NIST | UNITED STATES DEPARTMENT OF COMMERCE
National Institute of Standards and Technology
Gaithersburg, Maryland 20899

MAR 25 1994

Sean Soong
Licensing Branch 2
Licensing Branch
Division of Fuel Cycle Safety and Safeguards, NMSS
United States Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Docket 70-398
License SNM-362
TAC No. L30550

Dear Dr. Soong:

In response to your letter of Feb. 23 requesting additional information on our decommissioning funding plan, we are providing the enclosed information.

If you have questions regarding this information, please contact Mr. T. Hobbs of the Health Physics Group at (301) 975-5800.

Sincerely,

L. E. Pevey, Chief
Occupational Health and Safety Division
(Materials Licensing Manager)

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NIST DECOMMISSIONING FUNDING PLAN DEVELOPMENT
Health Physics, April, 1993

Introduction

As required by the USNRC for license number SNM-362, a decommissioning funding plan has been developed for the eventual termination of radiological work covered by that license. Decommissioning a facility assures that the facilities and components involved in the terminated work are either sufficiently free of radiological contamination that they may be turned over to the general public or packaged and delivered to radioactive waste disposal authorities.

In developing this plan, the primary reference was NUREG/CR-1754, *Technology, safety and costs of decommissioning reference non-fuel-cycle nuclear facilities*, dated February, 1981, and its more recent addendum, NUREG/CR-1754-ADD-1, *Compendium of current information*, dated October, 1988. Only the work associated with license SNM-362 was reviewed. None of the facilities covered by the NIST reactor license was considered.

For this plan development, the NIST materials license operations were divided into three sections, one covering the laboratory facilities used for radiochemistry, sealed sources, etc., one covering the accelerator facilities, especially the terminated Linear Electron Accelerator project's Wing A of Bldg. 245, and one covering the portions of Bldg. 235 that are not included in the reactor license's indemnified areas. The projected costs for each of the sections were generated separately, using techniques that are explained in the appropriate section of this report, following this introductory section.

Labor costs were estimated using current civil service general schedule pay tables and the current overhead charge of 19% for personnel benefits now used for NIST Health Physics staff salaries, and Plant Division labor charges applied to work orders. The latter use a 52% charge-out overhead cost.

Comparison of current labor costs to those used in the NUREG for 1988 indicate that an average increase of 36% has occurred from 1988 to 1993. This increase, a factor of 1.36, was assumed to hold for all costs from 1988 to 1993. Therefore, the per unit costs cited in the reference information have been increased by a factor of 1.36.

Table 1 - LABOR COSTS IN 1993 $

	basic cost($/y)	o'head(%)	cost($/y)	cost($/d)
Supervisor(GS-14)	65000	19	77350	309
Foreman	52000	52	79040	316
Craftsman	42000	52	63840	255
Laborer	29000	52	44080	176
HP Technician(GS-8)	27000	19	32130	129
Secretary(GS-4)	19000	19	22610	90

Cost estimation

The NUREG reference uses a calculational scheme that subdivides the facility into components and further subdivides each component into unit portions. Calculations are performed with unitary elements and cost factors for each unitary element to derive a complete cost for decommissioning each component type.

Table 2 shows the components used for calculation, the dimensional unit for each component, and the number of units of each component in the standard size and configuration.

Table 2 - COMPONENT UNIT DETAILS

COMPONENT	units of DIM_PAR	DIM_PAR (standard unit size)
hood decontamination and RAW	cubic meters	2.835
glove box decontamination and RAW	cubic meters	0.5
bench decontamination and RAW	meters	8.7
sink decontamination and RAW	meters	10
vent decontamination and RAW	meters	10
wall decontamination[1]	square meters	59.16
floor decontamination[1]	square meters	19.72

[1] No RAW is considered for floor or wall/ceiling because a number of barrels of RAW are estimated for these, based on the materials estimated as required for decontamination. Little of the normal floor or wall/ceiling surfaces should be contaminated so that removal is required.

The tabulated unit cost factors from the tables in the NUREG, adjusted with the factor of 1.36, were used to generate costs for decommissioning the various components to be treated in a module. In the NUREG, values for UNIT_C_{xx}, in $k, were estimated for a variety of laboratory types, depending on the radionuclide used in a laboratory. As radionuclide work at NIST involves any radionuclide, almost any of the radionuclides might be encountered in the decommissioning project. Therefore, an average value was determined from all the various values shown in the NUREG for each of the unit component costs. The various unit cost factors used in this calculation are shown in Table 3, below.

Table 3 - UNIT COSTING FACTORS

(all values in $k)

COMPONENT	UNIT_C_{MP}	UNIT_C_{ES}	UNIT_C_{VR}	UNIT_C_{WP}
hood decontamination	0.90	0.87	0.08	0.33
hood RAW	1.35	0.69	0.08	0.05
glove box decontamination	4.96	6.09	0.07	0.29
glove box RAW	6.53	4.91	0.07	0.18
bench decontamination	0.12	0.19	0.08	0.37
bench RAW	0.35	0.18	0.08	0.04
sink decontamination	0.07	0.04	0.08	0.20
sink RAW	0.12	0.07	0.08	0.04
vent decontamination	0.08	0.04	0.11	0.14
vent RAW	0.11	0.04	0.11	0.03
wall decontamination	0.08	0.05	0.08	0.45
floor decontamination	0.04	0.04	0.08	0.45

In Table 3, UNIT_C_{XX} is the unit cost factor for each cost element, as used in this plan, with XX as:

MP = labor cost element,
ES = equipment and supplies cost element,
WP = waste packaging cost element,
and VR = waste volume reduction cost element.

Laboratory Section

Initial estimates and assumptions

Certain assumptions and decisions must be made prior to starting the decommissioning project. These influencing factors can be modified as additional information becomes available.

- There are 100 standard laboratory modules, each 5.8 meters long by 3.4 meters wide by 3.4 meters high.
- Each laboratory module has 1 hood of 2.835 m^3 volume, 1 sink with a 10 m long drain pipe, and a 10 meter length of vent/duct piping.
- Each laboratory has 1½ wall lengths of bench space.
- There are 10 glove boxes, each with 0.5 m^3 volume.
- Initial radiation surveys indicate that:
  - Five percent of a laboratory's floor area and 5% of the wall/ceiling area will need to be decontaminated.
  - Ten per cent of the bench length will need decontamination.
  - Ten per cent of the hoods will need decontamination.
  - Half of the glove boxes will need decontamination.
  - Ten per cent of the length of the vent/duct will need decontamination.
- Follow up radiation surveys, upon completion of decontamination efforts, indicate that each laboratory will generate 1 barrel (55-gallon or 0.21 m^3) of low level radioactive waste. The scrap contributions from components to be disposed of, estimated to be 1 hood, 1 glove box, 8.7 m of bench length, and 100 m of vent/duct length, are included in this.
- The total dimensions of the laboratories considered at NIST were about 20 times the dimensions of the NUREG's reference institutional user laboratory. That factor of 20 was applied to determine the labor costs for the preliminary development work. Actual decommissioning labor calculations use the actual dimensions of the components of the laboratories, so application of that factor was unnecessary as an extra element.
- The status of radioactive waste (RAW) disposal options is currently uncertain. The customarily used disposal site at Barnwell, SC, is in the process of closing to out-of-state customers such as NIST. It is assumed for the purposes of this plan that the Appalachian states group, i.e., Maryland, Pennsylvania, Delaware, and New Jersey, will complete the task of preparing to accept low-level radioactive wastes (LLRW) by the time that decommissioning is necessary for NIST. The cost of a 208-l (55-gallon) drum of LLRW is estimated at $1,000. This is assumed to include the cost for an agent to accept the waste at the NIST site and transport the waste to the disposal site.

Preliminary evaluation efforts costs

Prior to initiation of the labor on the project, certain tasks are required to minimize errors, reduce wasted effort, and assure adequate cleanliness of an area and its residual components for general public use. Table 4 shows these tasks and the work estimates required to accomplish those tasks, with a cost assigned by time spent by each involved worker type.

Table 4 - PRELIMINARY WORK EFFORT FOR LABORATORIES

(work days and 1993$)

	SUPERVISOR	FOREMAN	CRAFTSMAN	HP TECH	LABORER	SECTY
Prepare documents	25	75	0	0	0	25
Perform rad. survey	100	100	0	200	0	0
Develop work plan	25	50	0	25	0	25
$ per day	309	316	255	129	152	90
Total cost, $	46350	71100	0	29025	0	4500

A total cost for the initial work assessment, including the initial radiological surveys to classify the elements of the laboratories as "clean" or as candidates for decontamination or disposal is the sum of the various portions of the work, $150,975. Rest periods, preparation time, materials movements, etc. will increase the time required to do the work, so an ancillary time fraction of 50% is added to this. The total for this preliminary work is, thus, estimated to be $226,462. The segregation of elements into those to be cleaned of residual contamination or those to be dismantled and prepared for radioactive waste disposal will be included in subsequent projects, described below.

Work estimates

Using the product of DIM_PAR and UNIT_C_{XX} for each component, a cost for decommissioning each component can be calculated. Table 5 shows these data, with C_{XX} indicating the cost in $k. The DIM_PAR column indicates the total units to be treated and, in parentheses, the per cent of the total units in the laboratory complex.

Table 5 - COMPONENT COSTS FOR LABORATORIES

(C values in $k)

COMPONENT	DIM_PAR	C_{MP}	C_{ES}	C_{VR}	C_{WP}	Total $k
hood decontamination	28.35 (10%)	25.45	24.68	2.27	9.25	61.64
hood RAW	2.835 (1%)	3.82	1.97	0.23	0.15	6.17
glove box decontamination	2.5 (50%)	12.41	15.23	0.18	0.71	28.53
glove box RAW	0.5 (10%)	3.26	2.45	0.03	0.09	5.84
bench decontamination	87 (10%)	10.65	16.56	6.96	31.95	66.12
bench RAW	8.7 (1%)	3.08	1.54	0.71	0.35	5.68
sink decontamination	100 (10%)	6.80	4.08	8.00	20.40	39.28
sink RAW	10 (1%)	1.22	0.68	0.82	0.41	3.13
vent decontamination	100 (10%)	8.16	4.08	11.00	13.60	36.84
vent RAW	100 (10%)	10.88	4.08	10.88	2.72	28.56
wall decontamination	295.8 (5%)	24.14	16.09	23.66	133.11	197.00
floor decontamination	98.6 (5%)	4.02	4.02	7.89	44.25	60.19
SubTotal		113.89	95.47	72.63	257.00	538.98
50% ancillary time increase (prep., setup, rest periods, etc.)		56.94				56.94
25% contingency increase		42.71	23.87	18.16	64.25	148.98
TOTAL		213.54	119.33	90.78	321.25	744.91

The total dollar sum of the cost of decontaminating and preparing for radioactive waste disposal is $744,910. This includes the 50% increase in ancillary time for the labor cost figures and an overall 25% increase as a contingency fund. The 100 barrels of radioactive waste that are generated will cost $100,000 in the final disposal effort. The initial preparation and planning effort costs are $226,462. Thus, the total cost for decommissioning the laboratory portion of the NIST materials licensed activities, i.e., the sum of these three parts, will be **$1,071,372.**

Accelerator Section

Initial estimates and assumptions

Certain assumptions about this portion of the materials licensed facilities are necessary to project decommissioning costs. Among the assumptions and decisions are the following:

- The involvement of licensed materials in accelerator operations force the facilities to be treated as if they were licensed by authorities, regardless of their unlicensed status, per se. Also, it is quite likely that other regulatory impacts and public perceptions of the facilities will make it necessary to decommission them in a manner like those facilities that are licensed.
- Portions of certain beam intensive areas in the Wing A Linac complex will require removal of concrete to remove activation products. It is estimated that an average

depth of 0.1 m (4") will reduce radioactivity levels to acceptable. The cost of concrete removal, from a substantial wall, with final smooth finish restoration, is estimated to be $215 per square meter ($20 per square foot) of wall surface. Among the areas that will require this treatment are:

- the Linac tunnel, A010, 45.8 meters long by 0.9 meters wide by 0.9 meters high, 10% will be removed,
- Measurement Room No. 1, A018, a cube 12 meters on a side, 5% will be removed,
- the Magnet Room, A007, estimated to be the equivalent of a Measurement Room, 10% will be removed,

and,

- the entire Neutron Time of Flight Facility, NTOF and Blockhouse, G104 and G105, considered, with the shaft from the Magnet Room to the Blockhouse, to be the equivalent of a Measurement Room, 10% will be removed.

- The radiochemistry facility in Service Area No. 2, A006, is considered the equivalent of a standard radiochemistry laboratory, as treated in Part 1 of this plan. Associated with the hood is a pneumatic system for sample movement that will approximate another hood for the laboratory.
- The Low Scatter Room of the positive ion Van de Graaff, B23, is about 9 meters squared by 18 meters high, with a grating floor between the two levels and equipment on both levels. It will be considered as having 10% of its area contaminated with tritium. This will be treated as if it were wall contamination for cost estimating purposes.
- All the other accelerator and radiation use areas will be found with no contamination nor activation requiring action beyond the initial surveys.

Preliminary evaluation efforts costs

Just as in the standard laboratory portion of this plan, prior to initiation of the labor on the project, certain tasks are required to minimize errors, reduce wasted effort, and assure adequate cleanliness of an area and its residual components for general public use. Table 6 shows these tasks and the work estimates required to accomplish those tasks, with a cost assigned by time spent by each involved worker type. Given that a substantial learning curve will have been developed through implementing the work in Part 1, it is estimated that 25% of that effort will be required for the same result in Part 2, here, except for the radiological survey portion of the work. It is estimated that an equivalent amount of work for monitoring will be required here as for the laboratory facilities.

Table 6 - PRELIMINARY WORK EFFORT FOR THE ACCELERATOR

(work days and 1993$)

	SUPERVISOR	FOREMAN	CRAFTSMAN	HP TECH	LABORER	SECTY
Prepare documents	6.3	18.75	0	0	0	6.3
Perform rad. survey	100	100	0	200	0	0
Develop work plan	6.3	12.5	0	6.3	0	6.3
$ per day	309	316	255	129	152	90
Total cost, $	4793	41475	0	26613	0	1125

Thus, a total cost for the initial work assessment, including the initial radiological surveys to classify the elements of the areas as "clean" or as candidates for decontamination or disposal is $104,006. A 50% ancillary time addition for preparation, rest periods, etc. brings the total to $156,009.

Work estimates

Concrete removal will require Health Physics attendance and supervisory functions, so the $215 per square meter cost is estimated to increase to twice that figure, i.e., $430 per square meter. From the areas involved, 232.5 m^2 of wall surface will need removal and renovation; the total cost of this will be $99,975. The total volume of concrete removed will be 23.25 m^3, yielding a total of 112 barrels of RAW, costing $112,000. It is estimated that about 25% of that number of barrels of waste will be required to contain the materials used in the surface removal, including workers' Anti-C clothing, wipers, tools, etc. That calculates to 28 barrels, for a cost of $28,000. Thus, the total cost of concrete removal is estimated to be $239,975.

The single laboratory, with one hood, one sink/drain, and 10 m of vent/duct, but with no glove box nor bench, is estimated to be the size of a standard laboratory module and costs can be calculated to cost as shown in Table 7.

TABLE 7 - COMPONENT COSTS FOR ACCELERATOR LAB

(C values in $k)

COMPONENT	DIM. PAR	C_{wp}	C_{ex}	C_{vx}	C_{wv}	Total
hood decontamination	2.835 (100%)	2.54	2.47	0.23	0.93	6.17
hood RAW	2.835 (100%)	3.82	1.97	0.23	0.15	6.17
sink decontamination	10 (100%)	0.68	0.41	0.80	2.04	3.93
duct RAW	10 (100%)	1.09	0.41	1.09	0.27	2.86
wall decontamination	2.96 (5%)	0.24	0.16	0.24	1.33	1.97
floor decontamination	0.99 (5%)	0.04	0.04	0.08	0.44	0.60
Total $k		8.41	5.46	2.67	5.16	21.70
50% ancillary time increase (prep., setup, rest periods, etc.		4.21				4.21
25% contingency increase		3.15	1.37	0.67	1.29	6.48
TOTAL		15.77	6.83	3.34	6.45	32.39

The component cost for decommissioning the laboratory in the accelerator complex,

including the ancillary time for labor and the contingency factor, will be $32,390.

For the Low Scatter Room, the decontamination of 10% of the total wall area will involve 8 areas, i.e., 4 walls on each of 2 levels, and 2 floor areas on each of the 2 levels, each of the areas being 9 meters square, so the total wall area to be treated will be 64.8 square meters and the total floor area to be treated will be 16.2 square meters. Using the unit costing factors from Table 3 for wall and floor decontamination, the total cost to decommission the Low Scatter Room will be $42.8k for the walls and $9.9k for the floors. Thus, the total cost will be $52,700.

The total cost for decommissioning the accelerator complex is, therefore, estimated to be **$481,074**.

Reactor Section

Initial estimates and assumptions

There are two independent areas at the Reactor complex that do not fall within the indemnified area described in the Reactor license. These are that area within Bldg. 235 but outside the Confinement Building, and the Radioactive Waste Annex. For the purposes of this plan, these two areas will be treated separately, after the preliminary work effort costs are estimated.

The initial labor costs for the Annex will approximate those for the Accelerator portion described in the section immediately preceding this section. The labor costs for the laboratory portion of the Reactor will approximate the costs for the laboratory section described in the first section of this plan, because of the significant potential for tritium contamination of any surface within the building. Thus, the total labor costs for the preliminary studies and surveys are estimated to be $156,000 + $226,500 = $382,500.

Work estimates

The Radioactive Waste Annex is an appendage at the rear of Bldg. 235. It is approximately 7.5 meters wide by 12 meters long by 4.5 meters high. It is estimated that 75% of the floor and 50% of the walls will require decontaminating. Various pieces of equipment, e.g., compactor, barrel handling tools, bins, etc., are within the enclosed volume. It is estimated that the equipment will be the equivalent of 5 hoods, with 50% to be decontaminated and 25% to be treated as RAW. Table 8 shows the calculated values for the various elements in the costing process.

Table 8 - COMPONENT COSTS FOR RADIOACTIVE WASTE ANNEX

(C values in $k)

COMPONENT	DIM_PAR	C_{MP}	C_{ES}	C_{VR}	C_{WP}	Total $k
hood decontamination	7.09 (50%)	6.38	6.17	0.57	2.34	15.46
hood RAW	3.54 (25%)	4.78	2.45	0.28	0.18	7.69
wall decontamination	99 (50%)	7.92	4.95	7.92	44.55	65.34
floor decontamination	67.5 (75%)	2.70	2.70	5.40	30.38	41.18
Total $k		21.78	16.27	14.17	77.45	129.67
50% ancillary time increase (prep., setup, rest periods, etc.)		10.89				10.89
25% contingency increase		8.17	4.07	3.54	19.36	35.14
TOTAL		40.84	20.34	17.71	96.81	175.70

The cost for the Annex work is, then, $175,700. If an estimated 5 barrels of RAW are generated, a disposal cost of $5,000 is added to this, for a grand total for the area of $180,700.

The interior portion of Bldg. 235 that is not covered by the Reactor operating license can be described as follows:

- There are the equivalent of 20 standard laboratory modules, considering the warm, semi-warm, and hot labs.
- Each laboratory has 2 hoods; half will be decontaminated and half will be disposed of as RAW.
- There are 5 glove boxes in the complex; all will be disposed of as RAW.
- There is 1 sink/drain in each laboratory; 8 will be decontaminated and 2 will be RAW.
- There is a 10 meter length of vent/ducting for each laboratory; 5 will be decontaminated and 15 will be RAW.
- Workbenches cover 3.75 meters of each 5.8 meter wall length; 75% will be decontaminated and 25% will be RAW.
- One barrel of RAW will be generated for each laboratory.
- Ten barrels of RAW will be generated in decontaminating the non-laboratory part of the building.

The decommissioning component costs, based on these assumptions, will be as shown in Table 9.

Table 9 - COMPONENT COSTS FOR REACTOR LABORATORIES

(C values in $k)

COMPONENT	DBM PAR	C_{vp}	C_{ss}	C_{vs}	$C_{w/p}$	Total
hood decontamination	56.7 (50%)	50.89	49.35	4.54	18.51	123.29
hood RAW	56.7 (50%)	76.34	39.33	4.63	3.08	123.38
glove box decontamination	0	0.00	0.00	0.00	0.00	0.00
glove box RAW	2.5 (100%)	16.32	12.27	0.17	0.44	29.21
workbench decontamination	174 (75%)	21.30	33.13	13.92	63.89	132.24
workbench RAW	58 (25%)	20.51	10.25	4.73	2.37	37.86
sink decontamination	80 (80%)	5.44	3.26	6.40	16.32	31.42
sink RAW	20 (20%)	2.45	1.36	1.63	0.82	6.26
duct decontamination	100 (25%)	8.16	4.08	11.00	13.60	36.84
duct RAW	300 (75%)	32.64	12.24	32.64	8.16	85.68
wall decontamination	118.3 (10%)	9.65	6.44	9.46	53.24	78.79
floor decontamination	295.8 (75%)	12.07	12.07	23.66	132.76	180.56
Total $k		255.77	183.78	112.79	313.18	865.52
50% ancillary time increase (prep., setup, rest periods, etc.)		127.89				127.89
25% contingency increase		95.91	45.95	28.20	78.29	248.35
TOTAL		479.57	229.73	140.98	391.47	1241.76

The costs for component work on the interior portion of Bldg. 235 is estimated to be $1,241,760. Radioactive waste disposal for 30 barrels of RAW generated will cost $30,000. Thus, the total cost of the laboratory portion will be $1,271,760. Combined with the estimate for the preliminary work, $382,500, and the work to decommission the Radioactive Waste Annex, $180,700, the total cost for decommissioning the Reactor complex, exclusive of that portion of the facility that is covered by the Reactor license, is **$1,834,260**.

Total Decommissioning Costs for License SNM-362

Summing the costs of the various parts of the radiological areas used in work under license SNM-362 leads to a total cost estimate as shown in Table 10 for decommissioning.

Table 10 - SNM-362 TOTAL DECOMMISSIONING COST ESTIMATE

(in 1993 $k)

Facility	Cost in 1993 $
laboratories	1,071,372
accelerators	481,074
reactor	1,834,260
TOTAL	**3,386,706**

Estimates of the decommissioning costs projected into the future for license SNM-362 can be based on the "Implicit Price Deflators for Gross National Product", the inflation indicator commonly used by the Federal Government. This assumes about a 5% per annum increase in costs, leading to estimated costs in future years as shown in Table 11.

Table 11 - ESTIMATES OF FUTURE DECOMMISSIONING COSTS

Year	Projected Estimated Decommissioning Cost
1995	3,725,377
2000	4,572,053
2010	6,265,406
2025	8,805,436

A review of the estimated decommissioning costs for license SNM-362 will be performed at each license renewal application.

NIST DECOMMISSIONING FUNDING PLAN DEVELOPMENT
Health Physics, April, 1993

Introduction

As required by the USNRC for license number SNM-362, a decommissioning funding plan has been developed for the eventual termination of radiological work covered by that license. Decommissioning a facility assures that the facilities and components involved in the terminated work are either sufficiently free of radiological contamination that they may be turned over to the general public or packaged and delivered to radioactive waste disposal authorities.

In developing this plan, the primary reference was NUREG/CR-1754, *Technology, safety and costs of decommissioning reference non-fuel-cycle nuclear facilities*, dated February, 1981, and its more recent addendum, NUREG/CR-1754-ADD-1, *Compendium of current information*, dated October, 1988. Only the work associated with license SNM-362 was reviewed. None of the facilities covered by the NIST reactor license was considered.

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Labor costs were estimated using current civil service general schedule pay tables and the current overhead charge of 19% for personnel benefits now used for NIST Health Physics staff salaries, and Plant Division labor charges applied to work orders. The latter use a 52% charge-out overhead cost.

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Table 1 - LABOR COSTS IN 1993 $

	basic cost($/y)	o'head(%)	cost($/y)	cost($/d)
Supervisor(GS-14)	65000	19	77350	309
Foreman	52000	52	79040	316
Craftsman	42000	52	63840	255
Laborer	29000	52	44080	176
HP Technician(GS-8)	27000	19	32130	129
Secretary(GS-4)	19000	19	22610	90

Cost estimation

The NUREG reference uses a calculational scheme that subdivides the facility into components and further subdivides each component into unit portions. Calculations are performed with unitary elements and cost factors for each unitary element to derive a complete cost for decommissioning each component type.

Table 2 shows the components used for calculation, the dimensional unit for each component, and the number of units of each component in the standard size and configuration.

Table 2 - COMPONENT UNIT DETAILS

COMPONENT	units of DIM_PAR	DIM_PAR (standard unit size)
hood decontamination and RAW	cubic meters	2.835
glove box decontamination and RAW	cubic meters	0.5
bench decontamination and RAW	meters	8.7
sink decontamination and RAW	meters	10
vent decontamination and RAW	meters	10
wall decontamination[1]	square meters	59.16
floor decontamination[1]	square meters	19.72

[1] No RAW is considered for floor or wall/ceiling because a number of barrels of RAW are estimated for these, based on the materials estimated as required for decontamination. Little of the normal floor or wall/ceiling surfaces should be contaminated so that removal is required.

The tabulated unit cost factors from the tables in the NUREG, adjusted with the factor of 1.36, were used to generate costs for decommissioning the various components to be treated in a module. In the NUREG, values for UNIT_C_{XX}, in $k, were estimated for a variety of laboratory types, depending on the radionuclide used in a laboratory. As radionuclide work at NIST involves any radionuclide, almost any of the radionuclides might be encountered in the decommissioning project. Therefore, an average value was determined from all the various values shown in the NUREG for each of the unit component costs. The various unit cost factors used in this calculation are shown in Table 3, below.

Table 3 - UNIT COSTING FACTORS

(all values in $k)

COMPONENT	UNIT_C_{MP}	UNIT_C_{ES}	UNIT_C_{VR}	UNIT_C_{WP}
hood decontamination	0.90	0.87	0.08	0.33
hood RAW	1.35	0.69	0.08	0.05
glove box decontamination	4.96	6.09	0.07	0.29
glove box RAW	6.53	4.91	0.07	0.18
bench decontamination	0.12	0.19	0.08	0.37
bench RAW	0.35	0.18	0.08	0.04
sink decontamination	0.07	0.04	0.08	0.20
sink RAW	0.12	0.07	0.08	0.04
vent decontamination	0.08	0.04	0.11	0.14
vent RAW	0.11	0.04	0.11	0.03
wall decontamination	0.08	0.05	0.08	0.45
floor decontamination	0.04	0.04	0.08	0.45

In Table 3, UNIT_C_{XX} is the unit cost factor for each cost element, as used in this plan, with XX as:

MP = labor cost element,
ES = equipment and supplies cost element,
WP = waste packaging cost element,
and VR = waste volume reduction cost element.

Laboratory Section

Initial estimates and assumptions

Certain assumptions and decisions must be made prior to starting the decommissioning project. These influencing factors can be modified as additional information becomes available.

- There are 100 standard laboratory modules, each 5.8 meters long by 3.4 meters wide by 3.4 meters high.
- Each laboratory module has 1 hood of 2.835 m^3 volume, 1 sink with a 10 m long drain pipe, and a 10 meter length of vent/duct piping.
- Each laboratory has 1½ wall lengths of bench space.
- There are 10 glove boxes, each with 0.5 m^3 volume.
- Initial radiation surveys indicate that:
  - Five percent of a laboratory's floor area and 5% of the wall/ceiling area will need to be decontaminated.
  - Ten per cent of the bench length will need decontamination.
  - Ten per cent of the hoods will need decontamination.
  - Half of the glove boxes will need decontamination.
  - Ten per cent of the length of the vent/duct will need decontamination.
- Follow up radiation surveys, upon completion of decontamination efforts, indicate that each laboratory will generate 1 barrel (55-gallon or 0.21 m^3) of low level radioactive waste. The scrap contributions from components to be disposed of, estimated to be 1 hood, 1 glove box, 8.7 m of bench length, and 100 m of vent/duct length, are included in this.
- The total dimensions of the laboratories considered at NIST were about 20 times the dimensions of the NUREG's reference institutional user laboratory. That factor of 20 was applied to determine the labor costs for the preliminary development work. Actual decommissioning labor calculations use the actual dimensions of the components of the laboratories, so application of that factor was unnecessary as an extra element.
- The status of radioactive waste (RAW) disposal options is currently uncertain. The customarily used disposal site at Barnwell, SC, is in the process of closing to out-of-state customers such as NIST. It is assumed for the purposes of this plan that the Appalachian states group, i.e., Maryland, Pennsylvania, Delaware, and New Jersey, will complete the task of preparing to accept low-level radioactive wastes (LLRW) by the time that decommissioning is necessary for NIST. The cost of a 208-l (55-gallon) drum of LLRW is estimated at $1,000. This is assumed to include the cost for an agent to accept the waste at the NIST site and transport the waste to the disposal site.

Preliminary evaluation efforts costs

Prior to initiation of the labor on the project, certain tasks are required to minimize errors, reduce wasted effort, and assure adequate cleanliness of an area and its residual components for general public use. Table 4 shows these tasks and the work estimates required to accomplish those tasks, with a cost assigned by time spent by each involved worker type.

Table 4 - PRELIMINARY WORK EFFORT FOR LABORATORIES

(work days and 1992$)

	SUPERVISOR	FOREMAN	CRAFTSMAN	HP TECH	LABORER	SECTY
Prepare documents	25	75	0	0	0	25
Perform rad. survey	100	100	0	200	0	0
Develop work plan	25	50	0	25	0	25
$ per day	309	316	255	129	152	90
Total cost, $	46350	71100	0	29025	0	4500

A total cost for the initial work assessment, including the initial radiological surveys to classify the elements of the laboratories as "clean" or as candidates for decontamination or disposal is the sum of the various portions of the work, $150,975. Rest periods, preparation time, materials movements, etc. will increase the time required to do the work, so an ancillary time fraction of 50% is added to this. The total for this preliminary work is, thus, estimated to be $226,462. The segregation of elements into those to be cleaned of residual contamination or those to be dismantled and prepared for radioactive waste disposal will be included in subsequent projects, described below.

Work estimates

Using the product of DIM_PAR and UNIT_C_{XX} for each component, a cost for decommissioning each component can be calculated. Table 5 shows these data, with C_{XX} indicating the cost in $k. The DIM_PAR column indicates the total units to be treated and, in parentheses, the per cent of the total units in the laboratory complex.

Table 5 - COMPONENT COSTS FOR LABORATORIES

(C values in $k)

COMPONENT	DIM_PAR	C_{up}	C_{ES}	C_{VR}	C_{WP}	Total $k
hood decontamination	28.35 (10%)	25.45	24.68	2.27	9.25	61.64
hood RAW	2.835 (1%)	3.82	1.97	0.23	0.15	6.17
glove box decontamination	2.5 (50%)	12.41	15.23	0.18	0.71	28.53
glove box RAW	0.5 (10%)	3.26	2.45	0.03	0.09	5.84
bench decontamination	87 (10%)	10.65	16.56	6.96	31.95	66.12
bench RAW	8.7 (1%)	3.08	1.54	0.71	0.35	5.68
sink decontamination	100 (10%)	6.80	4.08	8.00	20.40	39.28
sink RAW	10 (1%)	1.22	0.68	0.82	0.41	3.13
vent decontamination	100 (10%)	8.16	4.08	11.00	13.60	36.84
vent RAW	100 (10%)	10.88	4.08	10.88	2.72	28.56
wall decontamination	795.8 (5%)	24.14	16.09	23.66	133.11	197.00
floor decontamination	48.6 (5%)	4.02	4.02	7.89	44.25	60.19
SubTotal		113.89	95.47	72.63	257.00	538.98
50% ancillary time increase (prep., setup, rest periods, etc.)		56.94				56.94
25% contingency increase		42.71	23.87	18.16	64.25	148.98
TOTAL		213.54	119.33	90.78	321.25	744.91

The total dollar sum of the cost of decontaminating and preparing for radioactive waste disposal is $744,910. This includes the 50% increase in ancillary time for the labor cost figures and an overall 25% increase as a contingency fund. The 100 barrels of radioactive waste that are generated will cost $100,000 in the final disposal effort. The initial preparation and planning effort costs are $226,462. Thus, the total cost for decommissioning the laboratory portion of the NIST materials licensed activities, i.e., the sum of these three parts, will be **$1,071,372.**

Accelerator Section

Initial estimates and assumptions

Certain assumptions about this portion of the materials licensed facilities are necessary to project decommissioning costs. Among the assumptions and decisions are the following:

- The involvement of licensed materials in accelerator operations force the facilities to be treated as if they were licensed by authorities, regardless of their unlicensed status, per se. Also, it is quite likely that other regulatory impacts and public perceptions of the facilities will make it necessary to decommission them in a manner like those facilities that are licensed.
- Portions of certain beam intensive areas in the Wing A Linac complex will require removal of concrete to remove activation products. It is estimated that an average

depth of 0.1 m (4") will reduce radioactivity levels to acceptable. The cost of concrete removal, from a substantial wall, with final smooth finish restoration, is estimated to be $215 per square meter ($20 per square foot) of wall surface. Among the areas that will require this treatment are:

- the Linac tunnel, A010, 45.8 meters long by 0.9 meters wide by 0.9 meters high, 10% will be removed,
- Measurement Room No. 1, A018, a cube 12 meters on a side, 5% will be removed,
- the Magnet Room, A007, estimated to be the equivalent of a Measurement Room, 10% will be removed,
- and, the entire Neutron Time of Flight Facility, NTOF and Blockhouse, G104 and G105, considered, with the shaft from the Magnet Room to the Blockhouse, to be the equivalent of a Measurement Room, 10% will be removed.

- The radiochemistry facility in Service Area No. 2, A006, is considered the equivalent of a standard radiochemistry laboratory, as treated in Part 1 of this plan. Associated with the hood is a pneumatic system for sample movement that will approximate another hood for the laboratory.
- The Low Scatter Room of the positive ion Van de Graaff, B23, is about 9 meters squared by 18 meters high, with a grating floor between the two levels and equipment on both levels. It will be considered as having 10% of its area contaminated with tritium. This will be treated as if it were wall contamination for cost estimating purposes.
- All the other accelerator and radiation use areas will be found with no contamination nor activation requiring action beyond the initial surveys.

Preliminary evaluation efforts costs

Just as in the standard laboratory portion of this plan, prior to initiation of the labor on the project, certain tasks are required to minimize errors, reduce wasted effort, and assure adequate cleanliness of an area and its residual components for general public use. Table 6 shows these tasks and the work estimates required to accomplish those tasks, with a cost assigned by time spent by each involved worker type. Given that a substantial learning curve will have been developed through implementing the work in Part 1, it is estimated that 25% of that effort will be required for the same result in Part 2, here, except for the radiological survey portion of the work. It is estimated that an equivalent amount of work for monitoring will be required here as for the laboratory facilities.

Table 6 - PRELIMINARY WORK EFFORT FOR THE ACCELERATOR

(work days and 1993$)

	SUPERVISOR	FOREMAN	CRAFTSMAN	HP TECH	LABORER	SECTY
Prepare documents	6.3	18.75	0	0	0	6.3
Perform rad. survey	100	100	0	200	0	0
Develop work plan	6.3	12.5	0	6.3	0	6.3
$ per day	309	316	255	129	152	90
Total cost, $	34793	41475	0	26613	0	1125

Thus, a total cost for the initial work assessment, including the initial radiological surveys to classify the elements of the areas as "clean" or as candidates for decontamination or disposal is $104,006. A 50% ancillary time addition for preparation, rest periods, etc. brings the total to $156,009.

Work estimates

Concrete removal will require Health Physics attendance and supervisory functions, so the $215 per square meter cost is estimated to increase to twice that figure, i.e., $430 per square meter. From the areas involved, 232.5 m^2 of wall surface will need removal and renovation; the total cost of this will be $99,975. The total volume of concrete removed will be 23.25 m^3, yielding a total of 112 barrels of RAW, costing $112,000. It is estimated that about 25% of that number of barrels of waste will be required to contain the materials used in the surface removal, including workers' Anti-C clothing, wipers, tools, etc. That calculates to 28 barrels, for a cost of $28,000. Thus, the total cost of concrete removal is estimated to be $239,975.

The single laboratory, with one hood, one sink/drain, and 10 m of vent/duct, but with no glove box nor bench, is estimated to be the size of a standard laboratory module and costs can be calculated to cost as shown in Table 7.

TABLE 7 - COMPONENT COSTS FOR ACCELERATOR LAB

(C values in $k)

COMPONENT	DIM PAR	C_{op}	C_{es}	C_{vs}	C_{wp}	Total
hood decontamination	2.835 (100%)	2.54	2.47	0.23	0.93	6.17
hood RAW	2.835 (100%)	3.82	1.97	0.23	0.15	6.17
sink decontamination	10 (100%)	0.68	0.41	0.80	2.04	3.93
duct RAW	10 (100%)	1.09	0.41	1.09	0.27	2.86
wall decontamination	2.96 (5%)	0.24	0.16	0.24	1.33	1.97
floor decontamination	0.99 (5%)	0.04	0.04	0.08	0.44	0.60
Total $k		8.41	5.46	2.67	5.16	21.70
50% ancillary time increase (prep., setup, rest periods, etc.		4.21				4.21
25% contingency increase		3.15	1.37	0.67	1.29	6.48
TOTAL		15.77	6.83	3.34	6.45	32.39

The component cost for decommissioning the laboratory in the accelerator complex,

including the ancillary time for labor and the contingency factor, will be $32,390.

For the Low Scatter Room, the decontamination of 10% of the total wall area will involve 8 areas, i.e., 4 walls on each of 2 levels, and 2 floor areas on each of the 2 levels, each of the areas being 9 meters square, so the total wall area to be treated will be 64.8 square meters and the total floor area to be treated will be 16.2 square meters. Using the unit costing factors from Table 3 for wall and floor decontamination, the total cost to decommission the Low Scatter Room will be $42.8k for the walls and $9.9k for the floors. Thus, the total cost will be $52,700.

The total cost for decommissioning the accelerator complex is, therefore, estimated to be **$481,074**.

Reactor Section

Initial estimates and assumptions

There are two independent areas at the Reactor complex that do not fall within the indemnified area described in the Reactor license. These are that area within Bldg. 235 but outside the Confinement Building, and the Radioactive Waste Annex. For the purposes of this plan, these two areas will be treated separately, after the preliminary work effort costs are estimated.

The initial labor costs for the Annex will approximate those for the Accelerator portion described in the section immediately preceding this section. The labor costs for the laboratory portion of the Reactor will approximate the costs for the laboratory section described in the first section of this plan, because of the significant potential for tritium contamination of any surface within the building. Thus, the total labor costs for the preliminary studies and surveys are estimated to be $156,000 + $226,500 = $382,500.

Work estimates

The Radioactive Waste Annex is an appendage at the rear of Bldg. 235. It is approximately 7.5 meters wide by 12 meters long by 4.5 meters high. It is estimated that 75% of the floor and 50% of the walls will require decontaminating. Various pieces of equipment, e.g., compactor, barrel handling tools, bins, etc., are within the enclosed volume. It is estimated that the equipment will be the equivalent of 5 hoods, with 50% to be decontaminated and 25% to be treated as RAW. Table 8 shows the calculated values for the various elements in the costing process.

Table 8 - COMPONENT COSTS FOR RADIOACTIVE WASTE ANNEX

(C values in $k)

COMPONENT	DIM PAR	C_{ud}	C_{ds}	C_{vs}	C_{wp}	Total $k
hood decontamination	7.09 (50%)	6.38	6.17	0.57	2.34	15.46
hood RAW	1.54 (25%)	4.78	2.45	0.28	0.18	7.69
wall decontamination	99 (50%)	7.92	4.95	7.92	44.55	65.34
floor decontamination	67.5 (75%)	2.70	2.70	5.40	30.38	41.18
Total $k		21.78	16.27	14.17	77.45	129.67
50% ancillary time increase (prep., setup, rest periods, etc.)		10.89				10.89
25% contingency increase		8.17	4.07	3.54	19.36	35.14
TOTAL		40.84	20.34	17.71	96.81	175.70

The cost for the Annex work is, then, $175,700. If an estimated 5 barrels of RAW are generated, a disposal cost of $5,000 is added to this, for a grand total for the area of $180,700.

The interior portion of Bldg. 235 that is not covered by the Reactor operating license can be described as follows:

- There are the equivalent of 20 standard laboratory modules, considering the warm, semi-warm, and hot labs.
- Each laboratory has 2 hoods; half will be decontaminated and half will be disposed of as RAW.
- There are 5 glove boxes in the complex; all will be disposed of as RAW.
- There is 1 sink/drain in each laboratory; 8 will be decontaminated and 2 will be RAW.
- There is a 10 meter length of vent/ducting for each laboratory; 5 will be decontaminated and 15 will be RAW.
- Workbenches cover 3.75 meters of each 5.8 meter wall length; 75% will be decontaminated and 25% will be RAW.
- One barrel of RAW will be generated for each laboratory.
- Ten barrels of RAW will be generated in decontaminating the non-laboratory part of the building.

The decommissioning component costs, based on these assumptions, will be as shown in Table 9.

Table 9 - COMPONENT COSTS FOR REACTOR LABORATORIES

(C values in $k)

COMPONENT	DIM PAR	C_{ce}	C_{ss}	C_{rs}	C_{wp}	Total
hood decontamination	56.7 (50%)	50.89	49.35	4.54	18.51	123.29
hood RAW	56.7 (50%)	76.34	39.33	4.63	3.08	123.38
glove box decontamination	0	0.00	0.00	0.00	0.00	0.00
glove box RAW	2.5 (100%)	16.32	12.27	0.17	0.44	29.21
workbench decontamination	174 (75%)	21.30	33.13	13.92	63.89	132.24
workbench RAW	58 (25%)	20.51	10.25	4.73	2.37	37.86
sink decontamination	80 (80%)	5.44	3.26	6.40	16.32	31.42
sink RAW	20 (20%)	2.45	1.36	1.63	0.82	6.26
duct decontamination	100 (25%)	8.16	4.08	11.00	13.60	36.84
duct RAW	300 (75%)	32.64	12.24	32.64	8.16	85.68
wall decontamination	83 (10%)	9.65	6.44	9.46	53.24	78.79
floor decontamination	248 (75%)	12.07	12.07	23.66	132.76	180.56
Total $k		255.77	183.78	112.79	313.18	865.52
50% ancillary time increase (prep., setup, rest periods, etc.)		127.89				127.89
25% contingency increase		95.91	45.95	28.20	78.29	248.35
TOTAL		479.57	229.73	140.98	391.47	1241.76

The costs for component work on the interior portion of Bldg. 235 is estimated to be $1,241,760. Radioactive waste disposal for 30 barrels of RAW generated will cost $30,000. Thus, the total cost of the laboratory portion will be $1,271,760. Combined with the estimate for the preliminary work, $382,500, and the work to decommission the Radioactive Waste Annex, $180,700, the total cost for decommissioning the Reactor complex, exclusive of that portion of the facility that is covered by the Reactor license, is **$1,834,260**.

Total Decommissioning Costs for License SNM-362

Summing the costs of the various parts of the radiological areas used in work under license SNM-362 leads to a total cost estimate as shown in Table 10 for decommissioning.

Table 10 - SNM-362 TOTAL DECOMMISSIONING COST ESTIMATE

(in 1993 $k)

Facility	Cost in 1993 $
laboratories	1,071,372
accelerators	481,074
reactor	1,834,260
TOTAL	**3,386,706**

Estimates of the decommissioning costs projected into the future for license SNM-362 can be based on the "Implicit Price Deflators for Gross National Product", the inflation indicator commonly used by the Federal Government. This assumes about a 5% per annum increase in costs, leading to estimated costs in future years as shown in Table 11.

Table 11 - ESTIMATES OF FUTURE DECOMMISSIONING COSTS

Year	Projected Estimated Decommissioning Cost
1995	3,725,377
2000	4,572,053
2010	6,265,406
2025	8,805,436

A review of the estimated decommissioning costs for license SNM-362 will be performed at each license renewal application.