3.5.6 Strippable Coating

See Section A.3.2.9.

A.3.5.7 Remove and Replace

The primary source of information for removing and replacing windows is Means' Building and Construction Cost Data 1982. In addition, a number of glass installation companies were contacted to confirm that the Means figures were reasonable. This book makes apparent the fact that windows vary in a number of respects including frame material (e.g., aluminum, steel, or wood), type of glass (e.g., standard or insulating), and the way in which the window opens (e.g., nonopening, awning, louver, sliding, or vertical hinge).

For the purposes of this report it is necessary to select a window type which is reasonably representative of windows in general, especially in terms of cost, production rate, and inputs required. In selecting a representative window, the costs of various window types are converted to a dollars-per-sq foot basis. This identifies windows that were relatively costly in terms of unit area. Replacement costs range from a low of $5.30 per sq foot for a sliding aluminum window using standard glass measuring eight by four feet to $31.00 per sq foot for a small casement window with screens and insulating glass measuring 1'-10" x 3'-2". Also considered for selecting a representative window are window size, manner in which the window opens, and whether the removal cost of that window type is unusually high or low.

The window used here is an awning type with insulating glass measuring 2'-10" x 6'-0" (17 sq feet). Means (p. 203) gives the installation cost as $295 per window which is equal to $17.35 per sq foot.

Means (p. 371) lists four window removal costs depending on whether the frame material is wood or metal, and depending on whether the window opening is up to 12 sq feet, or is larger than 12 but less than 50 sq feet. These costs are given on a dollars-per-opening basis rather than dollars-per-unit-area basis. Thus, for example, the removal cost for all metal windows from twelve to 50 sq feet is $27.00 each. For window sizes from six to 50 sq feet, the cost per sq foot varies between a low of $0.38 for large wood windows to $3.20 for small metal windows. The cost of removing the representative window is listed in Means as $19.20, or $1.13 per sq foot.

Removal requires one building laborer at $19.40 per hour plus one gas engine power tool at $4.58 per hour (in 1982 dollars).

The rate given for removal of windows of this type is ten window openings per shift. At 17 sq feet per window opening, the production rate converts to:

$$17 \text{ ft}^2/\text{opening} \times 10 \text{ openings/shift} \div 8 \text{ hr/shift} \times .0929 \text{ m}^2/\text{ft}^2$$

$$\times\ 7/8 \text{ adj} = 1.73 \text{ m}^2/\text{hr}$$

Dividing the hourly production rate into the hourly costs yields cost per sq meter:

$$\text{Labor: } \frac{\$19.40/\text{hr}}{1.13 \text{ m}^2/\text{hr}} = \$11.21/\text{m}^2$$

$$\text{Equipment: } \frac{\$4.58/\text{hr}}{1.73 \text{ m}^2/\text{hr}} = \$2.65/\text{m}^2$$

Total removal cost is the sum of these two figures:

$$\$11.21/\text{m}^2 + \$2.65/\text{m}^2 = \$13.86/\text{m}^2$$

Installing the replacement requires a crew of two carpenters at $24.35 per hour each for a total hourly labor cost of $48.70. According to Means, this crew can install eight windows in an eight-hour shift, or one per hour. Thus,