SELECTING COST-EFFECTIVE REMEDIAL ACTION ALTERNATIVES

R. Bonilla
Bechtel National, Inc.
Oak Ridge, TN

ABSTRACT

This paper provides a method for determining cost information for various remedial action alternatives. Twelve alternatives that involve various combinations of cleanup options are presented for buildings at the St. Louis Downtown Site (SLDS). Each of these alternatives has three components: building decontamination, building demolition, and remediation of contaminated subsoil.

INTRODUCTION

The cost study provides data for determining cost-effective remedial alternatives that will be fully developed and evaluated in the feasibility study and determines relative estimated costs of feasible remedial alternatives for each building.

SLDS occupies 18.2 ha (45 acres) in an industrial area on the eastern border of St. Louis, Missouri, approximately 90 m (300 ft) west of the Mississippi River. The population within 48.3 km (30 mi) of the property is 1,300,000, including 22,000 within 1.6 km (1 mi) of the property. SLDS is owned by a large multinational chemical company that manufactures various chemical products. From 1942 to 1957, the company refined uranium at SLDS under contracts with the Manhattan Engineer District (MED) and the Atomic Energy Commission (AEC), a predecessor of the U.S. Department of Energy (DOE).

Radiological, chemical, and hydrogeological characterization activities have been conducted at SLDS as part of the Formerly Utilized Sites Remedial Action Program (FUSRAP), which AEC initiated in 1974. FUSRAP, now managed by DOE, identifies and restores sites contaminated during the early years of the nation's atomic energy program or from commercial operations. SLDS was one of the first properties to be designated for remediation under FUSRAP.

A remedial investigation and feasibility study are being conducted, and an environmental impact statement is being prepared to determine the types and extent of contamination at SLDS and other FUSRAP properties in the St. Louis area (collectively referred to as the St. Louis Site) and to determine the best methods for conducting remedial action. The remedial investigation report for the St. Louis Site contains results of remedial investigation activities conducted by Bechtel National, Inc. from 1986 through 1990 to determine the extent of radioactive and chemical contamination at these properties.

The size and complexity of SLDS increase the challenge and costs associated with remedial action. The estimated cleanup cost of $267 million for SLDS is greater than that estimated for each of the other St. Louis FUSRAP sites.

CHARACTERIZATION

Table I shows areas of radioactive contamination under and adjacent to many buildings at SLDS and identifies buildings with residual surface contamination exceeding guidelines.

Subsurface Contamination

As plans for final remedial action at SLDS become more focused and detailed, the fate of these buildings and the underlying contaminated soil must be determined. Results of the radiological characterization of soils at SLDS indicate that contamination lies directly below 12 buildings and may be present underneath the slabs of 24. The fuel oil tank in Plant 6 and the wastewater treatment ponds in Plant 7W may have subsurface contamination as well. Buildings 50, 116B, 704, and 707 may be or are known to be structurally dependent on an adjacent building that has subsurface contamination.

Exterior Surface Contamination

Twenty buildings were surveyed for radioactive contamination on structural surfaces: 25, K1E, 81, 82, 50, 51, 51A, 52, 52A, 100, 101, 116, 116B, 117, 700, 704, 705, 706, 707, and 708 (Table I). Because these surveys were not meant to determine absolute boundaries of contamination, only general statements about the radiological status of these buildings can be made. Of the 12 buildings exhibiting subsurface soil contamination, 11 also had surface contamination.

Interior Surface Contamination

Of the 24 buildings suspected to have subsurface soil contamination, 6 were surveyed for interior surface contamination; 5 of these buildings exhibited surface contamination, and 1 showed no surface contamination above DOE guidelines. The five buildings exhibiting interior surface contamination included the four structurally dependent buildings (50, 116B, 704, and 707).

Roof Contamination

In addition to the original 20 buildings surveyed for exterior surface contamination, the roofs of Buildings X, 501, R, P, Q, C, B, L, Z, 53, 56, F, G, 10, T, V, and W were surveyed to determine whether emissions from buildings used for MED-AEC operations had contaminated the roofs of adjacent buildings. Of 33 buildings with roofs contaminated above DOE guidelines, 11 are known to have subsurface soil contamination, and 10 more may be found to have it. The four structurally dependent buildings have contaminated roofs.

COST STUDY

Selection of Potentially Feasible Remedial Alternatives

Zones of radioactive contamination were used to establish remedial alternatives for contaminated buildings and underlying soil. Zone I is the interior of the building, including the first floor concrete slab. Zone II is the area beneath the first floor concrete slab, including the foundation of the building, and is estimated to be 4 ft deep. Zone III is the area of soil directly beneath the building's footings and varies in depth at

TABLE I

SLDS Buildings With Known or Suspected Subsurface Soil Contamination and With Interior Surface and Roof Contamination

Building	Known Subsurface Soil Contamination	Suspected Subsurface Soil Contamination	Interior Surface Contamination	Roof Contamination
Plant 1				
25		X	X	X
K1E	X		X	X
K1		X		
L		X		X
Z		X		X
P				X
Q				X
R				X
B				X
C				X
10				X
F				X
G				X
8		X		
20		X		
X		X		X
5A		X		
5B		X		
Plant 2				
50		X	X	X
51	X		X	X
51A	X		X	X
52	X		X	X
52A	X		X	X
501				X
53				X
56				X
Plant 3				
62		X		
63		X		
Plant 10				
81				X
82		X		X
89		X		
Plant 5				
250		X		
245		X		
235		X		
247A		X		
247B		X		
248		X		
Plant 6				
116B		X	X	X
Fuel Tank		X		
100	X		X	X
101	X			
116	X		X	X
117	X		X	X
Plant 7				
Ponds		X		
700	X		X	X
708		X	X	X

TABLE I, CONT'D

Building	Known Subsurface Soil Contamination	Suspected Subsurface Soil Contamination	Interior Surface Contamination	Roof Contamination
708		X	X	X
704		X	X	X
705	X		X	X
706	X		X	X
707		X	X	X

different buildings. Zone IV is defined as the remaining area of soil around the building.

Media contaminated at levels above guidelines could remain intact only if supplemental limits were approved. Reference 4 lists dose estimates for various options in which contaminated subsoil would be left intact. In addition, if a building is not demolished and the soil is remediated below the bottom of footings, the structure must be underpinned.

Remedial action alternatives will focus on buildings and subsoil, which are the two major contaminated media at the site. The basic remedial action options for the buildings involve only Zone I and include:

- Decontamination
- No decontamination
- Demolition and disposal of the structure
- No demolition

The basic remedial action options for contaminated subsoil involve Zones II and III and include:

- No soil remediation
- Partial remediation to the base of the building footings (Zone II)
- Complete remediation by excavation to the maximum depth of the contamination (Zone III)

When combined, the options described above provide 12 alternatives for remediating buildings and underlying soils (see Fig. 1), from total removal of all existing sources of contamination in the building and underlying soil (Alternative 1), to the no action alternative (Alternative 12). Factors that must be considered in selecting alternatives include the age and structural integrity of the building, extent and concentration of surface and soil contamination, current and future use of the buildings, the potential presence of mixed waste [containing asbestos insulation and building materials, lead paint and pipe, polychlorinated biphenyls (PCBs), or process residues], and cost. For example, these factors should be considered when deciding whether to partially remediate the soil by excavating to the base of footings and apply supplemental limits to the remainder of the contamination or to demolish the building, thereby providing access to deeper contamination.

Thus, the feasibility of implementing an alternative depends in part on the extent and concentration of the surface and subsoil contamination of the building. These two factors are directly related to the exposure risk presented by a building. Therefore, in evaluating the implementability of an alternative, potential building exposure risks posed by contamination of the building surface or underlying soil were defined as either high, or low to none. Combinations of these parameters established four different cases:

1. High exposure risk from both surface and underlying soil contamination
2. High exposure risk from building surfaces; exposure risk from soil low to none
3. High exposure risk from underlying soil; exposure risk from building surfaces low to none
4. Exposure risk low to none from both building surfaces and underlying soil

Figure 1 shows the exposure risk for each alternative in terms of one or more of the four cases, based on the assumption that when exposure risk is high, the source of contamination must be totally removed. However, if exposure risk is low to none, partial remediation is feasible when an appropriate justification of supplemental limits is established. For example, if both the subsoil and the surface of a building are contaminated to an extent that poses high exposure risk (Case 1), Alternatives 1, 4, and 7 would best remedy the building because they completely remove all sources of contamination. Other alternatives would require that supplemental limits be determined, which would be difficult to justify if exposure risk were high.

As shown in Fig. 1, buildings should be grouped based on their exposure risk, and feasible remedial alternatives determined for groups rather than individual buildings to simplify the organizing, compiling, and transmitting of information (see Tables II and III). Nevertheless, specific characteristics of some buildings (e.g., Buildings 101, 706, and 117) required that they be considered individually. The building groups are:

1. Buildings with interior, roof, and subsurface contamination
2. Buildings with interior, roof, and adjacent soil contamination
3. Buildings with roof and adjacent soil contamination
4. Buildings with roof contamination
5. Buildings with adjacent soil contamination

Group 1, which was most thoroughly characterized, includes Buildings K1E, 51, 51A, 52, 52A, 100, 101, 116, 117, 700, 705, and 706. A feasibility study of Group 1 concludes that only Buildings 101 and K1E are candidates for underpinning. In addition, preliminary calculations for evaluation of supplemental limits for radioactively contaminated soil beneath Group 1 buildings (4) indicate that none of the areas evaluated pose human exposure threats in excess of the radiation protection standard for the general public (100 mrem/year).

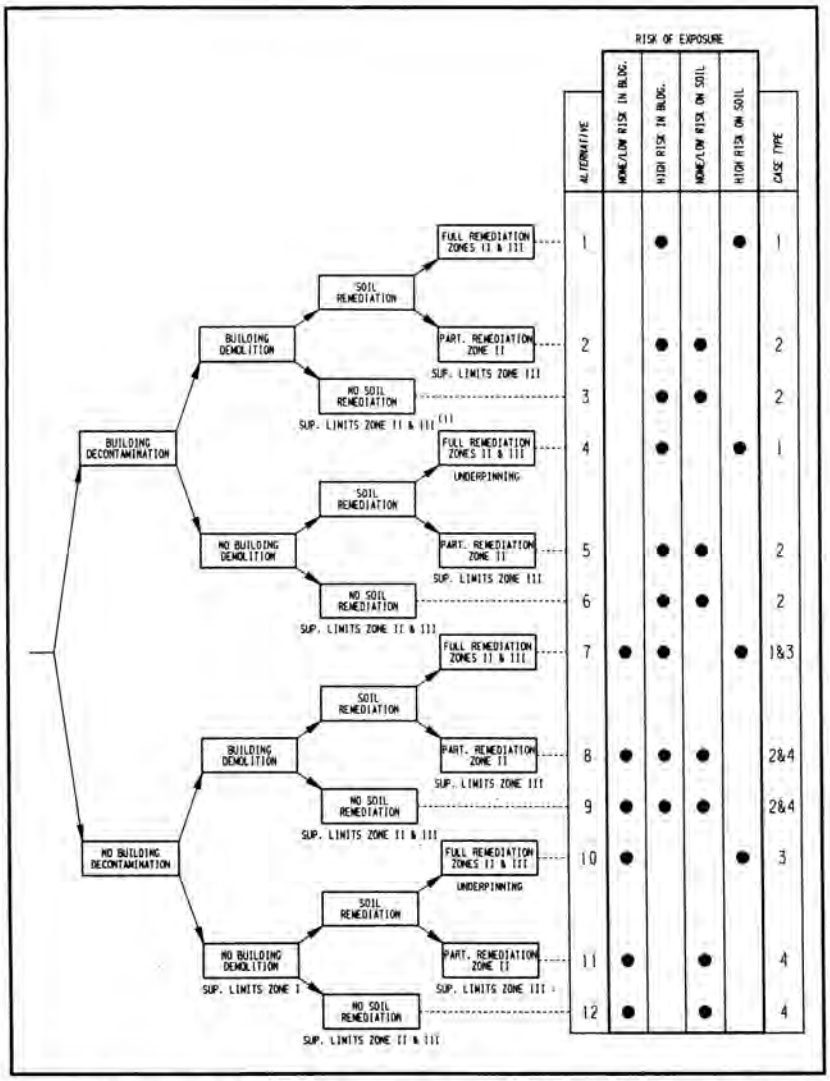

Fig. 1. Alternatives for remediating buildings and underlying soil at SLDS.

Thus, the benefit of remediating soils beneath buildings is debatable.

Based on these studies and radiological characterizations of the buildings, remedial alternatives were selected for each building and were confirmed as feasible, with the exception of Alternatives 10 through 12, which require that supplemental limits of surface contamination in buildings be determined (Table II). For example, Building 101 is considered a part of Group 1 because it shows subsurface contamination; however, its interior and roof are not contaminated. Alternatives 1 through 6 were therefore rejected for Building 101 because they include building decontamination, which is not needed. Alternatives 7 through 12 could be feasible for Building 101 because they do not include decontamination of building surfaces; however, Alternatives 9 and 12 were rejected because preliminary supplemental limits for soil could not be justified (4). Therefore, Alternatives 7, 8, 10, and 11 were feasible. Note that Alternative 10 requires underpinning of the structure, which was feasible in this building.

Development of Cost Estimates

Historical data for similar subcontracts and industry standard cost data were used to develop cost estimates (Table II). For some buildings, an average rate per cubic yard was used:

- Open excavation of Zone II ($200 per cubic yard excavated)
- Open excavation of Zone III ($200 per cubic yard excavated)
- Trench excavation in Zone II buildings ($340 per cubic yard excavated)
- Building decontamination costs [varied based on the process used (4)]

Building-specific cost estimates were also developed, including:

- Underpinning of Buildings 101 and K1
- Building demolition estimates by building
- Building reconstruction estimates by building

These estimates considered subcontract costs for only excavation and decontamination. While the total project cost will include other elements, subcontracts are a major cost factor and serve as an appropriate basis for comparison. The extent to which DOE compensates the company that owns SLDS for reconstruction or replacement of facilities and for production downtime could greatly affect the relative costs of the alternatives.

TABLE II

Cost Study of Alternatives for Remediating Buildings and Underlying Soil at SLDS

ALTERNATIVE				BUILDING NUMBER KIE	51	51A	52	52A	100	101	116	117	700	705	706
1	BLDG.DECON	DEMOLITION	SOIL REM. ZONE II&III	$943,000	$1,110,000	$278,000	$684,000	$64,000	$413,000		$3,822,000		$1,826,000	$2,676,000	
2	BLDG.DECON	DEMOLITION	SOIL REM. ZONE II	$916,000	$675,000	$132,000	$419,000	$38,000	$270,000		$2,993,000	$1,210,000	$1,385,000	$2,307,000	
			Supl. Limits (zone III)												
3	BLDG.DECON	DEMOLITION	NO SOIL REM.								$2,275,000	$850,000		$2,026,000	$416,000
			Supl. Limits (zones II & III)												
4	BLDG.DECON	NO DEMOLITION	SOIL REM. ZONE II&III	$271,000											
			Underpin												
5	BLDG.DECON	NO DEMOLITION	SOIL REM. ZONE II	$121,000	$388,000	$145,000	$132,000	$20,000	$131,000		$1,406,000	$717,000	$836,000	$694,000	
			Supl. Limits (zone III)												
6	BLDG.DECON	NO DEMOLITION	NO SOIL REM.								$246,000	$104,000		$221,000	$75,000
			Supl. Limits (zones II & III)												
7	NO BLDG. DECON	DEMOLITION	SOIL REM. ZONE II&III	$931,000	$1,073,000	$274,000	$867,000	$82,000	$396,000	$6,948,000	$3,577,000		$1,748,000	$2,517,000	
8	NO BLDG. DECON	DEMOLITION	SOIL REM. ZONE II	$905,000	$637,000	$126,000	$403,000	$36,000	$253,000	$4,223,000	$2,747,000	$1,106,000	$1,308,000	$2,149,000	
			Supl. Limits (zone III)												
9	NO BLDG. DECON	DEMOLITION	NO SOIL REM.								$2,029,000	$746,000		$1,806,000	$341,000
			Supl. Limits (zones II & III)												
10	NO BLDG. DECON	NO DEMOLITION	SOIL REM. ZONE II&III	$259,000						$4,577,000					
		Supl. Limits (zone I)	Underpin												
11	NO BLDG. DECON	NO DEMOLITION	SOIL REM. ZONE II	$109,000	$350,000	$142,000	$115,000	$18,000	$114,000	$3,410,000	$1,220,000	$613,000	$762,000	$473,000	
		Supl. Limits (zone I)	Supl. Limits (zone III)												*
12	NO BLDG. DECON	NO DEMOLITION	NO SOIL REM.								$0	$0		$0	$0
		Supl. Limits (zone I)	Supl. Limits (zones II & III)												

Notes:

- Subsurface, interior and roof radiological contamination are present at all buildings except for Building 101 which shows only subsurface contamination and Building 706 which does not shows contamination at underlying soil. Building 117 subsurface contamination extends up to 4 ft depth (zone II) only.
- A preliminary evaluation of supplemental limits for soils was performed for all buildings in this table.
- Alternatives 10–12 need an evaluation of supplemental limits for buildings with the exception of Building 101.

TABLE III

Alternatives for Remediating Buildings and Underlying Soil at SLDS.

BUILDING NUMBER — Groups 2 and 3

ALTERNATIVE				GROUP 2: 25	50	116B	704	707	708	GROUP 3: 82	L	X	Z
1	BLDG.DECON	DEMOLITION	SOIL REM. ZONE II&III	D		D	D	D	D	D	D	D	D
2	BLDG.DECON	DEMOLITION	SOIL REM. ZONE II	DS		DS	DS	DS	DS	DS	DS	DS	DS
			Supl. Limits (zone III)										
3	BLDG.DECON	DEMOLITION	NO SOIL REM.	DS	X	DS	DS	DS	DS	DS	DS	DS	DS
			Supl. Limits (zone II&III)										
4	BLDG.DECON	NO DEMOLITION	SOIL REM. ZONE II&III	DU		DU	DU	DU	DU	DU	DU	DU	DU
			Underpin										
5	BLDG.DECON	NO DEMOLITION	SOIL REM. ZONE II	DS		DS	DS	DS	DS	DS	DS	DS	DS
			Supl. Limits (zone III)										
6	BLDG.DECON	NO DEMOLITION	NO SOIL REM.	DS	X	DS	DS	DS	DS	DS	DS	DS	DS
			Supl. Limits (zone II&III)										
7	NO BLDG. DECON	DEMOLITION	SOIL REM. ZONE II&III	D		D	D	D	D	D	D	D	D
8	NO BLDG. DECON	DEMOLITION	SOIL REM. ZONE II	DS		DS	DS	DS	DS	DS	DS	DS	DS
			Supl. Limits (zone III)										
9	NO BLDG. DECON	DEMOLITION	NO SOIL REM.	DS	X	DS	DS	DS	DS	DS	DS	DS	DS
			Supl. Limits (zone II&III)										
10	NO BLDG. DECON	NO DEMOLITION	SOIL REM. ZONE II&III	DBU		DBU	DBU	DBU	DBU	DBU	DBU	DBU	DBU
		Supl. Limits (zone I)	Underpin										
11	NO BLDG. DECON	NO DEMOLITION	SOIL REM. ZONE II	DBS		DBS	DBS	DBS	DBS	DBS	DBS	DBS	DBS
		Supl. Limits (zone I)	Supl. Limits (zone III)										
12	NO BLDG. DECON	NO DEMOLITION	NO SOIL REM.	DBS	B	DBS	DBS	DBS	DBS	DBS	DBS	DBS	DBS
		Supl. Limits (zone I)	Supl. Limits (zone II&III)										

BUILDING NUMBER — Groups 4 and 5

ALTERNATIVE				GROUP 4: 10	53	58	81	501	B	C	F	G	P	Q	R	GROUP 5: 5A	5B	8	20	62	63	89	236	245	247A	247B	248	250	K1
1	BLDG.DECON	DEMOLITION	SOIL REM. ZONE II&III																										
2	BLDG.DECON	DEMOLITION	SOIL REM. ZONE II																										
			Supl. Limits (zone III)																										
3	BLDG.DECON	DEMOLITION	NO SOIL REM.	X	X	X	X	X	X	X	X	X	X	X	X														
			Supl. Limits (zone II&III)																										
4	BLDG.DECON	NO DEMOLITION	SOIL REM. ZONE II&III																										
			Underpin																										
5	BLDG.DECON	NO DEMOLITION	SOIL REM. ZONE II																										
			Supl. Limits (zone III)																										
6	BLDG.DECON	NO DEMOLITION	NO SOIL REM.	X	X	X	X	X	X	X	X	X	X	X	X														
			Supl. Limits (zone II&III)																										
7	NO BLDG. DECON	DEMOLITION	SOIL REM. ZONE II&III													D	D	D	D	D	D	D	D	D	D	D	D	D	D
8	NO BLDG. DECON	DEMOLITION	SOIL REM. ZONE II													DS	DS	DS	DS	DS	DS	DS	DS	DS	DS	DS	DS	DS	DS
			Supl. Limits (zone III)																										
9	NO BLDG. DECON	DEMOLITION	NO SOIL REM.	X	X	X	X	X	X	X	X	X	X	X	X	DS	DS	DS	DS	DS	DS	DS	DS	DS	DS	DS	DS	DS	DS
			Supl. Limits (zone II&III)																										
10	NO BLDG. DECON	NO DEMOLITION	SOIL REM. ZONE II&III													DU	DU	DU	DU	DU	DU	DU	DU	DU	DU	DU	DU	DU	DU
		Supl. Limits (zone I)	Underpin																										
11	NO BLDG. DECON	NO DEMOLITION	SOIL REM. ZONE II													DS	DS	DS	DS	DS	DS	DS	DS	DS	DS	DS	DS	DS	DS
		Supl. Limits (zone I)	Supl. Limits (zone III)																										
12	NO BLDG. DECON	NO DEMOLITION	NO SOIL REM.	B	B	B	B	B	B	B	B	B	B	B	B	DS	DS	DS	DS	DS	DS	DS	DS	DS	DS	DS	DS	DS	DS
		Supl. Limits (zone I)	Supl. Limits (zone II&III)																										

Notes:

X: CONFIRMED AS FEASIBLE ALTERNATIVE
B: NEED SUPPLEMENTAL LIMITS OF BUILDING
S: NEED SUPPLEMENTAL LIMITS OF SOIL
U: NEED UNDERPINNING STUDY
D: NEED DRILL BOREHOLES SAMPLES

GROUP 2:
- Interior, roof, and adjacent soil contamination are present at these buildings, except for Building 50 which *shows interior and roof* contamination only.

GROUP 3:
- Roof and adjacent soil contamination are present in this group. Demolition alternatives would only require dismantling of the roof.

GROUP 4:
- Buildings with roof contamination. Demolition alternatives would only require dismantling of the roof.

GROUP 5:
- Soil contamination is adjacent to buildings.

Ranking of Remedial Alternatives Based on Cost

As explained above, each alternative consists of three components: (1) building decontamination or no decontamination, (2) building demolition or no demolition, and (3) full, partial, or no soil remediation.

Table II compares the relative costs of decontamination vs. no decontamination when components 2 and 3 remain constant. In addition, leaving a building standing generally is less expensive than demolishing it when two alternatives with components 1 and 3 are compared. An exception is Building 51A; demolition of this building is less expensive because building replacement cost is low. Leaving a building standing is also more economical than demolishing it when two alternatives with component 1 are compared. An exception is Building 101; demolishing and remediating buildings in Zone II is less expensive than underpinning and removing buildings in Zones II and III. Estimated costs of remediating each building using each alternative are summarized in Table II. Thus, for all buildings except Buildings 51A and 101, the alternatives (Fig. 1) can be ranked on the basis of cost in the following order, ranging from least expensive to most expensive: 12, 6, 11, 5, 10, 4, 9, 3, 8, 2, 7, 1.

CONCLUSIONS AND RECOMMENDATIONS

The cost for remediating buildings in Group 1 and the underlying soil is primarily a function of the demolition/no demolition component, followed by the soil remediation/no soil remediation component and then the decontamination/no decontamination component. Remedial cost was determined to be highest for Building 101 ($3.4 to 7.9 million), followed by Buildings 117 and 705 ($0.6 to 1.2 million and $0.5 to 2.7 million, respectively).

Buildings in Group 2 include Buildings 25, 50, 116B, 704, 707, and 708. These buildings show interior, roof, and adjacent soil contamination, except that Building 50 exhibits only interior and roof contamination. Buildings in Group 3 include Buildings 82, L, X, and Z. Because the nature and extent of contamination in soil beneath Group 3 buildings are uncertain, further characterization is recommended. A justification of supplemental limits for soil and an underpinning study may be necessary, depending on the soil characterization results. In addition, the need to determine supplemental limits of each building's surface contamination is anticipated, as shown in Table III.

Buildings in Group 4, which show only roof contamination, include Buildings 10, 53, 56, 81, 501, B, C, F, G, P, Q, and R. A maximum of four remedial alternatives are feasible for Group 4. Alternatives 3, 6, and 9 are certainly feasible; supplemental limits for roof contamination must be determined to evaluate whether Alternative 12 is feasible.

Finally, buildings in Group 5, which have contamination adjacent to them, include 5A, 5B, B, 20, 62, 63, 235, 245, 247A, 247B, 24B, 250, and K1. Soil underneath the buildings needs to be further characterized. Subsequently, a justification of supplemental limits for soil and an underpinning study may be necessary, as shown in Table III.

This cost study provided feasible alternatives and rough order-of-magnitude cost estimates for buildings in Group 1 to guide determinations of the cost-effectiveness of remedial alternatives in preliminary screening of alternatives during the feasibility study. In addition, this study established the need for further characterization to support the determination of cost-effective remedial alternatives for the remaining buildings. A more extensive study is needed to determine the relative cost-effectiveness of decontaminating these buildings to reduce contaminant volume, as opposed to demolition and disposal of the structures as contaminated material.

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