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PNL-6350
"Property related costs of radiological accidents"
authors: JJ Tawil and FC Bold
Pacific Northwest Lab, Richland, WA

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PROPERTY-RELATED COSTS OF
RADIOLOGICAL ACCIDENTS

J. J. Iawil
F. C. Bold

February 1990

Prepared for
Division of Safety Review and Oversight
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Richland, Washington 99352

ABSTRACT

This report provides documentation for a database and a set of computer programs used to evaluate the property-related costs of a severe accident at a nuclear power plant. The database, which was compiled largely through interviews with knowledgeable persons both in the public and private sectors, consists of the costs, physical inputs, rates and contaminant removal efficiencies of a large number of decontamination procedures. The computer programs utilize this database along with information specific to the contaminated site. The output of the program consists of detailed information that includes the least costly method for effectively decontaminating each surface at the site, various types of property losses associated with the contamination, the time at which each subarea within the site should be decontaminated to minimize these property losses, the collective dose to radiation workers, the costs for surveying and monitoring activities, the costs to dispose of the radiological waste generated during cleanup, and the quantity of various types of labor and equipment necessary to carry out the indicated decontamination program. The capabilities of these computer codes and the associated database are demonstrated with a sequence of hypothetical accident scenarios at the Indian Point reactor site in New York State.

EXECUTIVE SUMMARY

This report is an extensive revision of an earlier report, *Off-Site Consequences of Radiological Accidents: Methods, Costs, and Schedules for Decontamination*, (NUREG/CR-3413 1985). The earlier report, produced by the Pacific Northwest Laboratory (PNL) for the United States Nuclear Regulatory Commission (NRC), was motivated by the accident at Three Mile Island, which focused increased attention by the public and by regulators on the off-site consequences of severe radiological accidents. Since that report was published, the much more serious Chernobyl accident took place in April, 1986. This accident, near Kiev in the Soviet Union, has had international repercussions and has raised interest in reactor accident consequences and site restoration issues.

One of the major findings of PNL's earlier research on radiological accident consequences was that decontamination costs and property losses resulting from a severe accident could easily run into the billions of dollars, accounting for the majority of the off-site accident costs. Prior to PNL's research into these issues, only very limited means were available for assessing these costs. In addition, these earlier estimates made little use of site-specific information, and it seemed likely that decontamination costs and property losses should be sensitive to site-specific factors, such as the land use of the affected property and its value. A final concern was that the evaluation of the decontamination costs was based on approximations of the cost to decontaminate just a few types of property.

In view of the apparent shortcomings of these evaluation techniques and the major contribution of decontamination costs and property losses to accident risk, PNL's original research effort was undertaken. At the beginning of this effort, a search was conducted to determine the type of information that was available on decontamination procedures. It soon became clear that information on well-documented procedures for decontaminating various materials was very limited. Some tests had been done with respect to active products from nuclear weapons, but these results were not completely applicable, due to substantial differences in the nature of the contaminants. There were also documented procedures for using very powerful, but also very costly, techniques to decontaminate laboratory facilities and other small areas. However, because of the relatively high costs of these procedures and the specialized equipment used, they would be totally inappropriate for restoring an area of several hundred or several thousand square miles.

From these findings, several objectives were formulated to guide the earlier study. These were:

- to collect information from both published and unpublished sources relating to decontamination procedures and to identify the circumstances favorable to the application of each.
- to develop sufficient information to describe the relationship between the physical inputs and the output of a production technique. This permits the types of manpower and equipment required to carry out the decontamination efforts to be identified. Additionally, acquiring the costs of these inputs allows the cost of applying each of the procedures to be specified.
- to develop a methodology that uses data commonly available by political subdivision and that facilitates mapping these data to the area elements of any type of accident grid. Without such a methodology, the difficulty of adapting published data to a useful analytical framework can be a major disincentive to using site-specific information.
- to develop a computer program to evaluate decontamination and other property-related costs attributable to the accident. The program was also to have the capability to consider and evaluate a variety of cost-reducing site restoration strategies.

In meeting these objectives, PNL developed three major resources to evaluate off-site accident consequences and to develop site-restoration strategies. These were: 1) a Reference Database; 2) a set of procedures and analytical tools for preparing a Site Database; and 3) a computer program, called DECON, that would utilize the information in the two databases to produce the desired analyses.

The Reference Database contains information on applying decontamination methods to surfaces. Currently, 457 methods have been defined for use on 30 different surfaces, of which about 100 methods and 8 surfaces have been added since our original report. For each method, the Reference Database includes the following information:

- the cost of applying each method
- the efficiency with which the exposure level to an individual is reduced

- the rate at which the method is applied
- the quantity and type of labor required
- the quantity and type of equipment required
- the quantity and type of major materials required
- the costs for labor, equipment, fuel and materials
- the quantity of contaminated material requiring disposal

All of these data are contained in computer files. In addition, the sources from whom the information was obtained have been compiled and are included in Appendix C to facilitate updating of this database.

The second resource consists of procedures and analytical tools for preparing a Site Database. This resource facilitates the use of site-specific information. Two computer programs are available for this purpose. One, called *SD-INPUT*, is user-friendly; it produces menus and prompts the user for all of the site data required to conduct an analysis. However, this program will not map data from, say, political subdivisions to grid elements. *SD-INPUT* is particularly useful for smaller accidents which do not span several townships or counties.

The second program, called *IR-GRID*, is less user-friendly than *SD-INPUT*. However, it does allow the user to rely primarily on published data sources, since it will map data to grid elements. For this reason, *IR-GRID* may be more useful than *SD-INPUT* if the radiological accident extends over several townships or counties, thus facilitating the use of published data. *IR-GRID* also produces estimates of evacuation costs and temporary and permanent relocation costs, which *SD-INPUT* does not.

Both *SD-INPUT* and *IR-GRID* assemble the site-specific data into a form that can be used directly by *DECON*.

Other software tools are also provided as a part of the Site Database resource. These include programs for 1) plotting isopleths on a map of the accident site; 2) computing the dose at almost any point within the accident site; and 3) generating a set of dose-related information required by *DECON* for accidents in which radioactive decay and weathering can affect site restoration decisions.

The third resource is called *DECON*, the computer program for actually performing the site restoration analysis. This program has been designed to facilitate the planning of site restoration activities as well as to provide estimates of decontamination costs and other property losses. The structure and features of *DECON* are described in this report, and its capabilities are demonstrated by applying it to several hypothetical radiological accidents at the Indian Point site in New York State.

Among the information produced by *DECON* are the following:

- the cost-effective decontamination method used on each surface
- the rate at which the decontamination method is applied
- the types of labor used by the method
- the types of equipment used by the method
- the major materials required
- the efficiency of the method in reducing inhalation or external dose
- the collective dose to radiation workers
- the dose commitment from exposure to decontaminated surfaces
- the year to decontaminate each grid element in order to minimize total property losses
- potential social benefits from a government buy-out of contaminated property.

The capabilities of *DECON* include evaluating strategies 1) to prohibit specific operations on selected surfaces, 2) to require prespecified methods on selected surfaces, 3) to evaluate the tradeoff between cleanup standards and other variables, such as latent cancer fatalities, decontamination costs, property losses, radiological waste generated, etc., 4) to transport radiological wastes to disposal areas at different distances from the site or to an on-site disposal pit, 5) to impose different cleanup standards and/or restrictions on subareas within the accident site, and 6) to impose different cleanup standards on different surfaces according to the expected level of health risk posed by the surface. These capabilities can be used alone or in combination to explore a virtually unlimited number of cleanup strategies.

ACKNOWLEDGMENTS

Many individuals made important contributions to the original report, and we again acknowledge their invaluable assistance without mentioning them by name. For this revision, the following people were especially helpful. R.L. Darwin and R.W. Schultz gathered and systematically organized the data for the Indian Point case study. This was a substantial effort that they efficiently organized and executed. D.L. Strenge provided support on matters and questions relating to health physics.

We also thank the large number of individuals whom we contacted for the new information in this volume. They were highly cooperative and generous with their information and expertise.

We thank Marlene Hale and her word processing crew for their work on this volume, and Judy Danko who coordinated the typing. Also to be thanked is Wendy Owen for her assistance with intermediate drafts.

In the spirit of tradition, we, the authors accept full responsibility for the errors that remain, as well as the new ones that have been introduced since the original version.

TABLE OF CONTENTS

ABSTRACT	iii
EXECUTIVE SUMMARY	v
ACKNOWLEDGEMENTS	ix
1.0 INTRODUCTION	1.1
1.1 ORGANIZATION	1.1
1.2 BACKGROUND	1.2
1.3 OBJECTIVES	1.4
1.4 METHODOLOGY AND OVERVIEW	1.6
1.4.1 The Reference Database	1.7
1.4.2 The Site Database	1.10
1.4.3 DECON	1.11
1.4.4 A Decontamination Analysis of the Indian Point Reactor Site	1.11
2.0 THE REFERENCE DATABASE	2.1
2.1 CONTENTS OF THE REFERENCE DATABASE	2.2
2.2 DECONTAMINATION OPERATIONS, COSTS, AND EFFICIENCIES	2.3
2.2.1 Decontamination Costs	2.3
2.3 PROCEDURES FOR INTERDICTED AREAS	2.6
2.4 DECONTAMINATION COSTS FOR VARIOUS SURFACES	2.8
2.4.1 Land Surfaces	2.8
2.4.1.1 Agricultural Fields	2.8
2.4.1.2 Orchards	2.10
2.4.1.3 Vacant Land	2.11
2.4.1.4 Wooded Land	2.13
2.4.1.5 Asphalt Streets and Roads	2.13
2.4.1.6 Lawns	2.18
2.4.2 Water Bodies	2.21
2.4.2.1 Reservoirs	2.21
2.4.3 Structures and Contents	2.23
2.4.3.1 Roofs	2.23
2.4.3.2 Exterior Walls	2.26
2.4.3.3 Interior Floors, Walls and Glass Surfaces	2.29
2.4.3.4 Building Contents	2.30
2.4.4 Automobiles	2.33
2.5 HAULING COSTS	2.34
2.6 WASTE BURIAL COSTS	2.36

TABLE OF CONTENTS (Cont.)

2.7	SURVEYING AND MONITORING COSTS	2.37
2.8	DECONTAMINATION EFFICIENCIES FOR VARIOUS SURFACES	2.38
2.8.1	Cost and Efficiencies of Decontamination Methods	2.40
3.0	THE SITE DATABASE	3.1
3.1	SOFTWARE FOR PREPARING THE SITE DATABASE	3.1
3.2	CONTENTS OF THE SITE DATABASE	3.2
3.2.1	Population	3.2
3.2.2	Contamination Level	3.3
3.2.3	Area and Type of Property Contaminated.	3.4
3.2.4	Value of the Contaminated Property.	3.5
3.2.5	Employment by Major Sector.	3.6
3.3	SELECTION OF THE GRID	3.6
3.3.1	Rectangular Grid	3.7
3.3.2	Radial Grid	3.7
3.3.3	Grid Elements Bounded by the Radiological Isopleths	3.9
3.3.4	Irregular Grid Based on Political Subdivision Boundaries.	3.9
3.3.5	Irregular Grid Based on Political Subdivision Boundaries and Isopleths	3.10
4.0	DECON--A COMPUTER PROGRAM TO ESTIMATE THE PROPERTY-RELATED COSTS OF SEVERE RADIOLOGICAL ACCIDENTS	4.1
4.1	LOGICAL STRUCTURE OF DECON	4.1
4.1.1	Minimizing Economic Costs Through Site-Restoration Actions	4.1
4.1.1.1	Residual Contamination	4.2
4.1.1.2	Deterioration and Obsolescence.	4.3
4.1.1.3	Altered Market Conditions	4.4
4.1.1.4	Deferred Use of Property.	4.4
4.1.1.5	Decontamination Costs	4.5
4.2	MINIMIZING PROPERTY-RELATED LOSSES.	4.6
4.2.1	Algorithm to Maximize Property Values	4.6
4.2.2	Effects on Property Values When No Decontamination is Required	4.8
4.2.3	Property that Cannot Be Decontaminated.	4.8
4.2.4	Properties with Negative Net Present Values	4.8
4.2.5	Property Value Concepts in DECON.	4.9
4.3	SPECIAL FEATURES.	4.11
4.3.1	Subarea Analysis.	4.11
4.3.2	Pre-Rain Analysis	4.11
4.3.3	Restrictions.	4.12

TABLE OF CONTENTS (Cont.)

4.3.4	Required Methods.	4.13
4.3.5	Variation in Exposure Levels.	4.13
4.3.6	Cost-Risk Analysis.	4.14
4.4	COMPUTATIONAL MODELS	4.15
4.4.1	Contamination Model	4.15
4.4.2	Population Dose	4.15
4.4.3	Dose to Radiation Workers	4.16
4.4.4	Number of Cars to be Decontaminated	4.17
4.4.5	Surveying and Monitoring Costs.	4.18
4.4.6	Hauling Costs	4.19
4.4.7	Waste Burial Costs.	4.19
4.5	USER-SELECTABLE PARAMETER VALUES	4.19
4.6	FLEXIBILITY OF DECON	4.20
4.7	INTERPRETATION OF DECON OUTPUT	4.21
4.7.1	Title Page and Listing of Assumptions	4.22
4.7.2	Summary Report.	4.26
4.7.3	Detailed Surface Analysis Report.	4.32
4.7.4	Labor and Equipment Requirements Report	4.35
4.7.5	Decontamination Methods Report.	4.37
4.7.6	Surveying and Monitoring Report	4.37
4.8	PRODUCING COMPLEMENTARY CUMULATIVE DISTRIBUTION FUNCTIONS	4.39
5.0	A CASE STUDY: THE INDIAN POINT REACTOR SITE	5.1
5.1	DESCRIPTION OF PROCEDURE	5.1
5.2	PREPARATION OF THE DATA	5.3
5.2.1	Step 1: Running CRAC2.	5.3
5.2.2	Step 2: Running DOSES.	5.4
5.2.3	Step 3: Running GRID	5.4
5.2.4	Step 4: Defining the Grid Elements	5.5
5.2.5	Steps 5 and 6: Collecting and Organizing the Data.	5.5
5.2.6	Step 7: Running IR-GRID.	5.5
5.2.7	Steps 8 and 9: Running DECON and Reporting Results	5.13
5.3	A COMPARISON OF MAJOR RESULTS FOR 18 ACCIDENT SCENARIOS	5.13
5.4	USING COST/RISK RELATIONSHIPS TO SELECT A BASE CASE CLEANUP LEVEL	5.16
5.5	BASE CASE RESULTS FOR THE SST2/PASQUILL D SCENARIO	5.19
5.6	EVALUATING OTHER CLEANUP STRATEGIES	5.20
5.6.1	Pre-Rain Cleanup.	5.20
5.6.2	Off-Site Waste Disposal	5.20
5.6.3	Restricting Access to Wooded Areas.	5.22
5.6.4	Restricting the Use of Water on Outside Surfaces.	5.23

TABLE OF CONTENTS (Cont.)

5.6.5 Applying Different Cleanup Criteria to Different Surface Types	5.23
5.7 CONCLUSIONS	5.23

APPENDIX A: DECONTAMINATION OPERATIONS

A.0 INTRODUCTION.	A.1
A.1 LAND SURFACES	A.3
A.1.1 Agricultural Fields	A.3
A.1.1.1 Low-Pressure Water	A.3
A.1.1.2 Fixative	A.4
A.1.1.3 Leach	A.10
A.1.1.4 Clear	A.11
A.1.1.5 Scrape	A.13
A.1.1.6 Plow	A.15
A.1.1.7 Deep Plow	A.16
A.1.1.8 Cover	A.18
A.1.2 Orchards	A.20
A.1.2.1 Water	A.20
A.1.2.2 Fixative - Aerial Application	A.21
A.1.2.3 Fixative - Ground Application	A.22
A.1.2.4 Defoliate	A.25
A.1.2.5 Leach	A.26
A.1.2.6 Scrape Without Tree Removal	A.28
A.1.2.7 Plow	A.30
A.1.2.8 Remove and Replace	A.31
A.1.2.9 Radical Prune	A.35
A.1.2.10 Cover, Trees Removed	A.37
A.1.2.11 Cover, Trees in Place	A.38
A.1.2.12 Scrape, Trees Removed	A.39
A.1.3 Vacant Land	A.39
A.1.3.1 Fixatives	A.39
A.1.3.2 Clear	A.40
A.1.3.3 Scrape	A.41
A.1.3.4 Water	A.41
A.1.3.5 Leach	A.42
A.1.3.6 Plow	A.43
A.1.3.7 Deep Plow	A.44
A.1.3.8 Cover	A.44
A.1.4 Wooded Land	A.44
A.1.4.1 Fixative	A.44
A.1.4.2 Defoliate	A.49
A.1.4.3 Clear	A.49

TABLE OF CONTENTS (Cont.)

A.1.4.4	Grub and Scrape	A.50
A.1.4.5	Manual Scrape	A.51
A.1.4.6	Cover Scraped Land	A.52
A.1.4.7	Cover Unscraped Land	A.52
A.1.5	Asphalt Streets	A.52
A.1.5.1	Mobile Vacuumized Street Sweeping	A.53
A.1.5.2	Low-Pressure Water Wash	A.65
A.1.5.3	High-Pressure Water	A.73
A.1.5.4	Very High-Pressure Water Flushing	A.86
A.1.5.5	Foam	A.89
A.1.5.6	Strippable Coating	A.92
A.1.5.7	Planing	A.95
A.1.5.8	Tack Coat	A.98
A.1.5.9	Sealer	A.101
A.1.5.10	Road Oil	A.104
A.1.5.11	Thin Asphalt Overlay	A.106
A.1.5.12	Resurface	A.110
A.1.5.13	Medium-Thickness Asphalt Overlay	A.111
A.1.5.14	Removal and Replacement	A.111
A.1.6	Other Asphalt Surfaces	A.114
A.1.7	Concrete Streets, Roads and Parking	A.114
A.1.7.1	Vacuum	A.114
A.1.7.2	Low-Pressure Water Wash	A.114
A.1.7.3	High-Pressure Water Wash	A.114
A.1.7.4	Very High-Pressure Water Wash	A.114
A.1.7.5	Foam	A.114
A.1.7.6	Strippable Coating	A.114
A.1.7.7	Planing	A.114
A.1.7.8	Tack Coat	A.115
A.1.7.9	Sealer	A.115
A.1.7.10	Road Oil	A.115
A.1.7.11	Thin Asphalt Overlay	A.115
A.1.7.12	Resurface	A.115
A.1.7.13	Medium-Thickness Asphalt Overlay	A.116
A.1.7.14	Removal and Replacement	A.116
A.1.8	Other Concrete Surfaces	A.116
A.1.9	Lawns	A.117
A.1.9.1	Vacuuming	A.117
A.1.9.2	Water	A.117
A.1.9.3	Leaching	A.118
A.1.9.4	Close Mowing	A.121
A.1.9.5	Fixative	A.124

TABLE OF CONTENTS (Cont.)

A.1.9.6 Removal and Replacement	A.125
A.2 WATER BODIES	A.127
A.2.1 Reservoirs	A.127
A.2.1.1 Drain	A.129
A.2.1.2 Scrape	A.130
A.2.1.3 Dredge	A.130
A.2.1.4 Ion Exchange	A.133
A.3 STRUCTURES	A.134
A.3.1 Roofs	A.134
A.3.1.1 Vacuuming	A.135
A.3.1.2 Low-Pressure Water Flushing	A.136
A.3.1.3 High-Pressure Water	A.136
A.3.1.4 Sandblasting	A.138
A.3.1.5 Fixative	A.139
A.3.1.6 Foam	A.140
A.3.1.7 Strippable Coating	A.142
A.3.1.8 Removal and Replacement	A.144
A.3.2 Exterior Wood Walls	A.145
A.3.2.1 Water Wash	A.146
A.3.2.2 Wash and Scrub	A.146
A.3.2.3 Fixative	A.147
A.3.2.4 Vacuum	A.148
A.3.2.5 Hydroblast	A.148
A.3.2.6 High-Pressure Water	A.149
A.3.2.7 Remove and Replace	A.149
A.3.2.8 Foam	A.152
A.3.2.9 Strippable Coating	A.153
A.3.3 Exterior Brick Walls	A.153
A.3.3.1 Water Wash	A.154
A.3.3.2 Wash and Scrub	A.154
A.3.3.3 Fixative	A.154
A.3.3.4 Vacuum	A.154
A.3.3.5 Hydroblast	A.154
A.3.3.6 High-Pressure Water	A.154
A.3.3.7 Scarify	A.154
A.3.3.8 Remove and Replace	A.154
A.3.3.9 Foam	A.156
A.3.3.10 Strippable Coating	A.156
A.3.4 Exterior Reinforced Concrete Walls	A.157
A.3.4.1 Water Wash	A.157
A.3.4.2 Wash and Scrub	A.157
A.3.4.3 Fixative	A.157

TABLE OF CONTENTS (Cont.)

A.3.4.4	Vacuum	A.157
A.3.4.5	Hydroblast	A.157
A.3.4.6	High-Pressure Water	A.157
A.3.4.7	Scarify	A.157
A.3.4.8	Remove and Replace	A.157
A.3.4.9	Remove Structure	A.159
A.3.4.10	Foam	A.159
A.3.4.11	Strippable Coating	A.159
A.3.5	Exterior Glass	A.159
A.3.5.1	Water Wash	A.161
A.3.5.2	Wash and Scrub	A.161
A.3.5.3	Fixative	A.161
A.3.5.4	Vacuum	A.161
A.3.5.5	Foam	A.161
A.3.5.6	Strippable Coating	A.161
A.3.5.7	Remove and Replace	A.161
A.3.6	Interior Wood/Plaster	A.164
A.3.6.1	Vacuum	A.164
A.3.6.2	Wash and Scrub	A.164
A.3.6.3	Strippable Coating	A.164
A.3.6.4	Foam	A.164
A.3.6.5	Fixative	A.165
A.3.6.6	Remove and Replace	A.165
A.3.7	Interior Concrete Walls	A.167
A.3.7.1	Vacuum	A.168
A.3.7.2	Wash and Scrub	A.168
A.3.7.3	Strippable Coating	A.168
A.3.7.4	Foam	A.168
A.3.7.5	Fixative	A.168
A.3.7.6	Scarify	A.168
A.3.7.7	High-Pressure Water	A.168
A.3.7.8	Hydroblast	A.168
A.3.7.9	Remove and Replace	A.169
A.3.8	Interior Glass	A.170
A.3.8.1	Water Wash	A.170
A.3.8.2	Wash and Scrub	A.170
A.3.8.3	Fixative	A.170
A.3.8.4	Vacuum	A.170
A.3.8.5	Foam	A.170
A.3.8.6	Strippable Coating	A.170
A.3.8.7	Remove and Replace	A.170
A.3.9	Carpeted Floors	A.170

TABLE OF CONTENTS (Cont.)

A.3.9.1	Vacuum	A.171
A.3.9.2	Foam	A.171
A.3.9.3	Fixative	A.171
A.3.9.4	Remove and Replace	A.171
A.3.9.5	Steam Clean	A.172
A.3.9.6	Shampoo	A.173
A.3.10	Linoleum Floors	A.173
A.3.10.1	Vacuum	A.173
A.3.10.2	Wash and Scrub	A.174
A.3.10.3	Strippable Coating	A.174
A.3.10.4	Foam	A.174
A.3.10.5	Fixative	A.174
A.3.10.6	Remove and Replace	A.174
A.3.11	Wood Floors	A.175
A.3.11.1	Vacuum	A.175
A.3.11.2	Wash and Scrub	A.175
A.3.11.3	Strippable Coating	A.175
A.3.11.4	Foam	A.175
A.3.11.5	Sand	A.176
A.3.11.6	Fixative	A.176
A.3.11.7	Remove and Replace	A.177
A.3.12	Interior Concrete Walls	A.179
A.3.12.1	Vacuum	A.179
A.3.12.2	Wash and Scrub	A.179
A.3.12.3	Strippable Coating	A.179
A.3.12.4	Foam	A.179
A.3.12.5	Scarify	A.179
A.3.12.6	Resurface	A.181
A.3.12.7	High-Pressure Water	A.181
A.3.12.8	Hydroblast	A.181
A.3.12.9	Scarify and Resurface	A.181
A.3.12.10	Fixative	A.182
A.3.13	Remove Structure	A.182
A.3.13.1	Wooden Structures	A.182
A.3.12.2	Brick and Concrete Structures	A.185
A.4	BUILDING CONTENTS	A.186
A.4.1	Hard-Surface Furnishings	A.187
A.4.1.1	Vacuum	A.187
A.4.1.2	Dust	A.188
A.4.1.3	Water Wash	A.189
A.4.1.4	Strippable Coating	A.189
A.4.1.5	Remove and Replace	A.191

TABLE OF CONTENTS (Cont.)

A.4.2	Soft-Surface Furnishings	A.192
A.4.2.1	Vacuum	A.192
A.4.2.2	Steam	A.193
A.4.2.3	Foam	A.193
A.4.2.4	Reupholster	A.195
A.4.2.5	Remove and Replace	A.196
A.4.3	Electronic Equipment	A.197
A.4.3.1	Vacuum	A.197
A.4.3.2	Spray Cleaner	A.198
A.4.3.3	Remove and Replace	A.199
A.4.4	Paper Products	A.200
A.4.4.1	Vacuum "As Is"	A.200
A.4.4.2	Vacuum Item by Item	A.201
A.4.4.3	Vacuum Sheet by Sheet	A.201
A.4.4.4	Copy and Replace	A.202
A.5	VEHICLES	A.203
A.5.1	Auto Exteriors	A.203
A.5.1.1	Ordinary Spray Wash	A.203
A.5.1.2	Detailed Wash	A.203
A.5.1.3	Repainting	A.203
A.5.2	Auto Interiors	A.204
A.5.2.1	Vacuum	A.204
A.5.2.2	Detailed Vacuum and Clean	A.204
A.5.2.3	Remove Contents, Clean, and Replace	A.205
A.5.2.4	Re-Upholster	A.205
A.5.3	Auto Tires	A.205
A.5.4	Auto Engine/Drive Train	A.206
A.5.5	Vehicle Transport	A.206
A.6	OTHER ACTIVITIES	A.207
A.6.1	Surveying and Monitoring Operations	A.207
A.6.1.1	Aerial Radiological Survey	A.207
A.6.1.2	Mobile Air and Soil Sampling	A.208
A.6.1.3	Mobile Gamma Scanning	A.212
A.6.1.4	Manual Survey of Building Surfaces	A.213
A.6.1.5	Manual Survey of Exterior Surfaces	A.215
A.6.1.6	Placement of TLDs	A.215
A.6.1.7	Replacement of TLDs	A.216
A.6.1.8	Air Sampler Operations	A.217
A.6.1.9	Soil and Crop Sampling	A.225
A.6.1.10	The Frequency and Extent of Surveying and Monitoring Operations	A.226
A.6.2	Hauling	A.228

TABLE OF CONTENTS (Cont.)

A.6.3 Waste Burial	A.230
A.6.4 Distribution of Automobiles	A.240
APPENDIX B: DECONTAMINATION EFFICIENCIES	B.1
APPENDIX C: SOURCES	C.1
APPENDIX D: DATA SOURCES FOR INDIAN POINT STUDY	D.1
APPENDIX E: PREPARATION OF THE SITE DATABASE	E.1
E.0 INTRODUCTION	E.1
E.1 THE DOSE PROGRAM	E.1
E.1.1 Dose Assessment Models	E.2
E.1.1.1 External Plume Exposure	E.2
E.1.1.2 Plume Inhalation Dose	E.3
E.1.1.3 Exposure to Contaminated Ground	E.4
E.1.1.4 Summary	E.5
E.2 THE GRID PROGRAM.	E.5
E.3 SITE DATA PROGRAMS	E.7
E.3.1 Imputing Data Values to Grid Elements	E.7
E.3.2 Transformation of Land Uses into Surface Types	E.10
E.3.2.1 Land Use Categories Currently Implemented	E.11
E.3.2.2 Relationship of Land Use to Surface Type	E.11
REFERENCES	Ref.1
DISTRIBUTION LIST	Dist.1

FIGURES

2.1	Costs and Efficiencies of Decontamination Methods:	
	Agricultural Fields	2.42
2.2	Costs and Efficiencies of Decontamination Methods: Orchards . . .	2.43
2.3	Costs and Efficiencies of Decontamination Methods:	
	Vacant Land	2.44
2.4	Costs and Efficiencies of Decontamination Methods:	
	Wooded Land	2.45
2.5	Costs and Efficiencies of Decontamination Methods:	
	Asphalt Streets/Parking	2.46
2.6	Costs and Efficiencies of Decontamination Methods:	
	Concrete Streets/Parking	2.47
2.7	Costs and Efficiencies of Decontamination Methods:	
	Other Paved Asphalt.	2.48
2.8	Costs and Efficiencies of Decontamination Methods:	
	Other Paved Concrete	2.49
2.9	Costs and Efficiencies of Decontamination Methods: Lawns	2.50
2.10	Costs and Efficiencies of Decontamination Methods: Reservoirs . .	2.51
2.11	Costs and Efficiencies of Decontamination Methods: Roofs	2.52
2.12	Costs and Efficiencies of Decontamination Methods:	
	Exterior Wood Walls	2.53
2.13	Costs and Efficiencies of Decontamination Methods:	
	Exterior Brick Walls	2.54
2.14	Costs and Efficiencies of Decontamination Methods:	
	Exterior Concrete Walls	2.55
2.15	Costs and Efficiencies of Decontamination Methods:	
	Exterior Glass	2.56
2.16	Costs and Efficiencies of Decontamination Methods:	
	Linoleum Floors	2.57
2.17	Costs and Efficiencies of Decontamination Methods:	
	Wood Floors	2.58
2.18	Costs and Efficiencies of Decontamination Methods:	
	Carpeted Floors	2.59
2.19	Costs and Efficiencies of Decontamination Methods:	
	Concrete Floors	2.60
2.20	Costs and Efficiencies of Decontamination Methods:	
	Wood/Plaster Walls	2.61
2.21	Costs and Efficiencies of Decontamination Methods:	
	Interior Concrete	2.62
2.22	Costs and Efficiencies of Decontamination Methods:	
	Interior Glass	2.63
2.23	Costs and Efficiencies of Decontamination Methods:	
	Hard-Surface Furnishings	2.64

FIGURES (Cont.)

2.24	Costs and Efficiencies of Decontamination Methods: Soft-Surface Furnishings	2.65
2.25	Costs and Efficiencies of Decontamination Methods: Electronic Equipment	2.66
2.26	Costs and Efficiencies of Decontamination Methods: Paper Products	2.67
2.27	Costs and Efficiencies of Decontamination Methods: Automobile Exteriors	2.68
2.28	Costs and Efficiencies of Decontamination Methods: Automobile Interiors	2.69
2.29	Costs and Efficiencies of Decontamination Methods: Automobile Tires	2.70
2.30	Costs and Efficiencies of Decontamination Methods: Automobile Engine/Drive Train	2.71
3.1	Typical Radial Grid Geometry	3.8
4.1	Primary Logic of DECON	4.1
4.2	DECON Assumptions List	4.23
4.3	Summary Report	4.27
4.4	Detailed Surface Analysis Report	4.33
4.5	Labor and Equipment Requirements Report	4.36
4.6	Decontamination Methods by Surface Type and Area	4.38
4.7	Surveying and Monitoring Report	4.40
5.1	Accident Site with Isopleths: SST1/Pasquill A Scenario	5.6
5.2	Evacuation Costs vs. Early Dose Limit: SST1	5.10
5.3	Evacuation Costs vs. Early Dose Limit: SST2	5.10
5.4	Evacuation Costs vs. Early Dose Limit: SST3	5.11
5.5	Temporary Relocation Costs vs. Dose Limit: SST1	5.11
5.6	Temporary Relocation Costs vs. Dose Limit: SST2	5.12
5.7	Temporary Relocation Costs vs. Dose Limit: SST3	5.12
5.8	Permanent Relocation Costs vs. Dose Limit: SST1	5.14
5.9	Permanent Relocation Costs vs. Dose Limit: SST2	5.14
5.10	Permanent Relocation Costs vs. Dose Limit: SST3	5.15
5.11	Incremental Cost per Fatality Avoided: SST1/Pasquill D	5.18
5.12	Incremental Cost per Fatality Avoided: SST2/Pasquill D	5.18
5.13	Incremental Cost per Fatality Avoided: SST2/Pasquill F	5.19
5.14	Summary Results for the Base Case	5.21
5.15	Exposure Factors	5.24

APPENDIX FIGURES

VI K-1	Decontamination of roughly textured asphalt (or concrete) by firehosing (standard nozzle). Initial mass loading equal 25 g/ft ²	B.6
VI K-2	Decontamination of smoothly textured asphalt (or concrete) by firehosing (standard nozzle). Initial mass loading equal 25 g/ft ²	B.7
VI K-3	Decontamination of roughly textured asphalt (or concrete) by firehosing (standard nozzle). Initial mass loading equal 5 g/ft ²	B.8
VI K-4	Decontamination of smoothly textured asphalt (or concrete) by firehosing (standard nozzle). Initial mass loading equal 5 g/ft ²	B.9
VI K-5	Decontamination of roughly textured asphalt (or concrete) by mechanized flushing (three consecutive passes). Initial mass loading equal 5 g/ft ² and 25 g/ft ²	B.10
VI K-6	Decontamination of roughly textured asphalt (or concrete) by mechanized flushing. Particle size = 44 to 100 microns .	B.11
VI K-7	Decontamination of smoothly textured asphalt (or concrete) by mechanized flushing (two consecutive passes). Initial mass loading equal 5 g/ft ² and 12 g/ft ²	B.12
VI K-8	Decontamination of roughly textured asphalt (or concrete) by "vacuumized" sweeper. Initial mass loading equal 25 g/ft ²	B.13
VI K-9	Decontamination of roughly textured asphalt (or concrete) by "vacuumized" sweeper. Particle size = 44 to 100 microns .	B.14
VI K-10	Decontamination of sloped roofs by firehosing. Initial mass loading = 25 g/ft ²	B.15
VI K-11	Influence of snow depth on the decontamination effectiveness of the rotary snow blower	B.16
E.1	Using GRID with a Site Map	E.6
E.2	Floor Plan for a Single-Family Residential Structure	E.22
E.3	Floor Plan for a Multi-Family Residential Structure	E.37
E.4	Floor Plan of an Industrial Structure	E.53

TABLES

1.1	Decontamination Operations and Associated Symbols	1.8
1.2	Surface Types/Categories Implemented by DECON	1.9
2.1	Implicit Price Deflators for Gross National Product	2.7
2.2	Summary of Representative Cost and Productivity Data for Agricultural Fields Decontamination Operations	2.10
2.3	Summary of Representative Cost and Productivity Data for Decontamination Operations on Orchards	2.12
2.4	Summary of Representative Cost and Productivity Data for Vacant Land Decontamination Operations	2.12
2.5	Summary of Representative Cost and Productivity Data for Wooded Land Decontamination Operations	2.13
2.6	Summary of Representative Cost and Productivity Data for Asphalt Road Decontamination Operations	2.19
2.7	Summary of Representative Cost and Productivity Data for Concrete Road Decontamination Operations	2.19
2.8	Summary of Representative Cost and Productivity Data for Other Asphalt Decontamination Operations	2.20
2.9	Summary of Representative Cost and Productivity Data for Other Concrete Decontamination Operations	2.20
2.10	Summary of Representative Cost and Productivity Data for Lawn Decontamination Operations	2.21
2.11	Summary of Representative Cost and Productivity Data for Reservoir Decontamination Operations	2.24
2.12	Summary of Representative Cost and Productivity Data for Roof Decontamination Operations	2.24
2.13	Summary of Representative Cost and Productivity Data for Decontamination Operations on Exterior Wood Walls	2.28
2.14	Summary of Representative Cost and Productivity Data for Decontamination Operations on Exterior Brick Walls	2.28
2.15	Summary of Data for Removal and Replacement of Windows	2.30
2.16	Summary of Representative Cost and Productivity Data for Decontamination Operations on Linoleum Floors	2.30
2.17	Summary of Representative Cost and Productivity Data for Decontamination Operations on Wood Floors	2.31
2.18	Summary of Representative Cost and Productivity Data for Decontamination Operations on Carpeted Floors	2.31
2.19	Summary of Representative Cost and Productivity Data for Decontamination Operations on Concrete Floors	2.31
2.20	Summary of Representative Cost and Productivity Data for Decontamination Operations on Painted Wood/Plaster Interior Walls	2.32

TABLES (Cont.)

2.21	Summary of Representative Cost and Productivity Data for Decontamination Operations on Interior Concrete Walls	2.32
2.22	Summary of Representative Cost and Productivity Data for Decontamination Operations on Hard-Surface Furnishings	2.34
2.23	Summary of Representative Cost and Productivity Data for Decontamination Operations on Soft-Surface Furnishings	2.34
2.24	Summary of Representative Cost and Productivity Data for Decontamination Operations on Electronic Equipment	2.35
2.25	Summary of Representative Cost and Productivity Data for Decontamination Operations on Paper Products	2.35
2.26	Summary of Representative Cost and Productivity Data for Automobile Exterior Decontamination Operations	2.35
2.27	Summary of Representative Cost and Productivity Data for Automobile Interior Decontamination Operations	2.35
2.28	Summary of Representative Cost and Productivity Data for Automobile Tires Decontamination Operations	2.36
2.29	Summary of Representative Cost and Productivity Data for Decontamination Operations on Automobile Engines and Drive Trains	2.36
2.30	Summary of Representative Cost and Productivity Data for Hauling	2.37
2.31	Summary of Surveying and Monitoring Activities	2.39
3.1	A Comparison of SD-INPUT and IR-GRID	3.1
3.2	Land Uses Currently Implemented in DECON	3.4
4.1	Distribution of Cars by Land Use, by Accident Time	4.18
4.2	Schedule of Surveying and Monitoring Activities	4.20
4.3	User-Selectable Parameters and Their Default Values	4.21
4.4	Derivation of Cost Adjustment Factors.	4.26
4.5	DECON Variables in CCDF.DAT	4.41
5.1	Siting Source Term (SST) Descriptions.	5.3
5.2	Ground Concentrations at Time of Deposition	5.4
5.3	Data for the Indian Point Site: Employment and Property	5.7
5.4	Data for the Indian Point Site: Population and Land Use	5.8
5.5	Indian Point: Selected Accident Consequences	5.15

APPENDIX TABLES

A.1.1.7.1	Deep Plowing Cost Data Summary	A.18
A.1.1.8.1	Summary of Excavation and Grading Cost Data for Soil Cover	A.20
A.1.2.3.1	Summary of Data for Spraying Orchards from the Ground, Excluding Material Cost	A.25
A.1.2.4.1	Summary of Data for Applying Defoliant to Orchard Trees	A.27
A.1.2.5.1	Summary of Leaching Data	A.28
A.1.2.8.1	Summary of Orchard Removal and Replacement Data	A.36
A.1.2.9.1	Cost Data for Radical Pruning Equipment from the Cooperative Extension, College of Agriculture, Washington State University	A.37
A.1.2.11.1	Summary of Cost Data for Soil Covering in Orchard, Trees in Place	A.39
A.1.4.1.1	Charges for Aerial Application by Carr Aviation	A.47
A.1.4.1.2	Summary of Aerial Application Cost by Source	A.48
A.1.4.1.3	Summary of Aerial Application of Fixative Cost Data	A.48
A.1.4.4.1	Summary of Grub and Scrape Data for Wooded Areas	A.51
A.1.4.7.1	Summary of Data for Covering Wooded Areas with Uncontaminated Soil without Grubbing	A.53
A.1.5.1.1	Summary of Vacuumized Street Sweeping Data for Kennewick, Washington	A.56
A.1.5.1.2	Yearly Labor Cost for Vacuumized Street Sweeping in Pasco, Washington	A.57
A.1.5.1.3	Street Sweeping Costs by Input for San Francisco California	A.59
A.1.5.1.4	Adjusted Street Sweeping Costs by Input for San Francisco, California	A.59
A.1.5.1.5	Street Sweeping Costs by Input for Washington State Department of Transportation	A.60
A.1.5.1.6	Adjusted Street Sweeping Costs by Input for Washington State Department of Transportation	A.60
A.1.5.1.7	Street Sweeping Cost Breakdown from Cal-Trans, State of California	A.61
A.1.5.1.8	Adjusted Street Sweeping Figures from Cal-Trans	A.62
A.1.5.1.9	Adjusted Street Sweeping Costs by Input for Cal-Trans State of California	A.62
A.1.5.1.10	Selected Street Sweeping Data	A.64
A.1.5.1.11	Summary of Vacuumized Street Sweeping Cost Data	A.66
A.1.5.2.1	Flushing Costs by Input for the Public Works Department, City of San Francisco	A.68
A.1.5.2.2	Estimated Flushing Costs from the City of San Francisco	A.68

APPENDIX TABLES (Cont.)

A.1.5.2.3	Typical Street Maintenance Crew, City of Portland	A.70
A.1.5.2.4	Portland Street Flushing Cost Data	A.70
A.1.5.2.5	Street Flushing Input Costs, City of Portland	A.70
A.1.5.2.6	Washington State Department of Transportation Estimates of Street Flushing Costs by Input	A.72
A.1.5.2.7	Summary of Mobile Street Flushing Data	A.74
A.1.5.3.1	Calculation of Hosing Equipment Costs	A.76
A.1.5.3.2	Summary of Manual Firehosing Information	A.78
A.1.5.3.3	Firehosing Equipment Costs, Bureau of Land Management Interagency Fire Center	A.82
A.1.5.3.4	Flow Rates and Prices for Haul Pumps	A.83
A.1.5.3.5	Means Cost Data for Firehosing Equipment	A.85
A.1.5.3.6	Summary of Means Cost Data	A.86
A.1.5.3.7	Summary of High-Pressure Water Cost Data	A.87
A.1.5.4.1	Cost Data for Very High-Pressure Water Spraying	A.89
A.1.5.5.1	Chemical and Shipping Costs for Foam Decontamination	A.90
A.1.5.5.2	Total Chemical Costs for Foam Decontamination	A.91
A.1.5.5.3	Cost Summary of Foam Decontamination of Pavement	A.92
A.1.5.6.1	Summary of Cost and Productivity Data for Decontamination of Paved Surfaces with Strippable Coating	A.94
A.1.5.7.1	Summary of Asphalt Road Planing Cost and Productivity	A.97
A.1.5.7.2	Hourly Cost Estimates of Inputs Specified by the Washington State Department of Transportation for Asphalt Road Planing	A.97
A.1.5.7.3	Summary of Hourly Cost Estimates for Asphalt Road Planing	A.98
A.1.5.7.4	Representative Asphalt Road Planing Cost Data	A.98
A.1.5.8.1	Summary of Data for Tack Coat Application to Asphalt Roads	A.100
A.1.5.9.1	Total Hourly Labor and Equipment Cost Estimates for Surface Sealing	A.104
A.1.5.9.2	Summary of Surface Coating Data for Asphalt Roads	A.105
A.1.5.10.1	Hourly Equipment Cost Estimate for Road Oil Distribution	A.105
A.1.5.10.2	Costs Per Square Meter for Road Oil Distribution	A.106
A.1.5.10.3	Summary of Road Oil Application Data for Asphalt Roads	A.106
A.1.5.11.1	Summary of Cost and Productivity Data for Paving Asphalt Roads with a One-Inch Layer of Asphalt	A.108
A.1.5.12.1	Summary of Asphalt Road Surfacing Data	A.110

APPENDIX TABLES (Cont.)

A.1.5.14.1	Means Cost Data for Asphalt Paving	A.112
A.1.5.14.2	Summary of Pavement Removal and Reconstruction Cost and Productivity Data	A.113
A.1.7.12.1	Summary of Concrete Road Resurfacing Data	A.116
A.1.7.14.1	Summary of Pavement Removal and Reconstruction Cost and Productivity Data	A.116
A.1.9.3.1	Prices of ferric Chloride by Various Suppliers for Large Volume Shipments	A.120
A.1.9.3.2	Summary of Leaching Cost and Productivity Data	A.121
A.1.9.4.1	Summary of Cost and Productivity Data for Close Mowing of Lawns	A.124
A.1.9.5.1	Summary of Cost and Productivity Data for Applying Fixative to Lawns	A.125
A.1.9.6.1	Summary of Cost and Productivity Data for Removing and Replacing Lawns	A.128
A.2.1.1	Summary of Dredging Cost Data	A.132
A.3.1.6.1	Summary of Cost and Productivity Data for Foam Decontamination of Roofs	A.142
A.3.1.7.1	Summary of Cost and Productivity Data for Decontamination of Roofs Using Strippable Coating	A.144
A.3.1.8.1	Summary of Roof Removal and Replacement Cost Data	A.146
A.3.2.2.1	Summary of Data for Wash and Scrub of Walls	A.147
A.3.2.7.1	Summary of Data for Removal and Replacement of Painted Exterior Wood Walls	A.153
A.3.2.8.1	Summary of Data for Foam Treatment of Painted Exterior Wood Walls	A.153
A.3.2.9.1	Summary of Data for Strippable Coating Treatment of Painted Exterior Wood Walls	A.154
A.3.3.8.1	Summary of Data for Removal and Replacement of Exterior Brick Walls	A.156
A.3.4.8.1	Summary of Data for Removal and Replacement of Exterior Reinforced Concrete Walls	A.159
A.3.5.7.1	Summary of Data for Removal and Replacement of Windows	A.163
A.3.6.6.1	Summary of Data for Removal and Replacement of Painted Wood, Plaster Walls	A.168
A.3.7.9.1	Summary of Data for Removal and Replacement of Interior Concrete Walls	A.170
A.3.9.4.1	Summary of Data for Removal and Replacement of Carpet	A.172
A.3.11.6.1	Summary of Data for Removal and Replacement of Linoleum Floors	A.175

APPENDIX TABLES (Cont.)

A.3.11.7.1	Summary of Data for Removal and Replacement of Wood Floors	A.179
A.3.12.5.1	Cost Data for Scarifying Concrete Surfaces	A.180
A.3.12.9.1	Summary of Data for Scarification and Resurfacing of Concrete Floors	A.182
A.4.1.1	Summary of Data for Water Wash Operation	A.190
A.4.1.2	Summary of Data for Application and Removal of Strippable Coating on Hard-Surface Furnishings	A.190
A.4.2.3.1	Summary of Data for Application and Removal of Foam on Soft-Surface Furnishings	A.195
A.4.3.3.1	Calculation of Replacement Cost of Electronic Equipment	A.199
A.5.1.1.1	Summary of Data for Ordinary Spray Was of Automobiles	A.203
A.5.1.2.1	Summary of Data for Detailed Washing of Automobile Exteriors	A.203
A.5.1.3.1	Summary of Data for Repainting Automobile Exteriors	A.204
A.5.2.1.1	Summary of Data for Vacuuming of Automobile Interiors	A.204
A.5.2.2.1	Summary of Data for Detailed Vacuuming and Cleaning	A.204
A.5.2.4.1	Summary of Data for Re-Upholstering Automobile Interiors	A.205
A.5.3.1	Summary of Data for Different Tire Decontamination Operations	A.205
A.5.4.1	Summary of Data for Decontaminating Automobile Engines and Drive Trains	A.206
A.6.1.1	Air Sample Test Costs by Type	A.211
A.6.1.2	Mobile Sampling Costs by Category	A.211
A.6.1.3	Building Survey Costs by Category	A.214
A.6.1.4	Operation and Maintenance Costs per Sample Station	A.220
A.6.1.5	Operation and Maintenance Costs per Air Sample Station Excluding Travel Costs	A.222
A.6.1.6	Summary Information of Surveying and Monitoring Techniques	A.227
A.6.1.7	Schedule of Surveying and Monitoring Activities	A.229
A.6.2.1	Estimated Hauling Costs and Rates by Mileage	A.230
A.6.2.2	Estimated Volume of Material per Square Meter to be Hauled	A.231
A.6.3.1	Summary of Waste Burial Data	A.239
A.6.3.2	Factor Input Requirements for Waste Burial	A.239