U.S. NUCLEAR REGULATORY COMMISSION

March 1976

REGULATORY GUIDE

OFFICE OF STANDARDS DEVELOPMENT

REGULATORY GUIDE 1.110

COST-BENEFIT ANALYSIS FOR RADWASTE SYSTEMS FOR LIGHT-WATER-COOLED NUCLEAR POWER REACTORS

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A. INTRODUCTION

Section II.D of Appendix I, "Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion 'As Low As Is Reasonably Achievable' for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents," to 10 CFR Part 50, "Licensing of Production and Utilization Facilities," requires that liquid and gaseous radwaste systems for light-water-cooled nuclear power reactors include all items of reasonably demonstrated technology that, when added to the system sequentially and in order of diminishing cost-benefit return, can, for a favorable cost-benefit ratio, effect reductions in dose to the population reasonably expected to be within 50 miles of the reactor. Values of $1000 per man-rem and $1000 per man-thyroid-rem are given as interim criteria pending the development and establishment of better criteria. Compliance with Section II.D of Appendix I to 10 CFR Part 50 (which specifically addresses doses to the population) and Sections II.A, II.B, and II.C (which address doses to nearby individuals) is required to meet the criterion, "as low as is reasonably achievable."

To implement the requirements of Appendix I, the NRC staff has developed a series of guides providing methods acceptable to the staff for the calculation of effluent releases, dispersion of effluents in the atmosphere and different water bodies, associated radiation doses to man, and cost-benefit aspects of treating radwastes. This regulatory guide describes a method for performing a cost-benefit analysis for liquid and gaseous radwaste system components.

The procedures and models provided in this guide will be subject to continuing review by the staff with the aim of providing greater flexibility to the applicant in meeting the requirements of Appendix I. As a result of such reviews, it is expected that alternative acceptable methods for calculation will be made available to applicants and that calculational procedures found to be unnecessary will be eliminated.

B. DISCUSSION

Each applicant for a permit to construct or a license to operate a light-water-cooled nuclear power reactor and each licensee with a license to operate a light-water-cooled nuclear power reactor is required to provide reasonable assurance that the design objectives for as low as is reasonably achievable effluent releases are satisfied by the liquid and gaseous radwaste system designs. It is the objective of this guide to provide an acceptable method of performing cost-benefit analysis, in conformance with Section II.D of Appendix I, to demonstrate that the plant design includes all items of reasonably demonstrated technology for reducing the cumulative population dose due to releases of radioactive materials from the reactor to levels as low as reasonably achievable. As an interim measure the Commission chose values of $1000 per man-rem and $1000 per man-thyroid-rem (or lesser values if demonstrated to be suitable for a particular site) to be used to implement the cost-benefit analysis.

Because the Commission has not outlined any procedures for including the effects of inflation in the analysis, the NRC staff's analysis is based on 1975 dollars; i.e., neither the costs nor the interim criteria are escalated for the predicted effects of inflation. Since the worth of a man-rem or man-thyroid-rem to the public is subject to the same fluctuations in value as the cost of equipment to reduce radioactive emissions, the NRC staff believes this approach to be reasonable.

The NRC staff has outlined a method for performing the required cost-benefit analysis and has provided cost parameters for estimating the costs for the various radwaste treatment equipment items in use, or proposed for use, at light-water-cooled nuclear power reactors. The methodology and cost parameters are presented in Appendix A to this guide. The costs presented consider the direct equipment cost and the costs of building space, supportive services, maintenance, interest, and operating as well as other costs generally considered in analyzing capital and operating costs in power plant estimating. The bases for the costs calculated by the NRC staff are given in Appendix B.

C. REGULATORY POSITION

1. In accordance with Section II.D, Appendix I to 10 CFR Part 50, each applicant for a permit to construct a light-water-cooled nuclear power reactor should demonstrate by means of a cost-benefit analysis that further reductions to the cumulative dose to the population within a 50-mile radius of the reactor site cannot be effected at an annual cost of $1000 per man-rem or $1000 per man-thyroid-rem (or such lesser costs as demonstrated to be suitable for a particular case).

2. The cost-benefit analysis should consider the reduction in releases of radioactive material from all effluent pathways. Liquid and gaseous radwaste system augments considered in the analysis should be selected in order of diminishing cost-benefit returns.

3. All costs should be given in terms of 1975 dollars (as is the $1000 per man-rem cost with which they are compared). Allowances for inflation after 1975 should not be factored into the cost estimates.

4. The method of calculation described in Appendix A and the parameters presented in Appendix B of this guide are acceptable to the NRC staff for performing the cost-benefit analysis.

5. In support of the cost-benefit analysis, the applicant should provide a complete evaluation including methodology used, components considered, and all assumptions and parameters used. Information to be submitted by the applicant is described in Appendix C to this guide. Use of parameters, assumptions, and models different from those given in Appendices A and B to this guide may result in differences between the evaluations by applicants and those by the NRC staff. Because of this, these parameters and assumptions should be clearly described and substantiated by the applicant.

D. IMPLEMENTATION

The purpose of this section is to provide information to license applicants and licensees regarding the NRC staff's plan for using this regulatory guide.

Except in those cases in which the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the method described herein will be used in the evaluation of construction permit applications docketed after June 4, 1976 unless this guide is revised as a result of suggestions from the public or additional staff review.

If an applicant wishes to use this regulatory guide in developing submittals for applications docketed on or before June 4, 1976, the pertinent portions of the application will be evaluated on the basis of this guide.

APPENDIX A

PROCEDURES FOR PERFORMING COST-BENEFIT ANALYSES

This appendix contains guidance for performing cost-benefit analyses on individual system augments, as well as the parameters needed for estimating costs. The bases for the parameters and worksheets appropriate for use with the following cost-benefit procedure are given in Appendix B.

1. The cumulative population man-rem exposure and man-thyroid-rem exposure should be determined for each effluent release source, e.g., liquid radwaste releases, ventilation releases, etc.

2. Potential reductions to the cumulative population exposure should be determined based on the addition of items of reasonably demonstrated technology which have the potential to reduce releases of radioactive materials.

3. Acceptable methods for performing some of the calculations need for items 1 and 2 above are contained in Regulatory Guides 1.109, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," and 1.111, "Methods for Estimating Atmospheric Transport and Dispersion for Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors," and in two regulatory guides now in preparation on the subjects of (1) calculation of releases of radioactive materials in liquid and gaseous effluents from light-water-cooled reactors and (2) methods for estimating aquatic dispersion of liquid effluents from routine reactor releases for the purpose of implementing Appendix I.

4. The total annual cost of each augment considered in item 2 above should be determined as follows:

a. The Total Direct Cost (TDC):

(1) Obtain the direct cost of equipment and materials from Table A-1.

(2) Multiply the direct labor cost obtained from Table A-1 by the appropriate labor cost correction factor from Table A-4 to obtain the corrected labor cost for the geographical area from Figure A-1, in which the plant is to be built.

(3) Add the costs obtained from steps (1) and (2) to obtain the Total Direct Cost.

b. Obtain the appropriate Indirect Cost Factor (ICF) from Table A-5.

c. Determine Total Capital Cost (TCC) by using the equation:

$$TCC = TDC \times ICF$$

d. Obtain the appropriate Capital Recovery Factor (CRF) from Table A-6.

e. Determine the Annual Fixed Cost (AFC) by using the equation:

$$AFC = TCC \times CRF$$

f. Obtain the Annual Operating Cost (AOC) and the Annual Maintenance Cost (AMC) from Tables A-2 and A-3. Multi-unit sites using shared radwaste systems should multiply the AOC by the number of reactors sharing the augment.

g. Determine the Total Annual Cost (TAC) by using the equation:

$$TAC = AFC + AOC + AMC$$

5. Determine the "benefit" of each augment by multiplying the dose reduction calculated in item 2 above by $1000 per man-rem and/or $1000 per man-thyroid-rem, as appropriate.

6. The system should be augmented with any items for which the TAC from item 4.g above is less than the value calculated in item 5, in the order of diminishing cost-benefit.

TABLE A-1

DIRECT COSTS - GASEOUS RADWASTE AUGMENTS

	Direct Costs (1975 $1000)		
	Equipment/Material	Labor	Total
BWR Offgas Recombiner	553	255	808
3-ton Charcoal Adsorber	53	14	67
Desiccant Dryer	218	176	394
Charcoal Vault Refrigeration	116	38	154
Main Condenser Vacuum Pump Charcoal/HEPA Filtration System	40	8	48
Clean Steam to Turbine Glands	81	215	296
Clean Steam to Steam Valves, 24" and Larger	137	110	247
Clean Steam to Steam Valves, 2-1/2" and Less Than 24"	183	55	238
15,000-cfm HEPA Filtration System	52(49)*	16(14)*	68(63)*
1,000-cfm Charcoal/HEPA Filtration System	28	10	38
15,000-cfm Charcoal/HEPA Filtration System	97(93)	31(26)	128(119)
30,000-cfm Charcoal/HEPA Filtration System	157(152)	51(41)	208(193)
Turbine Bldg. Chilled Water HVAC System	614	374	988
600-ft^3 Gas Decay Tank	33	24	57
PWR Hydrogen Recombiner	419	147	566
PWR Air Ejector Charcoal/HEPA Filtration Unit	14	10	24
Steam Generator Flash Tank Vent to Main Condenser	19	14	33

*In cases where the equipment may be located either in the auxiliary building or the turbine building and common usage does not indicate a definite preference of one location or the other, cost for both locations are listed with the turbine building location cost in parenthesis.

TABLE A-1 (Continued)

DIRECT COSTS - LIQUID RADWASTE AUGMENTS

	Direct Costs (1975 $1000)		
	Equipment/Material	Labor	Total
15-gpm Evaporator	386	201	587
30-gpm Evaporator	540	223	763
50-gpm Evaporator	655	233	888
Evaporator Distillate Demineralizer	36	24	60
50-gpm Demineralizer	43	29	50
100-gpm Demineralizer	64	31	95
200-gpm Demineralizer	94	35	129
400-gpm Demineralizer	102	44	146
100-gpm Precoat Filter	108	56	164
400-gpm Precoat Filter	202	112	314
20-gpm Cartridge Filter	13	11	24
2-gpm Reverse Osmosis	100	38	138
10,000-gal Tank	55	43	98

TABLE A-2

ANNUAL OPERATING COSTS* - GASEOUS RADWASTE AUGMENTS

	Total Operating Cost (1975 $1000/yr)
BWR Offgas Recombiner	3
3-ton Charcoal Adsorber	neg
Desiccant Dryer	3
Charcoal Vault Refrigeration	4
Main Condenser Vacuum Pump Charcoal/HEPA Filtration System	0.4
Clean Steam to Turbine Glands	24
Clean Steam to Steam Valves, 24" and Larger	3
Clean Steam to Steam Valves, 2-1/2" and Less Than 24"	3
15,000-cfm HEPA Filtration System	6
1,000-cfm Charcoal/HEPA Filtration System	2
15,000-cfm Charcoal/HEPA Filtration System	7
30,000-cfm Charcoal/HEPA Filtration System	9
Turbine Bldg. Chilled Water HVAC System	49
600-ft^3 Gas Decay Tank	neg
PWR Hydrogen Recombiner	4
PWR Air Ejector Charcoal/HEPA Filtration Unit	4
Steam Generator Flash Tank Vent to Main Condenser	1

ANNUAL OPERATING COSTS* - LIQUID RADWASTE AUGMENTS

Evaporation - PWR Dirty Waste	50
Evaporation - BWR Dirty Waste	169
Evaporation - Condensate Polisher Chemical Waste	114
Evaporation - Detergent Waste	20
Demineralization - Evaporator Distillate	5
Demineralization - BWR 2nd Waste Demineralizer in Series	15

*Operating costs are given for a single reactor. Operating costs for augments in shared radwaste systems should be multiplied by the number of reactors serviced by the augment.

TABLE A-2 (Continued)

ANNUAL OPERATING COSTS - LIQUID RADWASTE AUGMENTS

	Total Operating Cost (1975 $1000/yr)
Demineralization - PWR Clean Waste	5
Demineralization - BWR Dirty Waste	88
Demineralization - PWR Dirty Waste	18
Demineralization - PWR Turbine Bldg. Drains	95
Demineralization - PWR Steam Generator Blowdown	25
Precoat Filter - BWR Dirty Waste	53
Cartridge Filter	7
Reverse Osmosis - Detergent Waste	7
10,000-gal Tank	1

TABLE A-3

ANNUAL MAINTENANCE COSTS - GASEOUS RADWASTE AUGMENTS

	Total Maintenance Cost (1975 $1000/yr)
BWR Offgas Recombiner	20
3-ton Charcoal Adsorber	neg
Desiccant Dryer	6
Charcoal Vault Refrigeration	3
Main Condenser Vacuum Pump Charcoal/HEPA Filtration System	1
Clean Steam to Turbine Glands	4
Clean Steam to Steam Valves, 24" and Larger	4
Clean Steam to Steam Valves, 2-1/2" and Less Than 24"	12
15,000-cfm HEPA Filtration System	2
1,000-cfm Charcoal/HEPA Filtration System	0.6
15,000-cfm Charcoal/HEPA Filtration System	9
30,000-cfm Charcoal/HEPA Filtration System	18
Turbine Bldg. Chilled Water HVAC System	20
600-ft^3 Gas Decay Tank	neg
PWR Hydrogen Recombiner	10
PWR Air Ejector Charcoal/HEPA Filtration Unit	2
Steam Generator Flash Tank Vent to Main Condenser	1

ANNUAL MAINTENANCE COSTS - LIQUID RADWASTE AUGMENTS

15-gpm Evaporator	30
30-gpm Evaporator	30
50-gpm Evaporator	30
Evaporator Distillate Demineralizer	2
50-gpm Demineralizer	5
100-gpm Demineralizer	5
200-gpm Demineralizer	5
100-gpm Precoat Filter	10
400-gpm Precoat Filter	10
20-gpm Cartridge Filter	1
2-gpm Reverse Osmosis	9
10,000-gal Tank	2

TABLE A-4

LABOR COST CORRECTION FACTORS*

FPC** Geographic Region	Labor Cost Correction Factor
I	1.6
II	1.5
III	1.0
IV	1.4
V	1.1
VI	1.2
VII	1.3
VIII	1.2

*See Appendix B, "Labor Cost Correction Factors."
**See Figure A-1.

TABLE A-5

INDIRECT COST FACTORS

	Type Radwaste System	Indirect Cost Factor
1.	Single unit site, unitized* radwaste system	1.75
2.	Multi-unit site, shared radwaste system	1.75
3.	Multi-unit site, unitized* radwaste system	$\frac{1.75 + (n-1)1.5}{n}$ where n is the number of unitized radwaste systems at the site

*Each reactor has a separate, nonshared radwaste system.

TABLE A-6

CAPITAL RECOVERY FACTORS

Cost of Money (% per year, i)	Capital Recovery Factor*
5	0.0651
6	0.0726
7	0.0806
8	0.0888
9	0.0973
10	0.1061
11	0.1150
12	0.1241
13	0.1334
14	0.1428
15	0.1523

*Based on a service life of 30 years and the following equation:

$$CRF = \frac{i(1 + i)^{30}}{(1 + i)^{30} - 1}$$

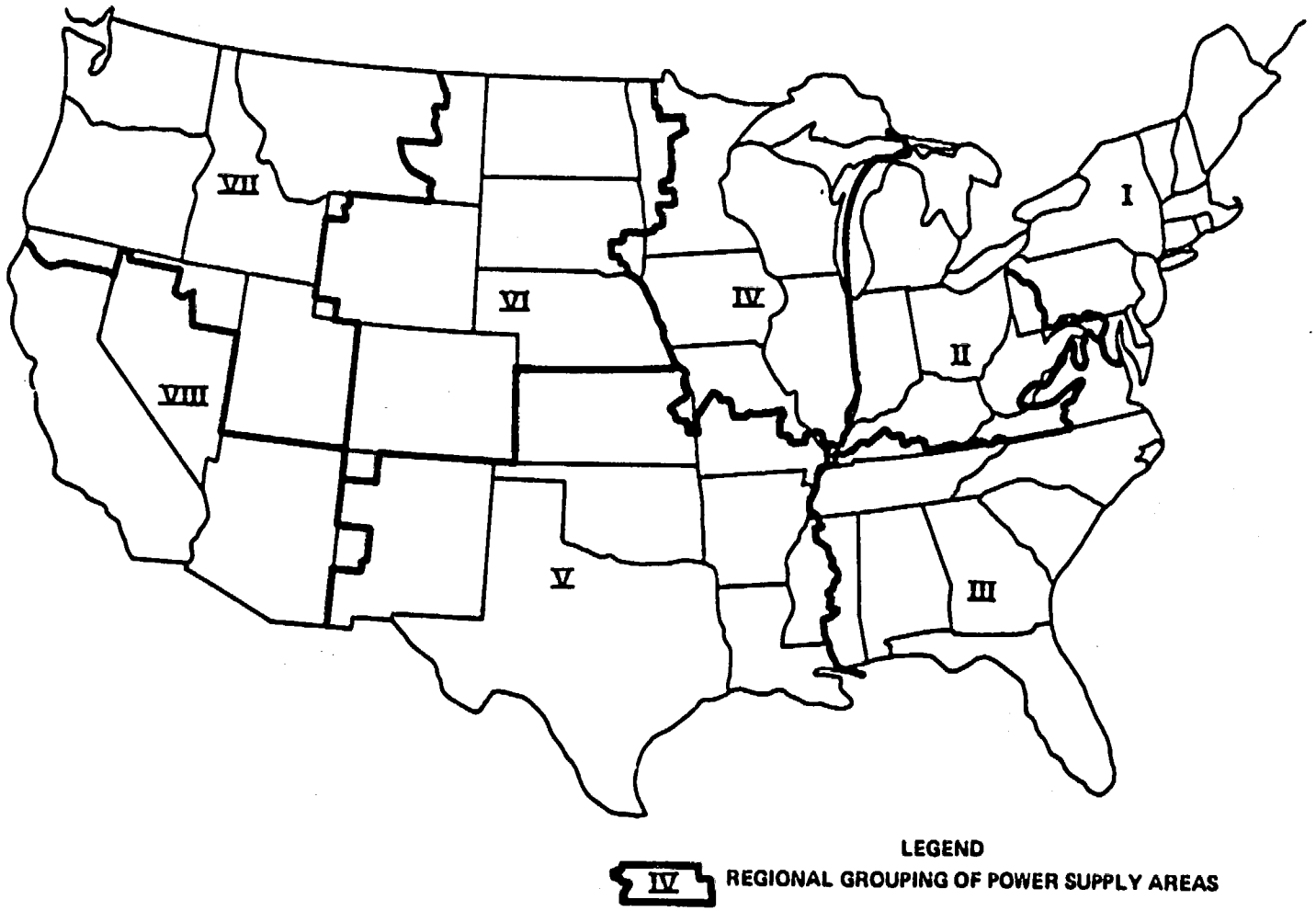

FIGURE A-1 ELECTRIC POWER SUPPLY AREAS IN THE UNITED STATES

APPENDIX B

BASES FOR PARAMETERS USED IN PERFORMING COST-BENEFIT ANALYSIS

This appendix contains detailed cost estimate sheets showing the methods and parameters used to obtain all costs associated with augments considered for the liquid and gaseous radwaste systems. The cost estimate sheets are grouped by radwaste system types. The first sheet in each case is an equipment cost worksheet for determining direct equipment costs. The second sheet is an operating cost worksheet. All costs are stated in terms of 1975 dollars. No attempt has been made to project the effect of inflation. Variations of labor costs and productivity with site locations are considered.* All costs are based on the assumption that the reactor is in the design stage and that augmentation of a radwaste system will not involve backfitting of an existing plant. Backfitting costs should be determined on a case-by-case basis.

1. Capital Costs

Capital costs are reported by grouping items by system and by plant location, which generally follow the NRC (AEC) accounting system given in NUS-531 (Ref. 1). The direct costs considered to be applicable to radwaste systems are structures, electrical services, equipment, and instrumentation and controls. Spare parts and a contingency allowance** are included in the direct costs. Total capital costs are obtained by multiplying direct costs by an indirect cost factor.

2. Direct Cost

Direct costs for each augment include equipment, site labor, and site materials. Principal equipment designs and hardware costs were obtained from utility companies, architect-engineers, and vendors. Costs for building space, electrical services, piping, and instrumentation were estimated considering equipment functions and arrangements.

Costs for electric services, piping, and instrumentation and controls were determined using judgment to estimate equipment layout, points of interface, and services required. The costs for equipment and building space are consistent with NRC staff recommendations for radwaste system quality assurance, materials, and seismic design. Space requirements were determined based on manufacturer's data or data from existing or proposed layout drawings.

3. Labor Cost Correction Factors

Labor cost adjustment factors were developed for each of the eight FPC electric power supply areas shown in Figure A-1 of Appendix A by calculating the average labor cost for selected cities (Ref. 2) in each area and adjusting this cost for estimated variations in labor productivity due only to differences in labor practices in the regions considered. Manpower costs were calculated by multiplying the estimated labor requirements in man-hours by the composite wage rate (Ref. 3). The calculated labor cost correction factors are tabulated in Table A-4 of Appendix A.

4. Indirect Cost Factor

Indirect costs as a percentage of direct costs are calculated in Table B-1.

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*Location effects of the eight FPC Power Supply areas are estimated and shown in Table A-4 of Appendix A.

**Contingency onsite labor and process equipment and material are all based on 10%.

TABLE B-1

INDIRECT COSTS

	1st Unit, Percentage of Direct Cost	Subsequent Units, Percentage of Direct Cost
Construction facilities, equipment, and services	10	5
Engineering and construction management services	20	10
Other owner's costs	10	5
Interest during construction	35*	35*
Total	75	55

*Based on a 10%/yr interest rate and a 4-year construction time for radwaste systems only. Interest during construction is estimated to be 25% of direct costs plus other indirect costs. This is equivalent to 35% of the direct costs.

The indirect escalators (factors) were estimated from preliminary architect/engineering data to be used to update the ORNL concept and ORCOST computer codes.

5. Operation And Maintenance Costs

Annual expenses for operation and maintenance (O&M) of the radwaste treatment systems were estimated for baseload power plants operating at 80% capacity factor. Manpower and supply costs were estimated by considering equipment functions in each case. Expenses for gases, steam, resins, auxiliary power, and other supplies and services were assessed individually. Maintenance costs were evaluated according to the type of service for which the equipment could be used. Operating costs include estimated manpower costs, costs of utilities and supplies, and effects on supporting plant systems interfacing with the augmented radwaste system (e.g., effect of an evaporator augment on the solid waste system). Also included are costs of handling wastes such as spent resins, demineralizer regenerants, evaporator bottoms, and filter media, as well as offsite handling, transportation, and burial costs.

6. Capital Recovery Factor

The capital recovery factor is a levelized annual charge which takes into account the cost of borrowed money and the depreciation of assets. It is calculated from the expression:

$$\frac{i(1+i)^n}{(1+i)^n-1}$$

where

i = cost of borrowed money expressed as a decimal

n = plant operating lifetime (yr)

In calculating the values used in Table A-5 of Appendix A, a plant operating lifetime of 30 years was used.

The capital recovery factor multiplied by the total capital cost will give the annual dollar charges for capital and capital-related expenses.

LIST OF APPENDIX B COST ESTIMATE SHEETS

TOTAL DIRECT COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment BWR Offgas Recombiner (Sheet 1)

	ITEM	DIRECT COST, (1975 $1000) LABOR	EQUIPMENT/MATERIALS	TOTAL	BASIS FOR COST ESTIMATE
1.	PROCESS EQUIPMENT	90	260	350	single unit, catalytic type w/heater and condenser, w/o instrumentation and controls, stainless steel, ASME VIII
2.	BUILDING ASSIGNMENT	100	50	150	30' x 40' x 25' @ $5/ft^3 (turbine building shielded area)
3.	ASSOCIATED PIPING SYSTEMS	18	12	30	augment piping connections only
4.	INSTRUMENTATION AND CONTROLS	24	96	120	allowance
5.	ELECTRICAL SERVICE	-	-	neg	4kw heaters on vessels neglected
6.	SPARE PARTS	-	85	85	75K for catalyst + 2% E/M in items 1 & 4 above
	SUBTOTAL	232	503	735	
7.	CONTINGENCY	23	50	73	10%
8.	TOTAL DIRECT COSTS	255	553	808	

ANNUAL OPERATING AND MAINTENANCE COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment BWR Offgas Recombiner (Sheet 2)

	ITEM	COST (1975 $1000) LABOR	OTHER	TOTAL	BASIS FOR COST ESTIMATE
1.	OPERATING LABOR, SUPERVISION, AND OVERHEAD			3.3	15 min/shift
2.	MAINTENANCE MATERIAL AND LABOR			20.0	routine conditioning of catalyst and equipment upkeep; 5% of E/M including I&C
3.	CONSUMABLES, CHEMICALS, AND SUPPLIES			-	in item 2
4.	UTILITIES AND SERVICES Waste Disposal Water Steam Electricity Building Services Other			neg	intermittent; 4kw heater load is negligible
5.	TOTAL O AND M ANNUAL COST			23.3	

TOTAL DIRECT COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM
FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment 3-ton Charcoal Adsorber (Sheet 1)

	ITEM	DIRECT COST (1975 $1000) LABOR	EQUIPMENT/MATERIALS	TOTAL	BASIS FOR COST ESTIMATE
1.	PROCESS EQUIPMENT	5	44.0	49.0	carbon steel, 350 psig, 200 ft^3 volume (augment to existing train of beds)
2.	BUILDING ASSIGNMENT	8	4.5	12.5	10' x 10' x 25' @ $5/$ft^3$ (turbine building shielded area)
3.	ASSOCIATED PIPING SYSTEMS	-	-	-	in item 1
4.	INSTRUMENTATION AND CONTROLS	-	-	neg	
5.	ELECTRICAL SERVICE	-	-	neg	
6.	SPARE PARTS	-	-	none	existing
	SUBTOTAL	13	48.5	61.5	
7.	CONTINGENCY	1	5.0	6.0	10%
8.	TOTAL DIRECT COSTS	14	53.5	67.5	

ANNUAL OPERATING AND MAINTENANCE COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment 3-ton Charcoal Adsorber (Sheet 2)

	ITEM	COST (1975 $1000) LABOR	OTHER	TOTAL	BASIS FOR COST ESTIMATE
1.	OPERATING LABOR, SUPERVISION, AND OVERHEAD			neg	
2.	MAINTENANCE MATERIAL AND LABOR			neg	allowance of 3% of equipment cost is negligible
3.	CONSUMABLES, CHEMICALS, AND SUPPLIES			neg	lifetime use of charcoal assumed
4.	UTILITIES AND SERVICES Waste Disposal Water Steam Electricity Building Services Other			neg	
5.	TOTAL O AND M ANNUAL COST			neg	

TOTAL DIRECT COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment Desiccant Dryer (Sheet 1)

	ITEM	DIRECT COST (1975 $1000) LABOR	EQUIPMENT/MATERIALS	TOTAL	BASIS FOR COST ESTIMATE
1.	PROCESS EQUIPMENT	25	75	100	redundant dryer vessels with 1 regeneration skid
2.	BUILDING ASSIGNMENT	95	50	145	40' x 36' x 20' @ $5/ft^3 turbine building (shielded area)
3.	ASSOCIATED PIPING SYSTEMS	10	5	15	augment piping connections only
4.	INSTRUMENTATION AND CONTROLS	12	48	60	allowance
5.	ELECTRICAL SERVICE	18	17	35	service for heaters, blowers, pumps, and compressors
6.	SPARE PARTS	-	3	3	
	SUBTOTAL	160	198	358	
7.	CONTINGENCY	16	20	36	10%
8.	TOTAL DIRECT COSTS	176	218	394	

ANNUAL CPERATING AND MAINTENANCE COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment Desiccant Dryer (Sheet 2)

	ITEM	COST (1975 $1000) LABOR	OTHER	TOTAL	BASIS FØR COST ESTIMATE
1.	OPERATING LABOR, SUPERVISION, AND OVERHEAD			3.3	15 min/shift
2.	MAINTENANCE MATERIAL AND LABOR			6.1	5% of equipment including I&C
3	CONSUMABLES, CHEMICALS, AND SUPPLIES			neg	
4.	UTILITIES AND SERVICES				
	Waste Disposal			neg	operating time does not require significant utilities and services
	Water			neg	
	Steam				
	Electricity			neg	
	Building Services				
	Other				
5.	TOTAL O AND M ANNUAL COST			9.4	

TOTAL DIRECT COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM
FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment Charcoal Vault Refrigeration (Sheet 1)

	ITEM	DIRECT COST (1975 $1000) LABOR	EQUIPMENT/MATERIALS	TOTAL	BASIS FOR COST ESTIMATE
1.	PROCESS EQUIPMENT	10	75	85	10-ton capacity, 3 refrigerators with drives, 32°F design
2.	BUILDING ASSIGNMENT	9	3	12	20' x 10' x 20' @ $2/ft^3 turbine building (nonshielded area)
3.	ASSOCIATED PIPING SYSTEMS				in item 1
4.	INSTRUMENTATION AND CONTROLS	4	6	10	allowance
5.	ELECTRICAL SERVICE	12	18	30	allowance
6.	SPARE PARTS	-	3	3	
	SUBTOTAL	35	105	140	
7.	CONTINGENCY	3	11	14	10%
8.	TOTAL DIRECT COSTS	38	116	154	

ANNUAL OPERATING AND MAINTENANCE COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment Charcoal Vault Refrigeration (Sheet 2)

	ITEM	COST (1975 $1000) LABOR	OTHER	TOTAL	BASIS FOR COST ESTIMATE
1.	OPERATING LABOR, SUPERVISION, AND OVERHEAD			3.3	15 min/shift
2.	MAINTENANCE MATERIAL AND LABOR			3.7	5% of equipment
3.	CONSUMABLES, CHEMICALS, AND SUPPLIES				in item 2
4.	UTILITIES AND SERVICES Waste Disposal Water Steam Electricity Building Services Other			0.5	electricity and cooling water
5.	TOTAL O AND M ANNUAL COST			7.5	

TOTAL DIRECT COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment Charcoal/HEPA Filtration System - Condenser Vacuum Pump (Sheet 1)

	ITEM	DIRECT COST (1975 $1000) LABOR	EQUIPMENT/MATERIALS	TOTAL	BASIS FOR COST ESTIMATE
1.	PROCESS EQUIPMENT	2	32.5	34.5	2000 CFM prefilter/4" charcoal bed/HEPA @ $15/cfm, 10 kw heater @ $250/kw
2.	BUILDING ASSIGNMENT	3.1	1.5	4.6	Turbine building 8' x 16' x 12' @ $3/ft^3 (nonshielded area)
3.	ASSOCIATED PIPING SYSTEMS	1.3	0.7	2.0	allowance
4.	INSTRUMENTATION AND CONTROLS				in item 1
5.	ELECTRICAL SERVICE	1	1.5	2.5	
6.	SPARE PARTS		0.5	0.5	
	SUBTOTAL	7.4	36.7	44.1	
7.	CONTINGENCY	.7	3.7	4.4	10%
8.	TOTAL DIRECT COSTS	8.1	40.4	48.5	

ANNUAL OPERATING AND MAINTENANCE COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment Charcoal/HEPA Filtration System - Condenser Vacuum Pump (Sheet 2)

	ITEM	COST (1975 $1000) LABOR	OTHER	TOTAL	BASIS FOR COST ESTIMATE
1.	OPERATING LABOR, SUPERVISION, AND OVERHEAD			neg	used only during startup and shutdown
2.	MAINTENANCE MATERIAL AND LABOR			1.2	4 HEPA filters @ $150 & 2 Charcoal filters @ $900, change every 2 years
3.	CONSUMABLES, CHEMICALS, AND SUPPLIES			-	in items 2 and 4
4.	UTILITIES AND SERVICES Waste Disposal Water Steam Electricity Building Services Other			0.2	$50/HEPA filter, $100/Charcoal filter
5.	TOTAL O AND M ANNUAL COST			1.4	

TOTAL DIRECT COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM
FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment Clean Steam to Turbine Glands (Sheet 1)

	ITEM	DIRECT COST (1975 $1000) LABOR	EQUIPMENT/MATERIALS	TOTAL	BASIS FOR COST ESTIMATE
1.	PROCESS EQUIPMENT	15	150	165	25,000 lb/hr reboiler @ $4/lb/hr & $25K/H.P. turbine glands
2.	BUILDING ASSIGNMENT	19	10	29	20' x 30' x 16' @ $3/ft^3
3.	ASSOCIATED PIPING SYSTEMS	32	18	50	equiv 1000 ft @ $50/ft
4.	INSTRUMENTATION AND CONTROLS	8	12	20	in addition to item 1
5.	ELECTRICAL SERVICE			neg	
6.	SPARE PARTS	-	5	5	
	SUBTOTAL	74	195	269	
7.	CONTINGENCY	7	20	27	10%
8.	TOTAL DIRECT COSTS	81	215	296	

ANNUAL OPERATING AND MAINTENANCE COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment Clean Steam to Turbine Glands (Sheet 2)

	ITEM	COST (1975 $1000) LABOR	OTHER	TOTAL	BASIS FOR COST ESTIMATE
1.	OPERATING LABOR, SUPERVISION, AND OVERHEAD			3.3	15 min/shift
2.	MAINTENANCE MATERIAL AND LABOR			4.0	40 man-days
3.	CONSUMABLES, CHEMICALS, AND SUPPLIES				
4.	UTILITIES AND SERVICES Waste Disposal Water Steam Electricity Building Services Other			21.0	10 Btu/kw-hr heat rate increase
5.	TOTAL O AND M ANNUAL COST			28.3	

TOTAL DIRECT COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM
FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment Clean Steam to Steam Valves 24" and Larger (Sheet 1)

	ITEM	DIRECT COST (1975 $1000) LABOR	EQUIPMENT/MATERIALS	TOTAL	BASIS FOR COST ESTIMATE
1.	PROCESS EQUIPMENT	100	120	220	22 valves @ $10K/valve, use existing reboiler
2.	BUILDING ASSIGNMENT			neg	install in existing space
3.	ASSOCIATED PIPING SYSTEMS			-	in item 1
4.	INSTRUMENTATION AND CONTROLS			-	in item 1
5.	ELECTRICAL SERVICE			neg	
6.	SPARE PARTS	-	5	5	
	SUBTOTAL	100	125	225	
7.	CONTINGENCY	10	12	22	10%
8.	TOTAL DIRECT COSTS	110	137	247	

ANNUAL OPERATING AND MAINTENANCE COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment Clean Steam to Steam Valves 24" and Larger (Sheet 2)

	ITEM	COST (1975 $1000) LABOR	OTHER	TOTAL	BASIS FOR COST ESTIMATE
1.	OPERATING LABOR, SUPERVISION, AND OVERHEAD			3.3	15 min/shift
2.	MAINTENANCE MATERIAL AND LABOR			4.0	40 man-days
3.	CONSUMABLES, CHEMICALS, AND SUPPLIES			neg	
4.	UTILITIES AND SERVICES				
	Waste Disposal				
	Water				
	Steam			neg	
	Electricity				
	Building Services				
	Other				
	TOTAL O AND M ANNUAL COST			7.3	

TOTAL DIRECT COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment Clean Steam to Steam Valves 2-1/2" and Less Than 24" (Sheet 1)

	ITEM	DIRECT COST (1975 $1000) LABOR	EQUIPMENT/MATERIALS	TOTAL	BASIS FOR COST ESTIMATE
1.	PROCESS EQUIPMENT	0	120	120	100 valves @ $1200 each
2.	BUILDING ASSIGNMENT	-	-	neg	
3.	ASSOCIATED PIPING SYSTEMS	40	20	60	
4.	INSTRUMENTATION AND CONTROLS	10	20	30	allowance
5.	ELECTRICAL SERVICE			-	none
6.	SPARE PARTS	-	6	6	
	SUBTOTAL	50	166	216	
7.	CONTINGENCY	5	17	22	10%
8.	TOTAL DIRECT COSTS	55	183	238	

ANNUAL OPERATING AND MAINTENANCE COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment Clean Steam to Steam Valves 2-1/2" and Less Than 24" (Sheet 2)

	ITEM	COST (1975 $1000) LABOR	OTHER	TOTAL	BASIS FOR COST ESTIMATE
1.	OPERATING LABOR, SUPERVISION, AND OVERHEAD			3.3	15 min/shift
2.	MAINTENANCE MATERIAL AND LABOR			12.0	1% of direct cost of equipment
3.	CONSUMABLES, CHEMICALS, AND SUPPLIES			-	in item 2
4.	UTILITIES AND SERVICES Waste Disposal Water Steam Electricity Building Services Other			neg	
5.	TOTAL O AND M ANNUAL COST			15.3	

TOTAL DIRECT COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment 15,000-cfm HEPA Filtration System - Auxiliary Building (Sheet 1)

	ITEM	DIRECT COST (1975 $1000) LABOR	EQUIPMENT/MATERIALS	TOTAL	BASIS FOR COST ESTIMATE
1.	PROCESS EQUIPMENT	5	40.0	45.0	prefilter/HEPA @ $3/cfm, use existing fan
2.	BUILDING ASSIGNMENT	7	4.5	11.5	16' x 12' x 12' @ $5/ft^3 (nonshielded area)
3.	ASSOCIATED PIPING SYSTEMS	3	2.0	5.0	
4.	INSTRUMENTATION AND CONTROLS				in item 1
5.	ELECTRICAL SERVICE				base
6.	SPARE PARTS		0.5	0.5	
	SUBTOTAL	15	47.0	62.0	
7.	CONTINGENCY	1	5.0	6.0	10%
8.	TOTAL DIRECT COSTS	16	52.0	68.0	

TOTAL DIRECT COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment 15,000-cfm HEPA Filtration System - Turbine Building (Sheet 2)

	ITEM	DIRECT COST (1975 $1000) LABOR	EQUIPMENT/MATERIALS	TOTAL	BASIS FOR COST ESTIMATE
1.	PROCESS EQUIPMENT	5	40.0	45.0	skid mounted filter housing w/o fans
2.	BUILDING ASSIGNMENT	4.6	2.3	6.9	16' x 12' x 12' @ $3/ft^3 (nonshielded area)
3.	ASSOCIATED PIPING SYSTEMS	3	2.0	5.0	
4.	INSTRUMENTATION AND CONTROLS				in item 1
5.	ELECTRICAL SERVICE				base
6.	SPARE PARTS	0	0.5	0.5	
	SUBTOTAL	12.6	44.8	57.4	
7.	CONTINGENCY	2	4.0	6.0	10%
8.	TOTAL DIRECT COSTS	14.6	48.8	63.4	

ANNUAL OPERATING AND MAINTENANCE COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment 15,000-cfm HEPA Filtration System (Sheet 3)

	ITEM	COST (1975 $1000) LABOR	OTHER	TOTAL	BASIS FOR COST ESTIMATE
1.	OPERATING LABOR, SUPERVISION, AND OVERHEAD			3.8	15 min/shift + 40 hr annual test
2.	MAINTENANCE MATERIAL AND LABOR			2.2	change every 2 yrs @ $150/filter element
3.	CONSUMABLES, CHEMICALS, AND SUPPLIES			-	in items 2 and 4
4.	UTILITIES AND SERVICES				
	Waste Disposal			0.8	$50/filter element
	Water				
	Steam				
	Electricity			1.0	additional fan electrical load
	Building Services				
	Other				
5.	TOTAL O AND M ANNUAL COST			7.8	

TOTAL DIRECT COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment 1000-cfm Charcoal/HEPA Filtration System (Sheet 1)

	ITEM	DIRECT COST (1975 $1000) LABOR	EQUIPMENT/MATERIALS	TOTAL	BASIS FOR COST ESTIMATE
1.	PROCESS EQUIPMENT	2.0	22.0	24.0	prefilter/4" charcoal/HEPA @ $20/cfm, 5 kw htr @ $400/kw
2.	BUILDING ASSIGNMENT	3.8	2.0	5.8	8' x 12' x 12' @ $5/ft^3 (nonshielded area)
3.	ASSOCIATED PIPING SYSTEMS	1.3	.7	2.0	
4.	INSTRUMENTATION AND CONTROLS			-	in item 1
5.	ELECTRICAL SERVICE	1.5	1.0	2.5	
6.	SPARE PARTS		0.5	0.5	
	SUBTOTAL	8.6	26.2	34.8	
7.	CONTINGENCY	1.0	2.0	3.0	10%
8.	TOTAL DIRECT COSTS	9.6	28.2	37.8	

ANNUAL OPERATING AND MAINTENANCE COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment 1000-cfm Charcoal/HEPA Filtration System (Sheet 2)

	ITEM	COST (1975 $1000) LABOR	OTHER	TOTAL	BASIS FOR COST ESTIMATE
1.	OPERATING LABOR, SUPERVISION, AND OVERHEAD			1.9	20 min/day + 40 hr annual test
2.	MAINTENANCE MATERIAL AND			.6	2 HEPA or prefilters @ $150 each and 1 charcoal @ $900 each every 2 yrs
3.	CONSUMABLES, CHEMICALS, AND SUPPLIES				in items 2 and 4
4.	UTILITIES AND SERVICES				
	Waste Disposal			.1	$50/HEPA or prefilter, $100/charcoal filter
	Water				
	Steam				
	Electricity			neg	
	Building Services				
	Other				
5.	TOTAL O AND M ANNUAL COST			2.6	

TOTAL DIRECT COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment ' 15,000-cfm Charcoal/HEPA Filtration System - Auxiliary Building (Sheet 1)

	ITEM	DIRECT COST (1975 $1000) LABOR	EQUIPMENT/MATERIALS	TOTAL	BASIS FOR COST ESTIMATE
1.	PROCESS EQUIPMENT	10	71	81	prefilter/4" charcoal/HEPA @ $5/cfm, 30kw htr @ $200/kw
2.	BUILDING ASSIGNMENT	12	8	20	16' x 20' x 12' @ $5/ft^3 (nonshielded area)
3.	ASSOCIATED PIPING SYSTEMS	3	2	5	
4.	INSTRUMENTATION AND CONTROLS			-	in item 1
5.	ELECTRICAL SERVICE	3	2	5	allowance
6.	SPARE PARTS		5	5	4 elements of each type
	SUBTOTAL	28	88	116	
7.	CONTINGENCY	3	9	12	10%
8.	TOTAL DIRECT COSTS	31	97	128	

TOTAL DIRECT COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment 15,000-cfm Charcoal/HEPA Filtration System - Turbine Building (Sheet 2)

	ITEM	DIRECT COST (1975 $1000) LABOR	EQUIPMENT/MATERIALS	TOTAL	BASIS FOR COST ESTIMATE
1.	PROCESS EQUIPMENT	10.0	71.0	81.0	prefilter/4" charcoal/HEPA @ $5/cfm, 30 kw htr @ $200/kw
2.	BUILDING ASSIGNMENT	7.7	3.8	11.5	16' x 20' x 12' @ $3/ft^3 (nonshielded area)
3.	ASSOCIATED PIPING SYSTEMS	3.0	2.0	5.0	
4.	INSTRUMENTATION AND CONTROLS				in item 1
5.	ELECTRICAL SERVICE	3.0	2.0	5.0	allowance
6.	SPARE PARTS	-	5.0	5.0	4 elements each type
	SUBTOTAL	23.7	83.8	107.5	
7.	CONTINGENCY	2.0	9.0	11.0	10%
8.	TOTAL DIRECT COSTS	25.7	92.8	118.5	

ANNUAL OPERATING AND MAINTENANCE COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment 15,000-cfm Charcoal/HEPA Filtration System (Sheet 3)

	ITEM	COST (1975 $1000) LABOR	OTHER	TOTAL	BASIS FOR COST ESTIMATE
1.	OPERATING LABOR, SUPERVISION, AND OVERHEAD			3.8	15 min/shift & 40-hr annual test
2.	MAINTENANCE MATERIAL AND LABOR			9.0	30 HEPA or prefilters @ $150 each & 15 charcoal filters @ $900 each every 2 yrs
3.	CONSUMABLES, CHEMICALS, AND SUPPLIES			-	in items 2 and 4
4.	UTILITIES AND SERVICES				
	Waste Disposal			1.5	$50/HEPA or prefilter, $100/charcoal
	Water				
	Steam				
	Electricity			1.3	8kw additional fan power for filter ΔP @ 0.018 $/kw-hr
	Building Services				
	Other				
5.	TOTAL O AND M ANNUAL COST			15.6	

TOTAL DIRECT COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM
FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment 30,000-cfm Charcoal/HEPA Filtration System - Auxiliary Building (Sheet 1)

	ITEM	DIRECT COST (1975 $1000) LABOR	EQUIPMENT/MATERIALS	TOTAL	BASIS FOR COST ESTIMATE
1.	PROCESS EQUIPMENT	15	117.0	132.0	prefilter/4" charcoal/HEPA @ $4/cfm, 60-kw htr @ $200/kw
2.	BUILDING ASSIGNMENT	20	13.6	33.6	28' x 20' x 12' @ $5/ft^3 (nonshielded area)
3.	ASSOCIATED PIPING SYSTEMS	5	3.0	8.0	base
4.	INSTRUMENTATION AND CONTROLS			-	in item 1
5.	ELECTRICAL SERVICE	6	4.0	10.0	allowance
6.	SPARE PARTS	-	5.0	5.0	4 elements each type
	SUBTOTAL	46	142.6	188.6	
7.	CONTINGENCY	5	14.0	19.0	10%
8.	TOTAL DIRECT COSTS	51	156.6	207.6	

TOTAL DIRECT COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM
FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment 30,000-cfm Charcoal/HEPA Filtration System - Turbine Building (Sheet 2)

	ITEM	DIRECT COST (1975 $1000) LABOR	EQUIPMENT/MATERIALS	TOTAL	BASIS FOR COST ESTIMATE
1.	PROCESS EQUIPMENT	15.0	117.0	132.0	prefilter/4" charcoal/HEPA @ $4/cfm, 60kw htr @ $200/kw
2.	BUILDING ASSIGNMENT	13.4	6.8	20.2	28' x 20' x 12' @ $3/ft^3 (nonshielded area)
3.	ASSOCIATED PIPING SYSTEMS	3.0	5.0	8.0	base
4.	INSTRUMENTATION AND CONTROLS				in item 1
5.	ELECTRICAL SERVICE	6.0	4.0	10.0	allowance
6.	SPARE PARTS	-	5.0	5.0	4 elements each type
	SUBTOTAL	37.4	137.8	175.2	
7.	CONTINGENCY	4.0	14.0	18.0	10%
8.	TOTAL DIRECT COSTS	41.4	151.8	193.2	

ANNUAL OPERATING AND MAINTENANCE COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment 30,000-cfm Charcoal/HEPA Filtration System - (Sheet 3)

	ITEM	COST (1975 $1000) LABOR	OTHER	TOTAL	BASIS FOR COST ESTIMATE
1.	OPERATING LABOR, SUPERVISION, AND OVERHEAD			3.8	15 min/shift + 40 hr annual test
2.	MAINTENANCE MATERIAL AND LABOR			18.0	60 HEPA or prefilters @ $150 each & 30 charcoal filters @ $900 each every 2 yrs
3.	CONSUMABLES, CHEMICALS, AND SUPPLIES			-	in items 2 and 4
4.	UTILITIES AND SERVICES				
	Waste Disposal			3.0	$50/HEPA or prefilter, $100/charcoal filter
	Water				
	Steam				
	Electricity			2.6	16kw additional fan HP for filter @ 0.018 $/kw-hr
	Building Services				
	Other				
5.	TOTAL O AND M ANNUAL COST			27.4	

TOTAL DIRECT COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM
FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment Turbine Building Chilled Water HVAC System (Sheet 1)

	ITEM	DIRECT COST (1975 $1000) LABOR	EQUIPMENT/MATERIALS	TOTAL	BASIS FOR COST ESTIMATE
1.	PROCESS EQUIPMENT	300	500	800	500-ton capacity, w/o air filters
2.	BUILDING ASSIGNMENT			-	Coolers can be installed in existing space saved by deletion of ducting.
3.	ASSOCIATED PIPING SYSTEMS			-	in item 1
4.	INSTRUMENTATION AND CONTROLS			-	in item 1
5.	ELECTRICAL SERVICE	40	50	90	
6.	SPARE PARTS	-	8	8	1% item 1
	SUBTOTAL	340	558	898	
7.	CONTINGENCY	34	56	90	10%
8.	TOTAL DIRECT COSTS	374	614	988	

ANNUAL OPERATING AND MAINTENANCE COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment Turbine Building Chilled Water HVAC System (Sheet 2)

	ITEM	COST (1975 $1000) LABOR	OTHER	TOTAL	BASIS FOR COST ESTIMATE
1.	OPERATING LABOR, SUPERVISION, AND OVERHEAD			3.3	15 min/shift
2.	MAINTENANCE MATERIAL AND LABOR			20.0	2-1/2% of equipment costs
3.	CONSUMABLES, CHEMICALS, AND SUPPLIES			-	in item 2
4.	UTILITIES AND SERVICES				
	Waste Disposal				
	Water			13.0	500 gpm @ 10¢/1000 gal & 50% load factor
	Steam				
	Electricity			33.0	400 kw @ 0.018 $/kw hr
	Building Services				
	Other				
5.	TOTAL O AND M ANNUAL COST			69.3	

TOTAL DIRECT COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment 600-ft^3 Waste Gas Decay Tank (Sheet 1)

	ITEM	DIRECT COST (1975 $1000) LABOR	EQUIPMENT/MATERIALS	TOTAL	BASIS FOR COST ESTIMATE
1.	PROCESS EQUIPMENT	2.5	20	22.5	600-ft^3, 150 psig, C.S., ASME VIII
2.	BUILDING ASSIGNMENT	18.0	9	27.0	15' x 15' x 20' @ $6/ft^3 (shielded area)
3.	ASSOCIATED PIPING SYSTEMS	1.0	1	2.0	10% of item 1
4.	INSTRUMENTATION AND CONTROLS			neg	
5.	ELECTRICAL SERVICE			neg	
6.	SPARE PARTS			neg	
	SUBTOTAL	21.5	30	51.5	
7.	CONTINGENCY	2.0	3	5.0	10%
8.	TOTAL DIRECT COSTS	23.5	33	56.5	

ANNUAL OPERATING AND MAINTENANCE COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment 600-ft^3 Waste Gas Decay Tank (Sheet 2)

	ITEM	COST (1975 $1000) LABOR	OTHER	TOTAL	BASIS FOR COST ESTIMATE
1.	OPERATING LABOR, SUPERVISION, AND OVERHEAD	-	-	neg	
2.	MAINTENANCE MATERIAL AND LABOR	-	-	neg	
3.	CONSUMABLES, CHEMICALS, AND SUPPLIES	-	-	neg	
4.	UTILITIES AND SERVICES Waste Disposal Water Steam Electricity Building Services Other			neg	
5.	TOTAL O AND M ANNUAL COST			neg	

TOTAL DIRECT COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment PWR Hydrogen Recombiner (Sheet 1)

	ITEM	DIRECT COST (1975 $1000) LABOR	EQUIPMENT/MATERIALS	TOTAL	BASIS FOR COST ESTIMATE
1.	PROCESS EQUIPMENT	50.0	300.0	350.0	skid mounted, catalytic type w/condenser, partial I&C single unit, ASME VIII
2.	BUILDING ASSIGNMENT	28.8	14.4	43.2	15' x 30' x 16' @ $6/ft^3 (shielded area)
3.	ASSOCIATED PIPING SYSTEMS	32.0	13.0	45.0	allowance
4.	INSTRUMENTATION AND CONTROLS	10.0	40.0	50.0	allowance
5.	ELECTRICAL SERVICE	13.0	12.0	25.0	allowance
6.	SPARE PARTS	-	2.0	2.0	
	SUBTOTAL	133.8	381.4	515.2	
7.	CONTINGENCY	13.0	38.0	51.0	10%
8.	TOTAL DIRECT COSTS	146.8	419.4	566.2	

ANNUAL OPERATING AND MAINTENANCE COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment PWR Hydrogen Recombiner (Sheet 2)

	ITEM	COST (1975 $1000) LABOR	OTHER	TOTAL	BASIS FOR COST ESTIMATE
1.	OPERATING LABOR, SUPERVISION, AND OVERHEAD			3.3	15 min/shift
2.	MAINTENANCE MATERIAL AND LABOR			10.0	3% of equipment cost
3.	CONSUMABLES, CHEMICALS, AND SUPPLIES			1.0	oxygen @ $2.5/10^3 cf & .25 cfm @ 7000 hrs
4.	UTILITIES AND SERVICES Waste Disposal Water Steam Electricity Building Services Other			neg	
5.	TOTAL O AND M ANNUAL COST			14.3	

TOTAL DIRECT COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment PWR Air Ejector Charcoal/HEPA Filtration Unit (Sheet 1)

	ITEM	DIRECT COST (1975 $1000) LABOR	EQUIPMENT/MATERIALS	TOTAL	BASIS FOR COST ESTIMATE
1.	PROCESS EQUIPMENT	3.0	7.5	10.5	chiller, heater, charcoal HEPA
2.	BUILDING ASSIGNMENT	3.0	1.5	4.5	10' x 10' x 15' @ $3/ft^3 (unshielded turbine bldg)
3.	ASSOCIATED PIPING SYSTEMS	2.0	1.0	3.0	allowance
4.	INSTRUMENTATION AND CONTROLS	0.5	1.5	2.0	allowance
5.	ELECTRICAL SERVICE	0.5	0.5	1.0	allowance
6.	SPARE PARTS	-	1.0	1.0	
	SUBTOTAL	9.0	13.0	22.0	
7.	CONTINGENCY	1.0	1.0	2.0	10%
8.	TOTAL DIRECT COSTS	10.0	14.0	24.0	

ANNUAL OPERATING AND MAINTENANCE COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment PWR Air Ejector Charcoal/HEPA Filtration Unit (Sheet 2)

	ITEM	COST (1975 $1000) LABOR	OTHER	TOTAL	BASIS FOR COST ESTIMATE
1.	OPERATING LABOR, SUPERVISION, AND OVERHEAD			3.8	15 min/shift + 40 hr annual test
2.	MAINTENANCE MATERIAL AND LABOR			2.0	includes replacement filter
3.	CONSUMABLES, CHEMICALS, AND SUPPLIES			-	in item 2
4.	UTILITIES AND SERVICES Waste Disposal Water Steam Electricity Building Services Other			neg	
5.	TOTAL O AND M ANNUAL COST			5.8	

TOTAL DIRECT COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment Steam Generator Flash Tank Vent to Main Condenser (Sheet 1)

	ITEM	DIRECT COST (1975 $1000) LABOR	EQUIPMENT/MATERIALS	TOTAL	BASIS FOR COST ESTIMATE
1.	PROCESS EQUIPMENT			-	no equipment required
2.	BUILDING ASSIGNMENT			neg	install in existing space
3.	ASSOCIATED PIPING SYSTEMS	13	7	20	200 ft of 10-in pipe with 2 valves
4.	INSTRUMENTATION AND CONTROLS	4	6	10	allowance
5.	ELECTRICAL SERVICE			neg	
6.	SPARE PARTS			neg	
	SUBTOTAL	17	13	30	
7.	CONTINGENCY	2	1	3	10%
8.	TOTAL DIRECT COSTS	19	14	33	

ANNUAL OPERATING AND MAINTENANCE COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment Steam Generator Flash Tank Vent to Main Condenser (Sheet 2)

	ITEM	COST (1975 $1000) LABOR	OTHER	TOTAL	BASIS FOR COST ESTIMATE
1.	OPERATING LABOR, SUPERVISION, AND OVERHEAD			1	allowance
2.	MAINTENANCE MATERIAL AND LABOR			1	2% Total Direct Cost
3.	CONSUMABLES, CHEMICALS, AND SUPPLIES			neg	
4.	UTILITIES AND SERVICES Waste Disposal Water Steam Electricity Building Services Other			neg	
5.	TOTAL O AND M ANNUAL COST			2	

TOTAL DIRECT COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment 15-gpm Evaporator (Sheet 1)

	ITEM	DIRECT COST (1975 $1000) LABOR	EQUIPMENT/MATERIALS	TOTAL	BASIS FOR COST ESTIMATE
1.	PROCESS EQUIPMENT	30	225	255	skid mounted, submerged tube bundle, ASME VIII, Incoloy in contact with process fluid
2.	BUILDING ASSIGNMENT	68	34	102	evap & services 25' x 30' x 20' @ $6/ft^3 plus 2,000 ft^3 increase in solid waste storage area
3.	ASSOCIATED PIPING SYSTEMS	35	30	65	inludes service piping
4.	INSTRUMENTATION AND CONTROLS	10	10	20	allowance
5.	ELECTRICAL SERVICE	40	25	65	allowance
6.	SPARE PARTS	--	27	27	2% of item 1 plus tube bundle
	SUBTOTAL	183	351	534	
7.	CONTINGENCY	18	35	53	10%
8.	TOTAL DIRECT COSTS	201	386	587	

TOTAL DIRECT COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment 30-gpm Evaporator (Sheet 2)

	ITEM	DIRECT COST (1975 $1000) LABOR	EQUIPMENT/MATERIALS	TOTAL	BASIS FOR COST ESTIMATE
1.	PROCESS EQUIPMENT	30	350	380	ASME VIII skid mounted, submerged, tube bundle, Incoloy in contact with process fluid
2.	BUILDING ASSIGNMENT	88	44	132	evap + services - 25' x 40' x 20' @ $6/ft^3 plus 2,000 ft^3 increase in solid waste storage area
3.	ASSOCIATED PIPING SYSTEMS	35	35	70	includes service piping
4.	INSTRUMENTATION AND CONTROLS	10	10	20	allowance
5.	ELECTRICAL SERVICE	40	25	65	allowance
6.	SPARE PARTS	-	27	27	2% of item 1 plus tube bundle
	SUBTOTAL	203	491	694	
7.	CONTINGENCY	20	49	69	10%
8.	TOTAL DIRECT COSTS	223	540	763	

TOTAL DIRECT COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment 50-gpm Evaporator (Sheet 3)

	ITEM	DIRECT COST (1975 $1000) LABOR	EQUIPMENT/MATERIALS	TOTAL	BASIS FOR COST ESTIMATE
1.	PROCESS EQUIPMENT	30	450	480	ASME VIII skid mounted, submerged, tube bundle, Incoloy in contact with process fluid
2.	BUILDING ASSIGNMENT	97	48	145	10% more than 30 gpm
3.	ASSOCIATED PIPING SYSTEMS	35	35	70	allowance
4.	INSTRUMENTATION AND CONTROLS	10	10	20	allowance
5.	ELECTRICAL SERVICE	40	25	65	allowance
6.	SPARE PARTS	-	27	27	2% of item 1 plus tube bundle
	SUBTOTAL	212	595	807	
7.	CONTINGENCY	21	60	81	10%
8.	TOTAL DIRECT COSTS	233	655	888	

ANNUAL OPERATING AND MAINTENANCE COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment Evaporator - BWR Dirty Waste - Floor Drains (Sheet 4)

	ITEM	COST (1975 $1000) LABOR	OTHER	TOTAL	BASIS FOR COST ESTIMATE
1.	OPERATING LABOR, SUPERVISION, AND OVERHEAD			12	2.6 x 10^6 gpy; 1000 hrs/yr labor
2.	MAINTENANCE MATERIAL AND LABOR			30	7-1/2% of equipment cost
3.	CONSUMABLES, CHEMICALS, AND SUPPLIES			neg	concentrate solidification chemicals in item 4
4.	UTILITIES AND SERVICES				
	Waste Disposal			70	100:1 feed to concentrate ratio @ 20/ft^3 disposal cost
	Water			27	1000 gpm @ 1500 hrs @ 30¢/1000 gal
	Steam			60	1500 hrs steam @ 20,000 lb/hr @ $2/1000 lbs
	Electricity				
	Building Services				
	Other				
5.	TOTAL O AND M ANNUAL COST			199	

ANNUAL OPERATING AND MAINTENANCE COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment Evaporator PWR Dirty Waste (Sheet 5)

	ITEM	COST (1975 $1000) LABOR	OTHER	TOTAL	BASIS FOR COST ESTIMATE
1.	OPERATING LABOR, SUPERVISION, AND OVERHEAD			6.0	500,000 gpy; 500 hrs/yr labor
2.	MAINTENANCE MATERIAL AND LABOR			30.0	7-1/2% of equipment cost
3.	CONSUMABLES, CHEMICALS, AND SUPPLIES			-	concentrate solidification chemicals in item 4
4.	UTILITIES AND SERVICES				
	Waste Disposal			27.0	50:1 feed to concentrate ratio @ $20/ft^3 disposal cost
	Water			5.0	1000 gpm @ 277 hrs @ 30¢/1000 gal
	Steam			12.0	277 hrs steam @ 20,000 lbs/hr @ $2/1000 lbs
	Electricity				
	Building Services				
	Other				
5.	TOTAL O AND M ANNUAL COST			80.0	

ANNUAL OPERATING AND MAINTENANCE COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment Evaporator - Condenser Polisher Chemical Waste (Sheet 6)

	ITEM	COST (1975 $1000) LABOR	OTHER	TOTAL	BASIS FOR COST ESTIMATE
1.	OPERATING LABOR, SUPERVISION, AND OVERHEAD			6.0	650,000 gpy; 500 hr/yr labor
2.	MAINTENANCE MATERIAL AND LABOR			30.0	7-1/2% of equipment cost
3.	CONSUMABLES, CHEMICALS, AND SUPPLIES				concentrate solidification chemicals in item 4
4.	UTILITIES AND SERVICES				
	Waste Disposal			87.0	20:1 feed to concentrate ratio @ $20/ft^3 disposal cost
	Water			6.5	1000 gpm @ 360 hrs @ 30¢/1000 gal
	Steam			14.4	360 hrs steam @ 20,000 lb/hr @ $2/1000 lbs
	Electricity				
	Building Services				
	Other				
5.	TOTAL O AND M ANNUAL COST			143.9	

ANNUAL OPERATING AND MAINTENANCE COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment Evaporator - Detergent Waste (Sheet 7)

	ITEM	COST (1975 $1000) LABOR	OTHER	TOTAL	BASIS FOR COST ESTIMATE
1.	OPERATING LABOR, SUPERVISION, AND OVERHEAD			6.0	160,000 gpy; 500 hrs/yr
2.	MAINTENANCE MATERIAL AND LABOR			30.0	7-1/2% of equipment cost
3.	CONSUMABLES, CHEMICALS, AND SUPPLIES			-	concentrate solidification chemicals in item 4
4.	UTILITIES AND SERVICES				
	Waste Disposal			8.6	50:1 feed to concentrate ratio @ $20/ft^3 disposal cost
	Water			1.6	1000 gpm @ 90 hrs @ 30¢/1000 gal
	Steam			3.6	90 hrs steam @ 20,000 lb/hr @ $2/1000 lbs
	Electricity				
	Building Services				
	Other				
5.	TOTAL O AND M ANNUAL COST			49.8	

TOTAL DIRECT COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM
FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment Evaporator Distillate Demineralizer (Sheet 1)

	ITEM	DIRECT COST (1975 $1000) LABOR	EQUIPMENT/MATERIALS	TOTAL	BASIS FOR COST ESTIMATE
1.	PROCESS EQUIPMENT	4.0	20.0	24.0	30 ft^3, SS, ASME VIII, 150 psi nonregenerative, w/resin
2.	BUILDING ASSIGNMENT	6.4	3.2	9.6	10' x 10' x 16' @ $6/$ft^3$ (shielded area)
3.	ASSOCIATED PIPING SYSTEMS	9.0	6.0	15.0	2" piping
4.	INSTRUMENTATION AND CONTROLS	2.0	3.0	5.0	remote conductivity readout
5.	ELECTRICAL SERVICE			neg	
6.	SPARE PARTS	-	1.0	1.0	
	SUBTOTAL	21.4	33.2	54.6	
7.	CONTINGENCY	2.0	3.0	5.0	10%
8.	TOTAL DIRECT COSTS	23.4	36.2	59.6	

ANNUAL OPERATING AND MAINTENANCE COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment Evaporator Distillate Demineralizer (Sheet 2)

	ITEM	COST (1975 $1000) LABOR	OTHER	TOTAL	BASIS FOR COST ESTIMATE
1.	OPERATING LABOR, SUPERVISION, AND OVERHEAD			1.8	1500 hrs operation @ 10% attendance
2.	MAINTENANCE MATERIAL AND LABOR			2.0	allowance
3.	CONSUMABLES, CHEMICALS, AND SUPPLIES			2.3	1 change per yr @ $75/ft^3
4.	UTILITIES AND SERVICES Waste Disposal Water Steam Electricity Building Services Other			0.6	30 ft^3 @ $20/ft^3 disposal cost
5.	TOTAL O AND M ANNUAL COST			6.7	

TOTAL DIRECT COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM
FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment 50-gpm Demineralizer (Sheet 1)

	ITEM	DIRECT COST (1975 $1000) LABOR	EQUIPMENT/MATERIALS	TOTAL	BASIS FOR COST ESTIMATE
1.	PROCESS EQUIPMENT	5	20.0	25.0	30 ft^3, SS, ASME VIII, 150 psi, nonregenerative, with resin
2.	BUILDING ASSIGNMENT	9	4.8	13.8	12' x 12' x 16' @ $5/$ft^3$ (shielded area)
3.	ASSOCIATED PIPING SYSTEMS	9	6.0	15.0	2" piping
4.	INSTRUMENTATION AND CONTROLS	4	6.0	10.0	
5.	ELECTRICAL SERVICE			neg	
6.	SPARE PARTS	-	2.0	2.0	miscellaneous supplies
	SUBTOTAL	27	38.8	65.8	
7.	CONTINGENCY	2	4.0	6.0	10%
8.	TOTAL DIRECT COSTS	29	42.8	71.8	

TOTAL DIRECT COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment 100-gpm Demineralizer (Sheet 2)

	ITEM	DIRECT COST (1975 $1000) LABOR	EQUIPMENT/MATERIALS	TOTAL	BASIS FOR COST ESTIMATE
1.	PROCESS EQUIPMENT	5	35.0	40.0	60 ft^3, SS, ASME VIII, 150 psi, nonregenerative, with resin
2.	BUILDING ASSIGNMENT	9	4.8	13.8	12' x 12' x 16' @ $6/$ft^3$ (shielded area)
3.	ASSOCIATED PIPING SYSTEMS	10	10.0	20.0	2-1/2" piping
4.	INSTRUMENTATION AND CONTROLS	4	6.0	10.0	
5.	ELECTRICAL SERVICE			neg	
6.	SPARE PARTS	-	2.0	2.0	miscellaneous supplies
	SUBTOTAL	28	57.8	85.8	
7.	CONTINGENCY	3	6.0	9.0	
8.	TOTAL DIRECT COSTS	31	63.8	94.8	

TOTAL DIRECT COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM
FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment 200-gpm Demineralizer (Sheet 3)

	ITEM	DIRECT COST (1975 $1000) LABOR	EQUIPMENT/MATERIALS	TOTAL	BASIS FOR COST ESTIMATE
1.	PROCESS EQUIPMENT	5	60.0	65.0	120 ft^3, SS, ASME VIII, 150 psi, nonregenerative, with resin
2.	BUILDING ASSIGNMENT	11	5.2	16.2	13' x 13' x 16' @ $6/$ft^3$ (shielded area)
3.	ASSOCIATED PIPING SYSTEMS	12	12.0	24.0	4" piping
4.	INSTRUMENTATION AND CONTROLS	4	6.0	10.0	
5.	ELECTRICAL SERVICE			neg	
6.	SPARE PARTS	-	2.0	2.0	miscellaneous supplies
	SUBTOTAL	32	85.2	117.2	
7.	CONTINGENCY	3	9.0	12.0	
8.	TOTAL DIRECT COSTS	35	94.2	129.2	

TOTAL DIRECT COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM
FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment 400-gpm Demineralizer - Steam Generator Blowdown Service (Sheet 4)

	ITEM	DIRECT COST (1975 $1000) LABOR	EQUIPMENT/MATERIALS	TOTAL	BASIS FOR COST ESTIMATE
1.	PROCESS EQUIPMENT	5	60.0	65.0	120 ft^3, SS, ASME VIII, 150 psi, nonregenerative, with resin
2.	BUILDING ASSIGNMENT	11	5.2	16.2	.3' x 13' x 16' @ $6/$ft^3$ (shielded area)
3.	ASSOCIATED PIPING SYSTEMS	20	20.0	40.0	6" piping
4.	INSTRUMENTATION AND CONTROLS	4	6.0	10.0	allowance
5.	ELECTRICAL SERVICE			neg	
6.	SPARE PARTS	-	2.0	2.0	miscellaneous supplies
	SUBTOTAL	40	93.2	133.2	
7.	CONTINGENCY	4	9.0	13.0	
8.	TOTAL DIRECT COSTS	44	102.2	146.2	

ANNUAL OPERATING AND MAINTENANCE COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment BWR - 2nd Waste Demineralizer In Series (Sheet 5)

	ITEM	COST (1975 $1000) LABOR	OTHER	TOTAL	BASIS FOR COST ESTIMATE
1.	OPERATING LABOR, SUPERVISION, AND OVERHEAD			3.3	15 min/shift
2.	MAINTENANCE MATERIAL AND LABOR			5.0	allowance
3.	CONSUMABLES, CHEMICALS, AND SUPPLIES			9.0	1 change per year @ 120 ft^3 @ \$75/ft^3 (one vessel change per year, regardless of size)
4.	UTILITIES AND SERVICES Waste Disposal Water Steam Electricity Building Services Other			2.4	120 ft^3/yr @ \$20/ft^3 disposal cost
5.	TOTAL O AND M ANNUAL COST			19.7	

ANNUAL OPERATING AND MAINTENANCE COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment Demineralizer - PWR Clean Wastes (Sheet 6)

	ITEM	COST (1975, $1000) LABOR	OTHER	TOTAL	BASIS FOR COST ESTIMATE
1.	OPERATING LABOR, SUPERVISION, AND OVERHEAD			1.8	10% of BRS shim bleed (50,000 gpy), 30 min/day
2.	MAINTENANCE MATERIAL AND LABOR			5.0	allowance
3.	CONSUMABLES, CHEMICALS, AND SUPPLIES			2.3	30 ft^3/yr @ \$75/ft^3
4.	UTILITIES AND SERVICES Waste Disposal Water Steam Electricity Building Services Other			0.6	30 ft^3/yr @ \$20/ft^3 disposal cost
5.	TOTAL O AND M ANNUAL COST			9.7	

ANNUAL OPERATING AND MAINTENANCE COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment Demineralizer - BWR Dirty Waste (Sheet 7)

	ITEM	COST (1975 $1000) LABOR	OTHER	TOTAL	BASIS FOR COST ESTIMATE
1.	OPERATING LABOR, SUPERVISION, AND OVERHEAD			6.5	2.6×10^6 gpy, 30 min/shift
2.	MAINTENANCE MATERIAL AND LABOR			5.0	allowance
3.	CONSUMABLES, CHEMICALS, AND SUPPLIES			64.5	860 ft^3 resin @ \$75/ft^3
4.	UTILITIES AND SERVICES Waste Disposal Water Steam Electricity Building Services Other			17.2	860 ft^3 @ \$20/ft^3 disposal cost
5.	TOTAL O AND M ANNUAL COST			93.2	

ANNUAL OPERATING AND MAINTENANCE COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment Demineralizer - PWR Dirty Wastes (w/o turbine building) (Sheet 8)

	ITEM	COST (1975 $1000) LABOR	OTHER	TOTAL	BASIS FOR COST ESTIMATE
1.	OPERATING LABOR, SUPERVISION, AND OVERHEAD			3.3	500,000 gpy; 15 min/shift
2.	MAINTENANCE MATERIAL AND LABOR			5.0	allowance
3.	CONSUMABLES, CHEMICALS, AND SUPPLIES			12.0	160 ft^3/yr @ \$75/ft^3
4.	UTILITIES AND SERVICES Waste Disposal Water Steam Electricity Building Services Other			3.2	160 ft^3/yr @ \$20/ft^3 disposal cost
5.	TOTAL O AND M ANNUAL COST			23.5	

ANNUAL OPERATING AND MAINTENANCE COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment Demineralizer - PWR Turbine Building Floor Drains (Sheet 9)

	ITEM	COST (1975 $1000) LABOR	OTHER	TOTAL	BASIS FOR COST ESTIMATE
1.	OPERATING LABOR, SUPERVISION, AND OVERHEAD			13.1	1 hr/shift, 2.6×10^6 gpy
2.	MAINTENANCE MATERIAL AND LABOR			5.0	allowance
3.	CONSUMABLES, CHEMICALS, AND SUPPLIES			64.5	860 ft^3 resin @ $75/$ft^3$
4.	UTILITIES AND SERVICES Waste Disposal Water Steam Electricity Building Services Other			17.2	860 ft^3/yr @ $20/$ft^3$ disposal cost
5.	TOTAL O AND M ANNUAL COST			99.8	

ANNUAL OPERATING AND MAINTENANCE COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment Demineralizer - PWR Steam Generator Blowdown (Sheet 10)

	ITEM	COST (1975 $1000) LABOR	OTHER	TOTAL	BASIS FOR COST ESTIMATE
1.	OPERATING LABOR, SUPERVISION, AND OVERHEAD			3.3	15 min/shift
2.	MAINTENANCE MATERIAL AND LABOR			5.0	allowance
3.	CONSUMABLES, CHEMICALS, AND SUPPLIES			16.9	225 ft^3 resin/yr @ \$75/ft^3
4.	UTILITIES AND SERVICES Waste Disposal Water Steam Electricity Building Services Other			4.5	225 ft^3/yr @ \$20/ft^3 disposal cost
5.	TOTAL O AND M ANNUAL COST			29.7	

TOTAL DIRECT COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM
FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment 20-gpm Cartridge Filter (Sheet 1)

	ITEM	DIRECT COST (1975 $1000) LABOR	EQUIPMENT/MATERIALS	TOTAL	BASIS FOR COST ESTIMATE
1.	PROCESS EQUIPMENT	2.0	5.0	7.0	SS, ASME VIII, 150 psi
2.	BUILDING ASSIGNMENT	5.6	3.0	8.6	16' x 12' x 20' @ $6/ft^3 (shielded area)
3.	ASSOCIATED PIPING SYSTEMS	1.5	1.0	2.5	allowance
4.	INSTRUMENTATION AND CONTROLS	0.6	2.4	3.0	allowance
5.	ELECTRICAL SERVICE			neg	
6.	SPARE PARTS	-	0.5	0.5	
	SUBTOTAL	9.7	11.9	21.6	
7.	CONTINGENCY	1.0	1.0	2.0	10%
8.	TOTAL DIRECT COSTS	10.7	12.9	23.6	

ANNUAL OPERATING AND MAINTENANCE COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment Cartridge Filter (Sheet 2)

	ITEM	COST (1975 $1000) LABOR	OTHER	TOTAL	BASIS FOR COST ESTIMATE
1.	OPERATING LABOR, SUPERVISION, AND OVERHEAD			4.5	10 changes @ 10 man-hrs/change @ $12/hr + 15 min/shift
2.	MAINTENANCE MATERIAL AND LABOR			1.0	allowance
3.	CONSUMABLES, CHEMICALS, AND SUPPLIES			1.0	10 changes/yr @ $100/change
4.	UTILITIES AND SERVICES Waste Disposal Water Steam Electricity Building Services Other			1.5	10 drums/yr @ $20/ft^3
5.	TOTAL O AND M ANNUAL COST			8.0	

TOTAL DIRECT COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment 100-gpm Precoat Filter (Sheet 1)

	ITEM	DIRECT COST (1975 $1000) LABOR	EQUIPMENT/MATERIALS	TOTAL	BASIS FOR COST ESTIMATE
1.	PROCESS EQUIPMENT	10	65.0	75	automated system 1 gpm/ft^2, ASME VIII
2.	BUILDING ASSIGNMENT	18	9.0	27	15' x 15' x 20' @ $6/ft^3 (shielded area)
3.	ASSOCIATED PIPING SYSTEMS	16	9.0	25	35% of equipment cost
4.	INSTRUMENTATION AND CONTROLS				in item 1
5.	ELECTRICAL SERVICE	7	13.0	20	allowance
6.	SPARE PARTS	-	2.0	2	2% of item 1
	SUBTOTAL	51	98.0	149	
7.	CONTINGENCY	5	10.0	15	10%
8.	TOTAL DIRECT COSTS	56	108.0	164	

TOTAL DIRECT COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment 400-gpm Precoat Filter (Sheet 2)

	ITEM	DIRECT COST (1975 $1000) LABOR	EQUIPMENT/MATERIALS	TOTAL	BASIS FOR COST ESTIMATE
1.	PROCESS EQUIPMENT	35	135.0	170	automated system; 1 gpm/ft^2 ASME VIII
2.	BUILDING ASSIGNMENT	24	12.0	36	15' x 20' x 20' @ $6/ft^3 (shielded area)
3.	ASSOCIATED PIPING SYSTEMS	31	16.0	47	35% of equipment cost
4.	INSTRUMENTATION AND CONTROLS	-	-	-	item 1
5.	ELECTRICAL SERVICE	12	18.0	30	allowance
6.	SPARE PARTS	-	3.0	3	
	SUBTOTAL	102	184.0	286	
7.	CONTINGENCY	10	18.0	28	10%
8.	TOTAL DIRECT COSTS	112	202.0	314	

ANNUAL OPERATING AND MAINTENANCE COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment Precoat Filter - BWR Dirty Waste (Sheet 3)

	ITEM	COST (1975 $1000) LABOR	OTHER	TOTAL	BASIS FOR COST ESTIMATE
1.	OPERATING LABOR, SUPERVISION, AND OVERHEAD			6.6	2 x 10^6 gpy, 30 min/shift
2.	MAINTENANCE MATERIAL AND LABOR			10.0	allowance
3.	CONSUMABLES, CHEMICALS, AND SUPPLIES			6.0	10 lbs precoat @ 10¢/lb per 1000 gal processed
4.	UTILITIES AND SERVICES Waste Disposal Water Steam Electricity Building Services Other			40.0	1 ft^3/sludge per 1000 gal processed @ $30/$ft^3$ disposal cost
5.	TOTAL O AND M ANNUAL COST			62.6	

TOTAL DIRECT COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM
FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment 2-gpm Reverse Osmosis (Sheet 1)

	ITEM	DIRECT COST (1975 $1000) LABOR	EQUIPMENT/MATERIALS	TOTAL	BASIS FOR COST ESTIMATE
1.	PROCESS EQUIPMENT	6.0	60.0	66.0	skid mounted w/500-gal SS feed tank, ASME VIII
2.	BUILDING ASSIGNMENT	19.2	9.6	28.8	12' x 25' x 16' @ $6/ft^3
3.	ASSOCIATED PIPING SYSTEMS	3.0	2.0	5.0	allowance
4.	INSTRUMENTATION AND CONTROLS			-	in item 1 .
5.	ELECTRICAL SERVICE	7.0	13.0	20.0	allowance
6.	SPARE PARTS	-	6.0	6.0	
	SUBTOTAL	35.2	90.6	125.8	
7.	CONTINGENCY	3.0	9.0	12.0	10%
8.	TOTAL DIRECT COSTS	38.2	99.6	137.8	

ANNUAL OPERATING AND MAINTENANCE COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment Reverse Osmosis - Detergent Wastes

	ITEM	COST (1975 $1000) LABOR	OTHER	TOTAL	BASIS FOR COST ESTIMATE
1.	OPERATING LABOR, SUPERVISION, AND OVERHEAD			3.1	160,000 gpy, 1300 hrs/yr @ 20% attendance
2.	MAINTENANCE MATERIAL AND LABOR			8.8	4% less bldg + 24 module with 3-yr life @ $600 each
3.	CONSUMABLES, CHEMICALS, AND SUPPLIES			neg	
4.	UTILITIES AND SERVICES				
	Waste Disposal			4.3	100:1 vol reduction @ $20/ft^3 disposal cost
	Water				
	Steam				
	Electricity			neg	
	Building Services				
	Other				
5.	TOTAL O AND M ANNUAL COST			16.2	

TOTAL DIRECT COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM
FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment 10,000-Gallon Tank (Sheet 1)

	ITEM	DIRECT COST (1975 $1000) LABOR	EQUIPMENT/MATERIALS	TOTAL	BASIS FOR COST ESTIMATE
1.	PROCESS EQUIPMENT	3	28	31	SS, ASME VIII, atmospheric service, 200°F
2.	BUILDING ASSIGNMENT	30	15	45	15' x 20' x 25' @ $6/ft^3 (shielded area)
3.	ASSOCIATED PIPING SYSTEMS	2	1	3	10% of item 1
4.	INSTRUMENTATION AND CONTROLS	4	6	10	allowance
5.	ELECTRICAL SERVICE			neg	
6.	SPARE PARTS	-	-	neg	
	SUBTOTAL	39	50	89	
7.	CONTINGENCY	4	5	9	10%
8.	TOTAL DIRECT COSTS	43	55	98	

ANNUAL OPERATING AND MAINTENANCE COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment 10,000-Gallon Tank (Sheet 2)

	ITEM	COST (1975 $1000) LABOR	OTHER	TOTAL	BASIS FOR COST ESTIMATE
1.	OPERATING LABOR, SUPERVISION, AND OVERHEAD			1.1	5 min/shift - log level readings
2.	MAINTENANCE MATERIAL AND LABOR			1.6	1/2% of equipment
3.	CONSUMABLES, CHEMICALS, AND SUPPLIES			neg	
4.	UTILITIES AND SERVICES Waste Disposal Water Steam Electricity Building Services Other			neg	
5.	TOTAL O AND M ANNUAL COST			2.7	

REFERENCES TO APPENDIX B

1. "Guide for Economic Evaluation of Nuclear Reactor Plant Designs," USAEC Report NUS-531, NUS Corporation, January 1969.

2. "Wage Rates for Key Construction Trades," Engineering News Record, pp. 36-37, January 2, 1975.

3. "Projections of Labor Requirements for Electric Power Plants Construction, 1974 - 2000," USAEC Report WASH-1334, Washington, D.C., August 1974.

APPENDIX C

DATA NEEDED FOR RADWASTE TREATMENT SYSTEM COST-BENEFIT ANALYSIS FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

This appendix describes information that should be submitted in support of radwaste treatment system cost-benefit analyses for light-water-cooled nuclear reactors. The information should be consistent with the contents of the Safety Analysis Report (SAR) and Environmental Report (ER) for the proposed reactor. Appropriate sections of the SAR and ER containing more detailed discussions of the required information should be referenced as appropriate. Each response, however, should be independent of the ER and SAR. All responses should be on a per reactor basis and should provide the following information:

1. Detailed cost estimate sheets similar to those shown on the following pages listing all parameters (and their bases) used in determining capital, operating, and maintenance costs associated with all augments considered in the cost-benefit analysis. All costs should be stated in terms of 1975 dollars.

2. The cost of borrowed money used in the cost analysis and the method of arriving at this cost.

3. If methods and parameters used in the cost-benefit analysis are different from those given in this guide, describe the methods used in detail and provide bases for all parameters. Include the following information:

   a. Decontamination factors assigned to each augment and fraction of "on-line" time assumed, i.e., hours per year used.

   b. Parameters and method used to determine the Indirect Cost Factor and the Capital Recovery Factor.

TOTAL DIRECT COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment _____

	ITEM	DIRECT COST (1975 $1000) LABOR	EQUIPMENT/MATERIALS	TOTAL	BASIS FOR COST ESTIMATE
1.	PROCESS EQUIPMENT				
2.	BUILDING ASSIGNMENT				
3.	ASSOCIATED PIPING SYSTEMS				
4.	INSTRUMENTATION AND CONTROLS				
5.	ELECTRICAL SERVICE				
6.	SPARE PARTS				
	SUBTOTAL				
7.	CONTINGENCY				
8.	TOTAL DIRECT COSTS				

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ANNUAL OPERATING AND MAINTENANCE COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment _____

	ITEM	COST (1975 $1000) LABOR	OTHER	TOTAL	BASIS FOR COST ESTIMATE
1.	OPERATING LABOR, SUPERVISION, AND OVERHEAD				
2.	MAINTENANCE MATERIAL AND LABOR				
3.	CONSUMABLES, CHEMICALS, AND SUPPLIES				
4.	UTILITIES AND SERVICES Waste Disposal Water Steam Electricity Building Services Other				
5.	TOTAL O AND M ANNUAL COST				