Duratek

Decommissioning Cost Estimate for the Ward Center for Nuclear Studies at Cornell University

Facilities Inventory Bldg. No. 2061

Rev 1 **July 2003**

Prepared for:
Cornell University

Prepared by:
Duratek, Inc
Commercial Operations
1009 Commerce Park Drive,
Suite 100
Oak Ridge, TN 37830

DECOMMISSIONING COST ESTIMATE

for the

Ward Center for Nuclear Studies at Cornell University

Facilities Inventory Bldg. No. 2061

Rev 1
July 2003

Prepared By: Paul C Ely — 7/28/03
Paul Ely
Senior Radiological Engineer — Date

Reviewed By: — 7/28/03
Doug Schult, CHP
Project Manager — Date

Approved By: — 7/27/03
Robin Shult
General Manager
Commercial Operations — Date

Prepared By:
Duratek, Inc.
1009 Commerce Park Drive, Suite 100
Oak Ridge, TN 37830

PROPRIETARY STATEMENT

This document is the property of the Cornell University and furnished with the understanding that the information herein will be held in confidence and will not be duplicated, used or disclosed either in whole or part without the written permission of Cornell University.

EXECUTIVE SUMMARY

Duratek, Inc (Duratek) performed an independent cost estimate for decommissioning the Ward Center located in Ithaca, New York. This estimate was prepared at the request of the Cornell University.

This cost estimate was developed using a systematic approach. Decommissioning criteria were identified and survey data were reviewed. Specific and general information regarding equipment and structures was used in determining decontamination and demolition methodologies in order to minimize overall decommissioning costs.

This estimate includes itemized costs for manpower and equipment resources, radioactive waste volume reduction, packaging, shipping and burial activities, the performance of final status surveys for buildings and structures and the removal of these released buildings. The estimated decommissioning cost is $3,603,086 in terms of 2003 dollars. This estimate does not include the costs associated with fuel removal and transport from Ward Center to the Department of Energy (DOE). This estimate is for budgetary purposes only and is not a proposal for Duratek to perform the decommissioning work.

A significant portion of the overall decommissioning costs is attributed to the disposal of radioactive waste. The radioactive waste disposal rate used for most of the waste in this estimate was based on shipping to Envirocare of Utah. Activated materials will be sent to the Barnwell South Carolina disposal facility.

TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF FIGURES

LIST OF TABLES

1.0 INTRODUCTION

1.1 Purpose

The Commercial Operations division of Duratek, Inc (Duratek) has prepared this document for the purpose of providing a decommissioning cost estimate for Ward Center for Nuclear Studies TRIGA Reactor and Zero Power Reactor at Cornell University. The cost estimate includes those activities and associated cost factors required to terminate the Ward Center TRIGA Reactor Nuclear Regulatory Commission (NRC) License R-80, Doc. No.50-157 and Zero Power Reactor Facility License R-89, Doc. No.50-97 and release of the reactor portions of the Ward Center for "unrestricted use." A New York State licensed gamma irradiation facility located in Ward Center will be closed August 30, 2003. The facility will be decommissioned and the New York State (NYS) license amended accordingly. The term "unrestricted use" means that there will be no future NRC restrictions on the use of the site.

The decommissioning is projected to start within the next year. The cost estimate provided by this report is in terms of 2003 dollars. This estimate is intended to be used for funding and budgetary purposes and does not constitute a proposal or cost estimate for Duratek to perform work.

1.2 Scope

The scope of this report is to present the estimated costs derived for decommissioning the Ward Center. The specific areas covered by this estimate include:

- TRIGA Reactor
- TRIGA Bioshield and Beam Ports
- Reactor complex
- Office and Laboratory Wing
- Zero Power Reactor

This estimate has been prepared to provide a budgetary decommissioning cost estimate and to support the requirements of 10 CFR 50.82(b), Termination of License – for Non-Power Reactor Licensees (Ref. 6-1). This estimate addresses activities related to the removal of hardware, structural materials, and miscellaneous materials as necessary to reduce levels of residual radioactivity to below the guideline values in accordance with the NRC criteria for license termination in Subpart E of 10CFR Part 20 (Ref. 6-2).

The current NRC guidance for acceptable license termination screening values (meeting the 10 CFR 20.1402 criteria) of common radionuclides for building surface contamination and surface soil contamination are presented in NUREG-

1757, *Consolidated NMSS Decommissioning Guidance, Decommissioning Process for Materials Licenses*, Appendix B, (Ref. 6-3).

Decommissioning costs are directly related to the degree of remediation required and the amount of radioactive waste generated. The extent of remediation is based on radiological data, proven decontamination processes and data from similar projects. The volume of radioactive wastes was estimated based on data provided from facility drawings, equipment sizes, radiological data, and proven volume reduction processes. Costs associated with the performance of final status surveys were estimated based on the size of the various areas being decommissioned and their prior radiological history.

The cost estimate for the Ward Center utilizes a combination of unit price estimates and task-based estimates to arrive at a total cost in 2003 dollars for decommissioning all areas. The unit cost methodology is modeled after the method used in the *Means Building Construction Cost Data* (Ref. 6-4). The decommissioning work is first divided into units of work, such as removing a 2-inch pipe run and then the unit of cost per foot of pipe is multiplied by the feet of pipe to arrive at the cost. A similar method is used for decontamination work, such as the decontamination of a concrete floor to a depth of 1/4 inch. The unit of cost per square foot of concrete floor area is multiplied by the square feet of floor area to arrive at the cost. The estimate includes the craft labor, supervision, health physics support, waste disposal, materials and equipment necessary to actually perform this task. Other work is priced using the task based methodology which is modeled after the method used by PNL (Pacific Northwest Laboratory) to prepare the estimates presented in NUREG/CR-1756, *Technology Safety and Costs of Decommissioning Reference Nuclear Research and Test Reactors*, March 1982 (Ref. 6-5). The work is divided into tasks such as decontaminating pool walls and then an estimate is generated for each task. The various costs derived from the two methods are combined and a project schedule is developed which defines the duration and man loading for the project. The schedule and man-loading information is used in the development of on site project management costs, travel and living costs, equipment rental costs, home office support costs, and owner oversight costs.

1.3 Assumptions and Bases

The following assumptions and bases were utilized in developing the cost estimate.

- The reactor fuel will have been removed and transported from Ward Center to the DOE prior to the start of decommissioning, costs for these activities are not included in this estimate.
- The Ward Center will be decontaminated and free released.

- The Gamma Irradiation Facility will be closed and decommissioned by Cornell.
- Some of the uncontaminated laboratory equipment located throughout the facility has a high intrinsic value and may be moved to another facility prior to decommissioning.
- The use of radioactive materials at the Ward Center has been well controlled and contaminated areas are well defined. Contamination outside of the defined areas is not anticipated and costs for remediation outside of these areas are not included in this estimate.
- Contaminated equipment will for the most part be shipped directly to a licensed radioactive waste disposal site. Some easily decontaminated equipment will be decontaminated on-site, surveyed for unrestricted release, and then sent to a landfill for disposal. Some equipment may be shipped to a volume reduction facility for processing prior to disposal.
- Cornell will provide security for the site, power will be available, and the Cornell University staff and management will be on site during decommissioning.
- Radioactive waste with low specific activity will be sent to Envirocare of Utah. It was assumed that concrete, protective clothing waste, and miscellaneous dry active waste would qualify for disposal at Envirocare of Utah.
- Radioactive waste not suitable for disposal at Envirocare of Utah will be sent to the Barnwell, South Carolina disposal site.
- The site remediation contractor will provide the demolition equipment and survey instrumentation at prevailing rates.
- Local decontamination technicians and supervisors will be used to staff this project; therefore, no travel and living funds are included for them. Health Physics technicians and supervisors and project management personnel will not be local hires; therefore, funds for travel and living expenses were included.
- Construction labor rates were obtained from 2003 RS Means Building Construction Cost Data for Binghamton, New York.

2.0 GENERAL FACILITY DESCRIPTION

The regional location of the Ward Center is shown in Figure 2-1; Figure 2-2 depicts the Ward Center site and adjacent Cornell structures; the Ward Center site is depicted on Figure 2-3. Figure 2-4, Figure 2-5 and Figure 2-6 presents plan views of the three floors of the Ward Center.

The Ward Center TRIGA Reactor is similar to the Oregon State University TRIGA Reactor that was used as the basis for the decommissioning estimate reported in NUREG/CR-1756, *Technology Safety and Costs of Decommissioning Reference Nuclear Research and Test Reactors*, March 1982 (Ref. 6-5). A full description of the facility is provided in *Final Safeguards Report to the U.S. Atomic Energy Commission for the Cornell University TRIGA Reactor* (Ref. 6-6) and *Supplement No. 1 to the Final Safeguards Report to the U.S. Atomic Energy Commission for the Cornell University TRIGA Reactor* (Ref. 6-7).

The Cornell University stopped routine operation of the Ward Center TRIGA Reactor on June 30, 2002 and plans to submit a request for a possession only license in 2003. The TRIGA is currently operated for short periods of time at low power levels in order to maintain operator qualifications. The University previously ceased operation of the ZPR reactor on September 6, 1996.

The spent fuel is the property of DOE and was leased to Ward Center. This lease requires DOE to take possession of the fuel when the University is done with it. Aluminum-clad and stainless steal-clad fuel that has been used at Ward Center, will be shipped to the National Engineering and Environmental Laboratory in Idaho Falls, Idaho.

Figure 2-1 Map of the Area Surrounding Cornell University

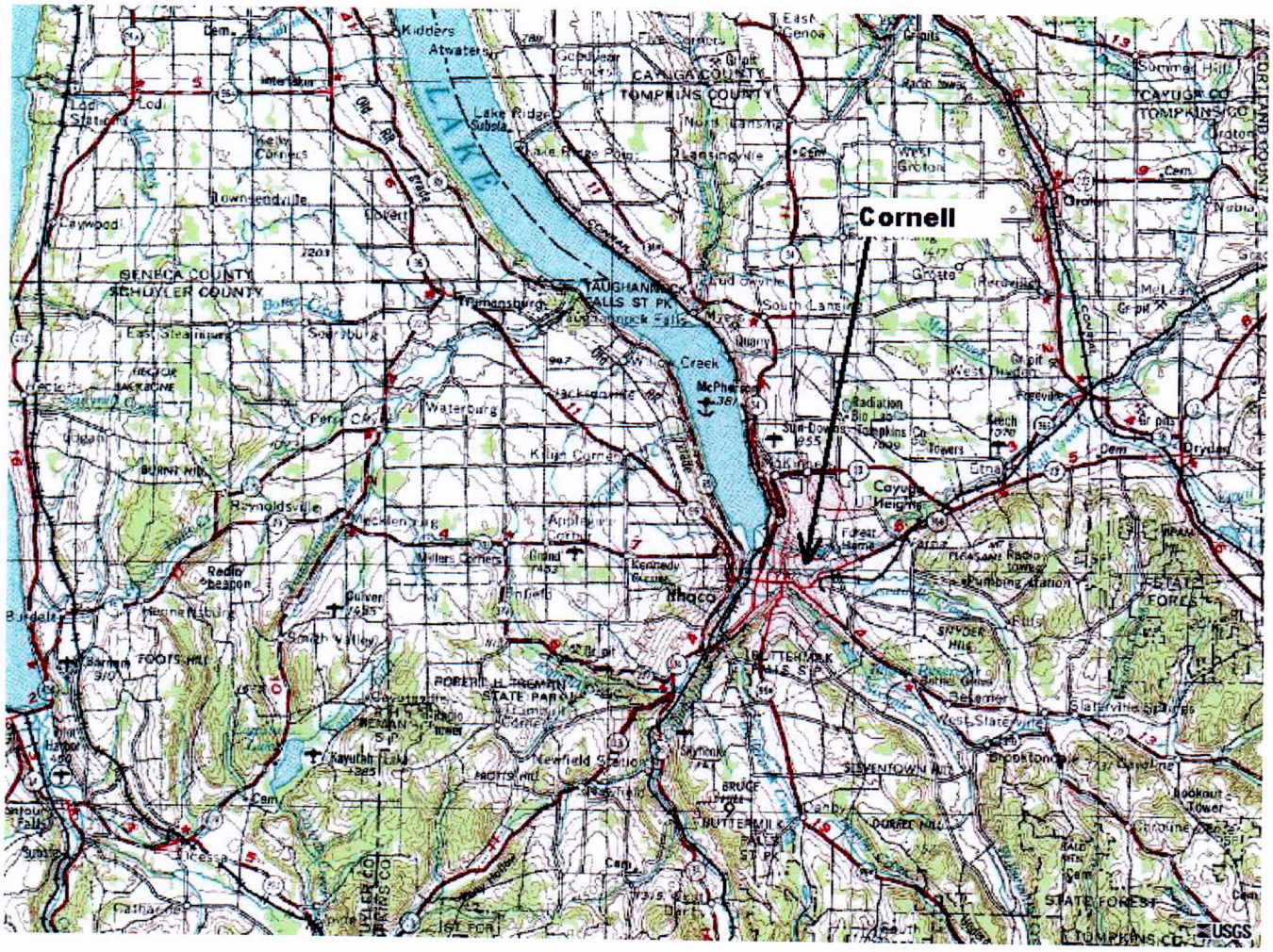


Figure 2-2 Cornell University Campus

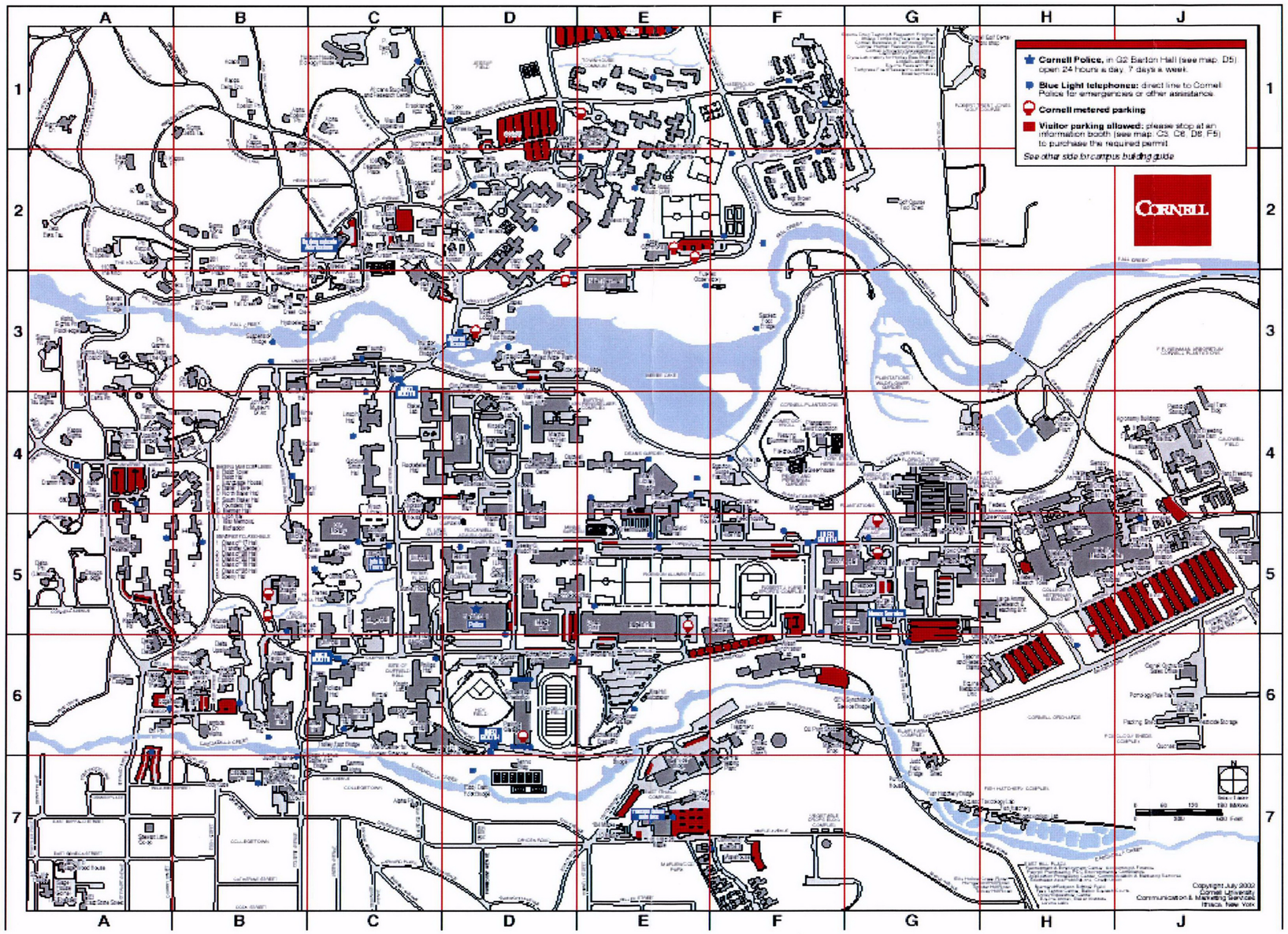
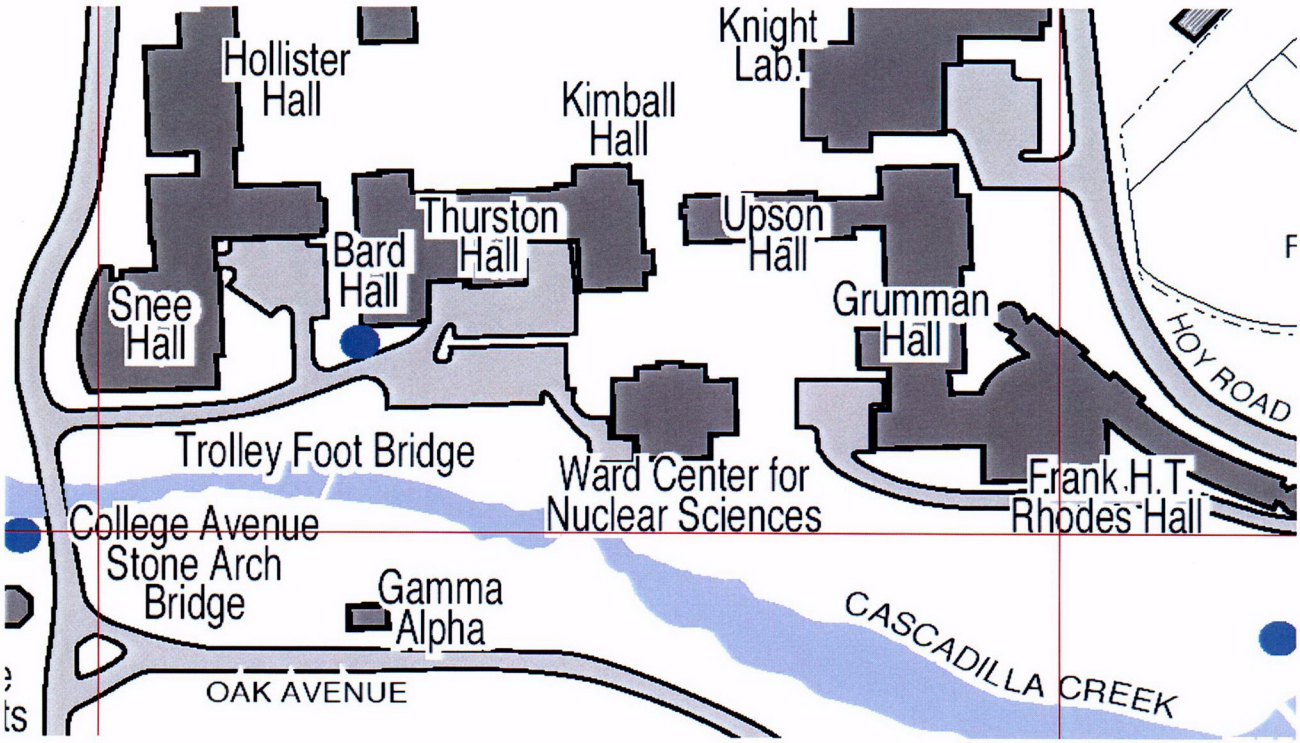


Figure 2-3 Cornell University Ward Center Site



C03

Figure 2-4 Ward Center Basement Plan View

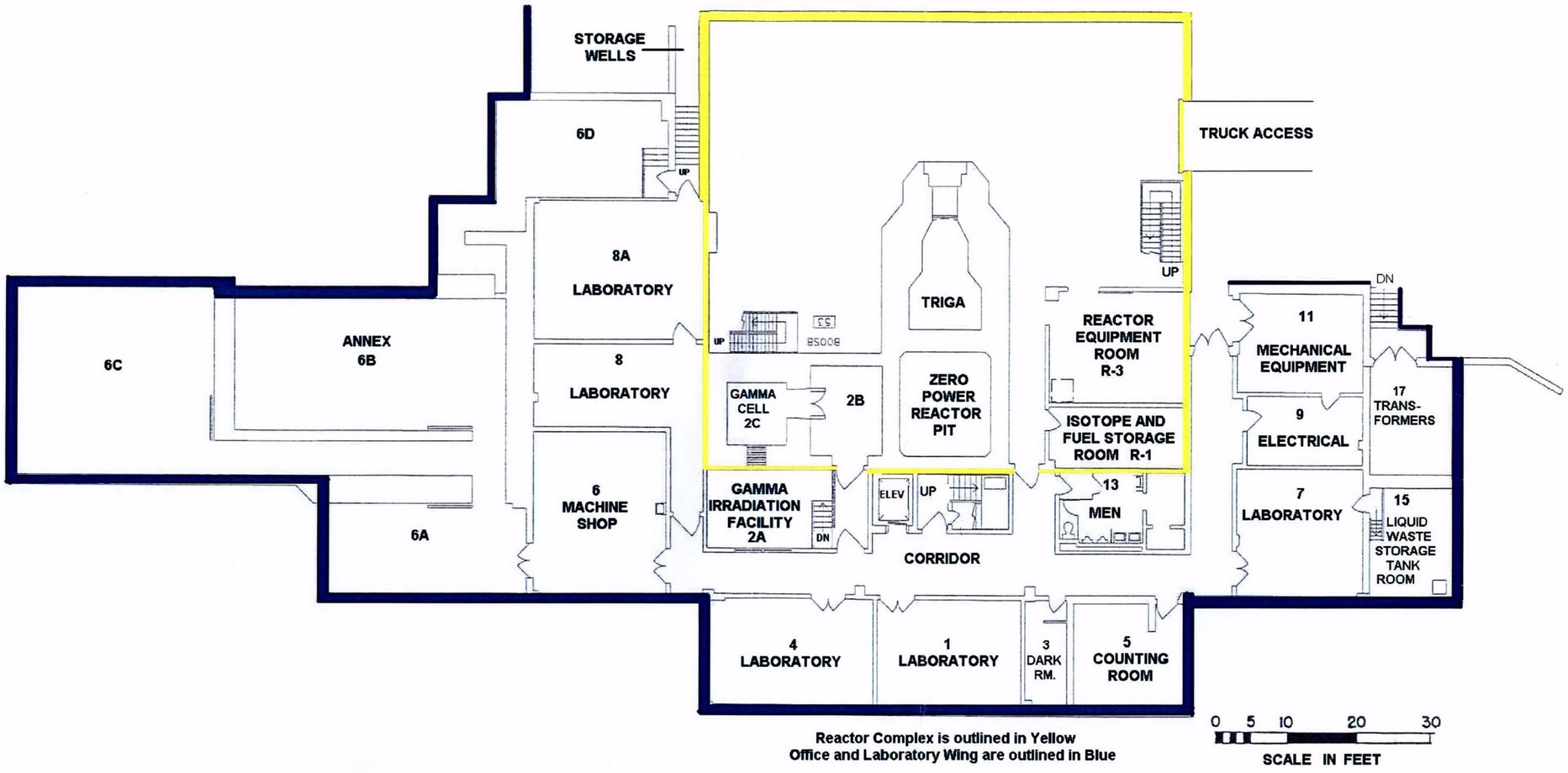


Figure 2-5 Ward Center 1st Floor Plan View

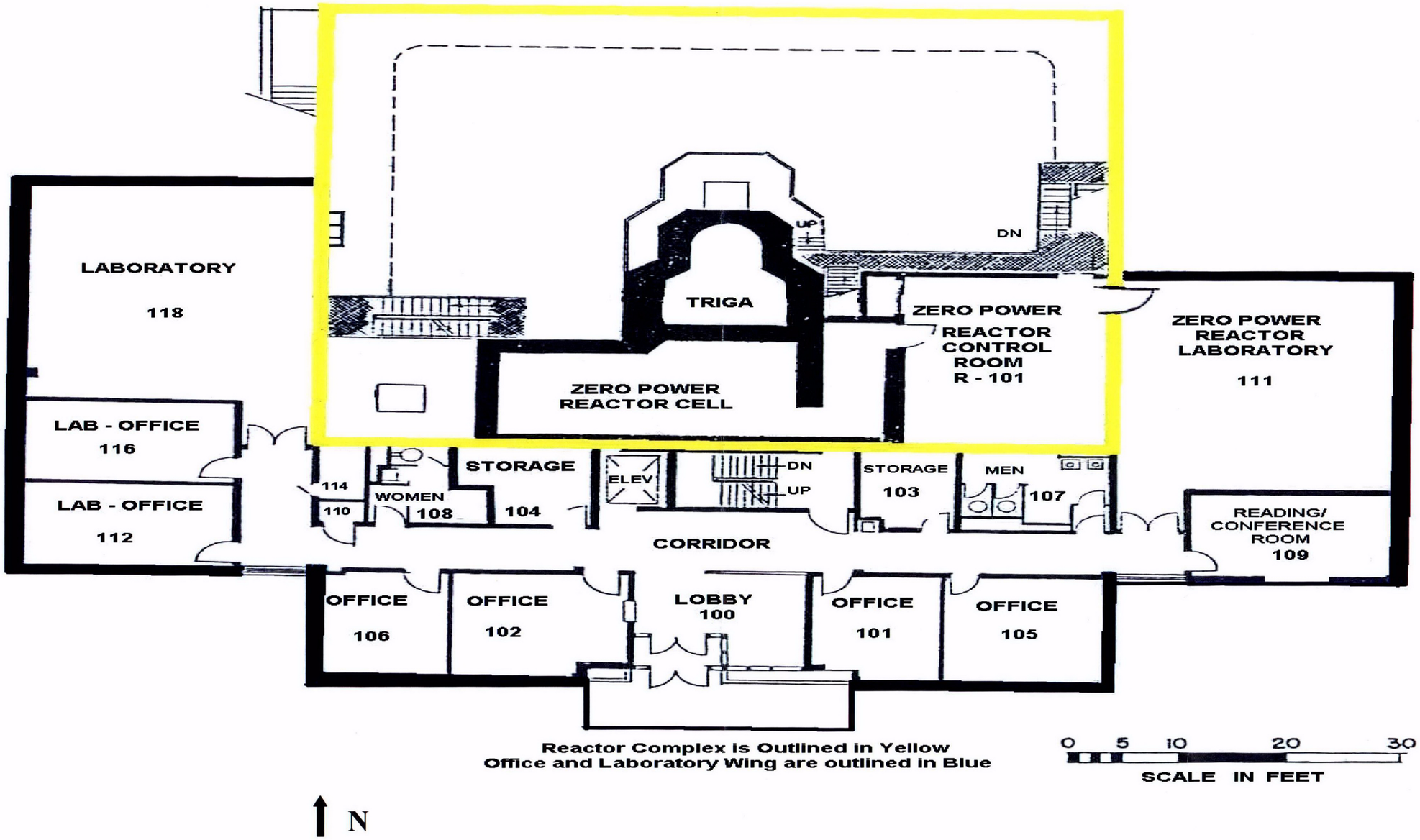
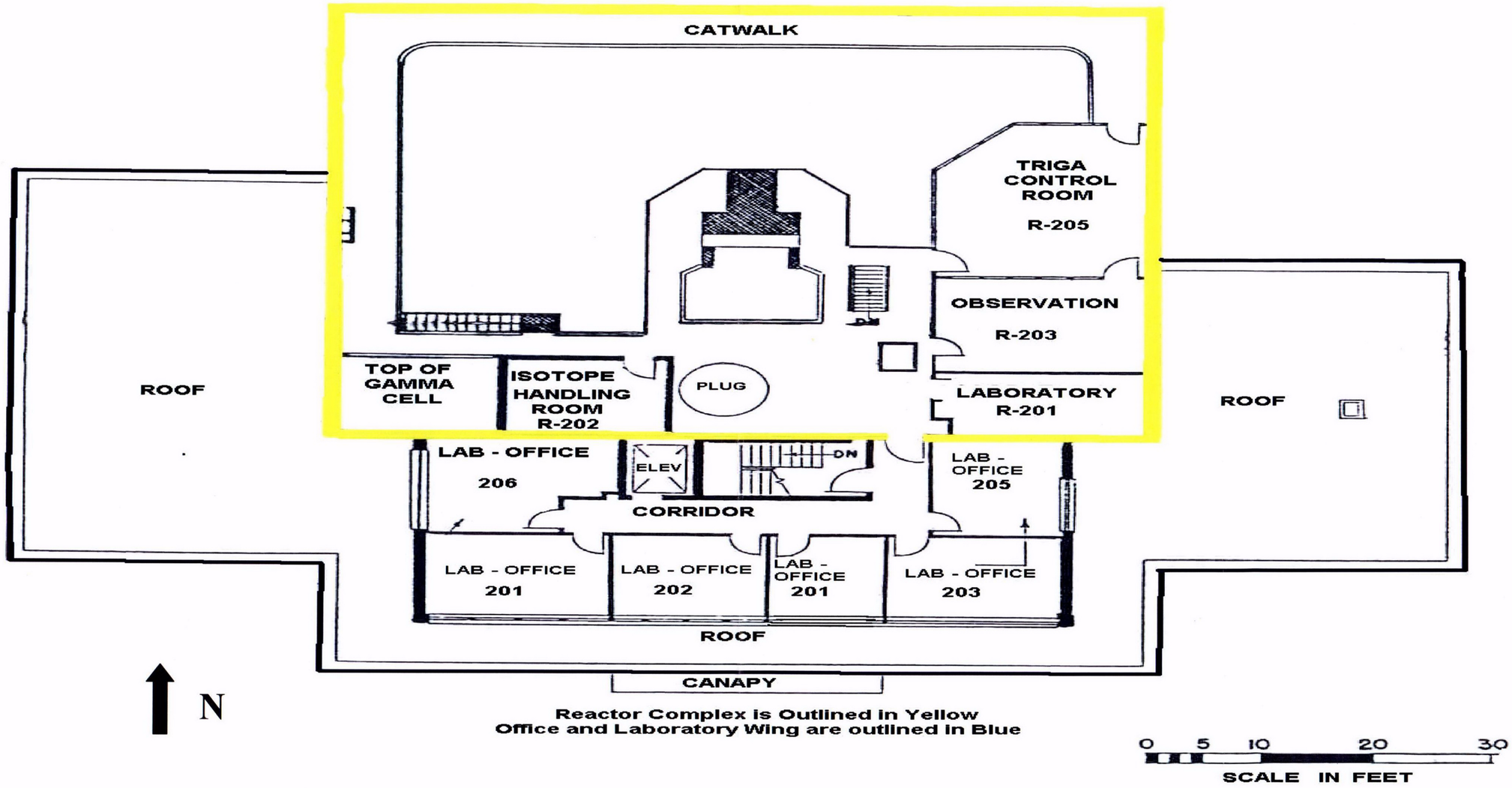


Figure 2-6 Ward Center 2nd Floor Plan View



3.0 DECOMMISSIONING CRITERIA

A Duratek engineers visited the Ward Center Facility in Ithaca, New York in February of 2003 to gather physical and radiological data. Facility sketches, building sketches, and radiological characterization data for affected areas were obtained.

3.1 Radionuclides of Interest

The base line radioactive material quantities were obtained from the estimate provided in NUREG/CR-1756, (Ref. 6-5). There are additional radionuclides reported in the characterization survey report (Ref. 6-8) that were not included in NUREG/CR-1756 and therefore do not have estimated quantities. After reactor shut down and for some time to come, ^{60}Co and, to a smaller extent, ^{65}Zn are the principal contributors to radiation dose from the reactor core and vessel. Most (>95%) of the radionuclide inventory at the facility is found in the reactor pool. Excluding fuel, this amounts to about 1,500 curies of neutron activation products at the time of shutdown. The radionuclides that potentially exist in the Ward Center along with estimated inventories are presented in Table 3-1.

Table 3-1 List of Expected Radionuclides

Nuclide	Half-Life (yr)	Inventory Ci
^{3}H	12.28	Not Available
^{14}C	5,730	1.11
^{39}Ar	269	2.53 x 10-3
^{41}Ca	103,000	4.6 x 10-4
^{45}Ca	0.446	0.23
^{46}Sc	0.233	2.34 x 10-2
^{51}Cr	0.0759	251
^{54}Mn	0.86	22.7
^{55}Fe	2.73	118
^{59}Fe	0.1222	4.74
^{57}Co	0.74	Not Available
^{58}Co	0.194	133
^{60}Co	5.27	567
^{59}Ni	76,000	0.11
^{63}Ni	100	12.6
^{65}Zn	0.67	67.2
^{90}Sr	29.1	Not Available
^{93m}Nb	13.6	2.34 x 10-5
^{94}Nb	20,000	2.6 x 10-4
^{95}Nb	0.0961	2.08 x 10-2

Nuclide	Half-Life (yr)	Inventory Ci
^{99}Tc	213,000	Not Available
^{124}Sb	0.16	Not Available
^{125}Sb	2.76	Not Available
^{129}I	15,700,000	Not Available
^{134}Cs	2.7	Not Available
^{137}Cs	30.17	Not Available
^{144}Ce	0.78	Not Available
^{152}Eu	13.48	Not Available
^{154}Eu	8.8	Not Available
^{155}Eu	4.96	Not Available
^{210}Pb	22.26	Not Available
^{226}Ra	1,600	Not Available
^{230}Th	77,000	Not Available
$^{233/234}U$	>159,200	Not Available
^{241}Pu	14.4	Not Available

The list of expected radionuclides provided above is based on the assumption that operations of the Ward Center has resulted in the neutron activation of reactor core components and other integral hardware or structural members which were situated adjacent to, or in close proximity to, the reactor core during operations. Specific items, which are considered to have been exposed to neutron activation, include materials composed of aluminum, steel, stainless steel, graphite, cadmium, lead, concrete and possibly others.

3.2 Radiological Criteria for License Termination

The overall objective of the Ward Center decommissioning is to remediate the facilities to a condition that corresponds to a calculated dose to the public of less than 25 mrem/year from applicable pathways. The facilities may then be released for unrestricted use. This dose limit appears in 10 CFR 20.1402, *Radiological Criteria for Unrestricted Use* (Ref. 6-9).

The Derived Concentration Guideline Level (DCGL) is defined in *MARSSIM* (Ref. 6-10) as the radionuclide-specific concentration within a survey unit corresponding to the release criterion. The DCGL is dependent upon several factors including the radionuclides of interest, applicable dose pathways, area occupancy and the future use of the facility. DCGLs assume a uniform level of residual radioactivity across the survey unit.

For the Ward Center it was assumed that the site qualified for a screening analysis to develop the DCGLs. A screening analysis can be based on one or more of the currently available screening tools: (1) building surface contamination and surface soil contamination are presented in NUREG-1757, Appendix B (Ref. 6-3).); (2) screening levels derived using D and D, Version 2.0 (Ref. 6-11), for the specific radionuclides(s) using the code's default parameters. The assumed DCGLs for

Ward Center were based on the look-up tables in NUREG-1757, Appendix B (Ref. 6-3).

The proposed DCGLs for surface contamination are based on the screening tables in NUREG-1757, Appendix B (Ref. 6-3). Buildings with surface contamination below these levels will be deemed acceptable for release for unrestricted use provided that:

- Residual radioactivity has been reduced to levels that are "as low as is reasonably achievable" (ALARA),
- The residual radioactivity is contained in the top layer of the building surface (i.e., there is no volumetric contamination), and
- The fraction of removable surface contamination does not exceed 0.1.

Table 3-2 Acceptable License Termination Screening Values of Common Radionuclides for Building Surface Contamination

Radionuclide	Symbol	Acceptable screening levels[1] for Unrestricted release (dpm/100cm²)
Hydrogen-3 (Tritium)	^{3}H	1.2E+08
Carbon-14	^{14}C	3.7E+06
Sodium-22	^{22}Na	9.5E+03
Sulfur-35	^{35}S	1.3E+07
Chlorine-36	^{36}Cl	5.0E+05
Manganese-54	^{54}Mn	3.2E+04
Iron-55	^{55}Fe	4.5E+06
Cobalt-60	^{60}Co	7.1E+03
Nickel-63	^{63}Ni	1.8E+06
Strontium-90	^{90}Sr	8.7E+03
Technetium-99	^{99}Tc	1.3E+06
Iodine-129	^{129}I	3.5E+04
Cesium-137	^{137}Cs	2.8E+04

[1] Screening levels are based on the assumption that the fraction of removable surface contamination is equal to 0.1. For cases when the fraction of removable contamination is undetermined or higher than 0.1, users may assume, for screening purposes, that 100% of surface contamination is removable, and therefore the screening levels should be decreased by a factor of 10. Alternatively, users having site-specific data on the fraction of removable contamination (e.g., within the 10% to 100% range) may calculate site-specific screening levels using DandD Version 1.

[2] Units are disintegrations per minute per 100 square centimeters (dpm/100 cm^2). 1 dpm is equivalent to 0.0167 becquerel (Bq). The screening values represent surface concentrations of individual radionuclides that would be deemed in compliance with the 0.25 mSv/yr (25 mrem/yr) unrestricted release dose limit in 10 CFR 20.1402. For radionuclides in a mixture, the "sum of fractions" rule applies; see 10 CFR Part 20, Appendix B, Note 4. Refer to NUREG-1757 for further information on application of the values in this table.

3.3 Reactor complex

The property, on which is situated the Cornell University Ward Center, was designated for construction in 1959. The Ward Center was constructed between 1959 and 1962.

The structure does not have a history of spills or other contamination and it is anticipated that, at the time of decommissioning, remediation will be minimal. It is assumed that some of the ventilation system components and some miscellaneous equipment will be disposed as radioactive waste. Decommissioning of the structure will follow decommissioning of the reactor and reactor equipment. The structure will then be surveyed using a license termination type survey with any additional structural decontamination performed in conjunction with the surveys.

The land area is not well defined, as there are no boundaries between the Ward Center and the nearby engineering buildings. Structurally and functionally the building consists of two main sections, the reactor complex, a relatively airtight reinforced concrete structure faced with brick veneer and an office and laboratory wing of reinforced concrete columns and beams faced with native stone.

The reactor complex is 63 feet by 70 feet in plan and 45 feet in height. This portion of the building, containing approximately 5,500 square feet of floor space, houses the two reactors and their control rooms, associated experimental and service areas, and the gamma irradiation cell. The office and laboratory wing, which is U-shaped, consists of east and west sections approximately 26 feet wide and a north section approximately 33 feet wide. The total length of the U is approximately 176 feet, thus providing approximately 10,000 square feet of floor area. This wing of the facility houses, in a basement and two stories, a counting room, laboratories, offices, a classroom, and building utility rooms.

The principal function of the reactor complex is to house the two reactors and their associated operational and experimental areas. The gamma irradiation facility is also located in the bay in the northeast corner; it is, however, functionally part of the office and laboratory wing. (The only access to the gamma cell from the reactor complex is through a 4 ft by 4 ft opening in the cell roof to permit heavy objects to be moved in and out by an overhead crane; normally the opening is kept closed by a removable concrete plug.)

The TRIGA reactor structure is approximately centered in the reactor complex and rises 25 ft above the basement floor level. The Zero Power Reactor is housed immediately north of the TRIGA in a self-contained, two-story high concrete cell. The south wall of the ZPR cell serves also as the north wall of the TRIGA pool. The remaining volume of the reactor complex is divided into rooms and working floor space on three levels: basement, first floor, and second floor. There are two stairways connecting the three levels. A pendant-operated 5-ton bridge crane mounted on rails running along the north and south walls, traverses the entire area of the bay. The crane can service both reactors and the gamma cell.

The reactor complex is a reinforced concrete structure. The interior surface of the concrete is coated with a vapor barrier and painted to provide a smooth surface capable of being readily decontaminated. Personnel access to the reactor complex section may be gained from the office and laboratory wing through only three doors, one at each floor level. A large door on the west wall at the basement level provides truck access to the bay for loading and unloading freight. Since the grade is a relatively steep slope from the north to the south, the basement of the entire building is underground at the front (north) end and above grade in the rear, permitting truck unloading at the basement level of the reactor complex.

The roof of the reactor complex is flat and consists of pre-stressed concrete beams, concrete roof slabs, 1-in. rigid vapor barrier insulation, and built-up roofing. All floors in the bay are protected with a Phenoline coating (except for the observation room, the second floor laboratory room, and the two control rooms, where asphalt tile is used).

3.3.1 Basement Plan

The ZPR cell and the TRIGA pool occupy the central portion of the basement, running on the north-south axis of the building. All other facilities in the basement are on either side of these two centrally located reactor structures. The northeast corner of the basement contains the gamma irradiation cell. Immediately west of the ZPR pit is a corridor permitting personnel access from the office and laboratory wing to the reactor complex. The isotope-and-fuel storage room occupies the northwest corner of the basement and immediately south of it is the reactor equipment room. The remaining basement floor area is available for experimental setups, in particular those utilizing neutron beams from the TRIGA.

3.3.2 First Floor Plan

Continuations of the ZPR cell and TRIGA pool occupy the north central portion of the first floor of the reactor complex. At the northeast corner is the roof of the gamma irradiation cell. At the northwest corner is the ZPR control room, which is connected by a labyrinth to the ZPR cell. The cell

broadens out at this level to include a grid-plate-and- fuel storage area. A removable grating in the ZPR cell floor affords access to the basement area of the cell. Access to the ZPR control room is either from a stairway platform in the main reactor area or from the ZPR laboratory in the west section of the office and laboratory wing. At the nose of the TRIGA and slightly below the first floor level is the top surface of the TRIGA thermal column shielding; this surface forms a working area around the vertical access to the thermal column.

3.3.3 Second Floor Plan

Access to the second floor of the reactor complex is afforded by stairways inside the bay and by a door into the north section of the office and laboratory wing. The second floor includes a balcony, or catwalk, around most of the perimeter of the bay. The TRIGA control room is situated on this floor, and immediately adjacent to it is the observation room, which permits viewing reactor operations without interfering with the operators. A laboratory room is located at the northwest corner adjacent to the observation room. Also at this level are the isotope handling room and a platform and working area surrounding the top of the TRIGA pool.

3.4 Office and Laboratory Wing

3.4.1 General

The U-shaped office and laboratory wing houses a classroom, offices, utility rooms, and a number of laboratory rooms. In addition, the main personnel entrance to the entire Laboratory is at the front (north) of the building at the first floor level of this wing. Two emergency exits are located at the basement level of this wing, one at the southeast and one at the southwest corner; the latter is also a delivery entrance.

The east and west sections of the office and laboratory wing consist of a basement and one story. The north section has in addition a setback second story. A centrally located enclosed stairwell and an adjacent elevator interconnect the three floors.

For radiation safety purposes, all parts of the building except the classroom and first floor offices and service rooms are off-limits to unescorted visitors. The principal control point for entrance to the restricted area of the building is the stairwell door opposite the lobby (The other three entrances--elevator, ZPR laboratory door, and rear delivery door-- may be opened only with keys that will be issued only to authorized personnel).

3.4.2 Gamma Irradiation Cell

The gamma irradiation cell and associated setup room and cold work area form a block of three rooms at the basement level. Although the cell proper and the set-up room are physically located within the reactor complex to permit utilization of the 5-ton crane for loading and unloading materials in the cell, functionally they are part of the laboratory wing.

3.4.3 Basement Plan

The basement level of the office and laboratory wing houses (in addition to the cold work area) a corridor, a chemistry laboratory, a machine shop, two rooms for introductory laboratory courses, a darkroom, a counting room, a men's toilet, a general laboratory room, and the electrical and mechanical utility rooms. All of these rooms open off the corridor, which may also be used to reach an entrance to the reactor complex. Two subterranean rooms are attached to the west wall of the basement: one is the transformer vault, accessible only from a stairway outside the building, and the other is the waste storage tank room, which opens off the general laboratory room.

The chemistry laboratory includes two hoods with suitable filters for work with low-level radioactive chemicals in addition to standard chemical laboratory equipment and utilities.

3.4.4 First Floor Plan

The first floor level of the office and laboratory wing consists of the lobby, a classroom, an office for the Reactor Supervisor and a secretary-receptionist, three faculty laboratory-offices, a faculty office, an office for the University Health Physicist and the University Radiation Safety Officer, an electronics maintenance room, the ZPR laboratory, a pantry, storage rooms, and toilet rooms. The stairwell and elevator are directly across the corridor from the lobby.

The ZPR laboratory also opens into the ZPR control room in the reactor complex.

3.4.5 Second Floor Plan

On the second floor are six laboratory-office rooms opening off a corridor that also leads to a door into the reactor complex.

3.5 Utilities and Auxiliary Services

Conventional utility services normal to the operations of a laboratory of this nature are provided, together with the auxiliary services required for the reactors

and the gamma irradiation facility. Compressed air, combustion gas, water, and electricity are supplied to all laboratory rooms including those that have been designed for dual use as laboratory-offices. The compressor for the air is located in the mechanical utility room. Necessary outlets for standard laboratory services are provided in the experimental areas of the reactor complex. The water system includes water purification equipment for the reactor cores as well as equipment for temporary storage of contaminated water.

3.6 TRIGA Reactor

The Ward Center reactor is a 500-kilowatt TRIGA Mark II reactor. The reactor and reflector assembly are located at the bottom of a plastic coated concrete tank 25 feet deep. Approximately 20 feet of water above the core provides vertical shielding. The core is shielded radially by a minimum of 6 feet of ilmenite concrete (235 lb/ft3), 1.5 feet of water and 1.0 feet of graphite reflector.

There are several experimental and irradiation facilities associated with the TRIGA reactor. A graphite thermal column approximately 4 feet by 4 feet by 8 feet extends for the outer face of the reflector assembly into the concrete shield structure. A track-mounted heavy concrete door provides horizontal access and shielding for the thermal column. There are two nesting coaxial removable plugs or square cross section in the center of the thermal-column door. Vertical access to the thermal column is also provided. Inside the thermal column near the inner end are a 32-inch by 32-inch by 36-inch hohlraum block and a 24-inch by 24-inch by 28-inch removable graphite block. The pool, which is approximately 11 feet by 12 feet in cross section, permits access to the flattened face of the reflector. Seven beam ports are provided for beam experiments and for the insertion of specimens for irradiation: two 3-inch thermal beam ports, four 6-inch radial beam ports, and one 4-inch throughport. The centerlines of all beam ports are located in the same horizontal plane approximately 2-feet 10-inches above the pool and room floors, which are at the same elevation.

3.7 Relation of Ward Center to Other TRIGA reactors

The design of the Ward Center fuel is similar to those of approximately 50 TRIGA type reactors currently operating worldwide with 24 in the United States.

The reactor and associated equipment will be decommissioned by removal of the core, draining water from the vessel, and removing activated and contaminated materials from the reactor. Once this has been completed, the structure will be surveyed using a license termination type survey with any additional decontamination performed in conjunction with the surveys.

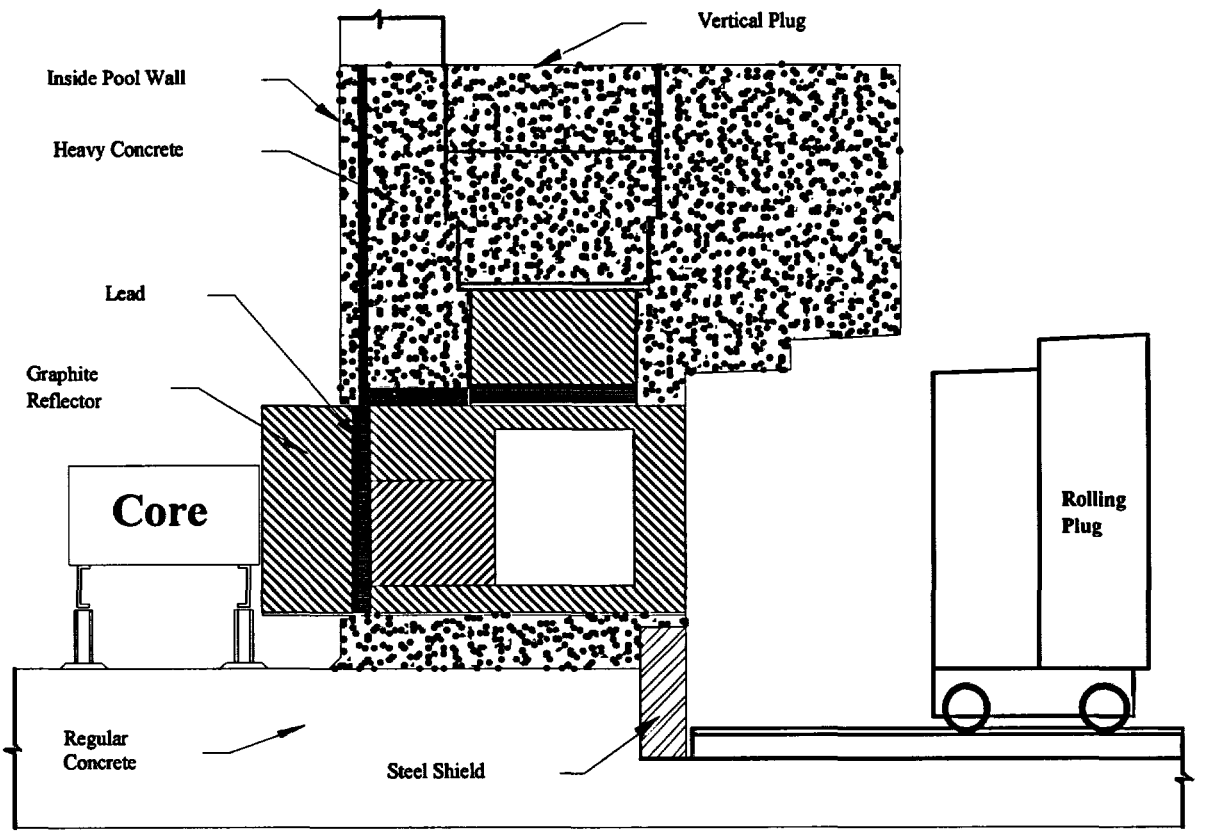
3.8 Outside Areas

There is no history of any spills of radioactive materials outside the identified building process areas. Based on current survey data, it is not anticipated that any soil remediation will be required. There is a discharge from the Reactor Building to the sanitary sewer system which runs near the building.

The natural surface drainage around the Ward Center site from roof drainage and storm run-off is routed to Cascadilla Creek by utilizing natural drainage and storm sewers.

The sanitary sewer and nearby storm sewers will be surveyed at locations just upstream and downstream locations relative to the Ward Center. In addition soil sampling, and license termination surveys of paved areas and unpaved areas will be performed in areas adjacent to the Ward Center in accordance with current regulatory requirements.

Figure 3-1 Ward Reactor Core and Thermal Column



4.0 ESTIMATION METHODS

The estimated cost to decommission the Ward Center is $3,603,086. This section of the cost estimate report provides an overview of the considerations and factors that influenced the decommissioning cost estimate. Table 4-1 provides a summary of the costs associated with each area of the facility.

Table 4-1: Decommissioning Cost Summary – Ward Center

Operation	Man-hours	Labor Plus Trav. & Liv.	Equipment, Contracts & Supplies	Radwaste Shipping & Disposal	Total Cost
TRIGA Reactor	746	$54,191	$27,775	$212,973	$294,939
TRIGA Bioshield & Beam Ports	5338	$424,827	$273,787	$741,581	$1,440,196
Reactor Bay	2374	$189,406	$52,730	$244,492	$486,628
Office & Laboratory Wing	926	$74,416	$16,941	$11,028	$102,384
Zero Power Reactor	128	$10,272	$2,338	$1,518	$14,128
Characterization Surveys	1040	$90,220	$4,274	$0	$94,494
Final Surveys	4160	$360,880	$17,097	$0	$377,977
Planning, Training, & Mobilization	272	$21,370	$0	$0	$21,370
Owner Oversight & Licensing	693	$50,353	$0	$0	$50,353
Totals	**15676**	**$1,275,934**	**$394,943**	**$1,211,592**	**$2,882,469**
			25% CONTINGENCY		**$720,617**
				GRAND TOTAL	**$3,603,086**

4.1 Cost Modifying Factors

There are modifying factors that significantly affect the overall cost for remediation. One of these factors is an adjustment for productivity related to personnel protection requirements and working temperatures. The degree of protection required depends upon the extent of contamination and specific activities to be performed in a given area. As the level of personnel protection increases, so does the impact on individual productivity and task duration. Adjustments were made to account for the implementation of personnel protective measures where applicable. This estimate used the standardized levels of

personnel protection described in Table 4-2. The Productivity Factors related to these levels of personnel protection are provided in Table 4-3 for Light Work and in Table 4-4 for Heavy Work.

Table 4-2 : Personnel Protective Equipment Protection Summary

Level A:	The highest available level of respiratory, skin, and eye protection
Level B:	The highest level of respiratory protection, but less skin protection than Level A. Level B is the minimum level recommended for initial site entries, or for other entry conditions dealing with unknown hazards.
Level C:	The same level of skin protection as Level B, but a lower level of respiratory protection.
Level D Modified:	Skin protection similar to or the same as Level C, without respiratory protection.
Level D:	Standard work uniform suitable for construction work: no respiratory protection and minimal skin protection.

Table 4-3: Hazardous and Toxic Waste Productivity Factors: Light Work

Variables	U/M	Level A			Level B			Level C			Level D Modified			Level D		
		T<70	70<T	T>85	T<70	70<T	T>85	T<70	70<T	T>85	T<70	70<T	T>85	T<70	70<T	T>85
A. Standard losses	Min.	160	160	160	140	140	140	128	128	128	76	76	76	32	32	32
B. Scheduled/heat stress breaks	Min.	60	90	120	43	65	86	35	63	101	30	47	63	30	33	44
C. Dexterity losses	Min.	78	69	60	74	69	64	55	51	44	4	4	3	5	5	5
D. Total time lost per 8-hr. WD	Min.	298	319	340	257	274	290	218	242	273	110	127	142	67	70	81
E. Productivity time per 8-hr. WD	Min.	182	161	140	223	206	191	262	238	207	370	353	338	413	410	399
F. Productivity time on clean site	Min.	430	430	430	430	430	430	430	430	430	430	430	430	430	430	430
G. HTW Productivity Factor		**0.42**	**0.37**	**0.33**	**0.52**	**0.48**	**0.44**	**0.61**	**0.55**	**0.48**	**0.86**	**0.82**	**0.79**	**0.96**	**0.95**	**0.93**

Notes:

- Standard delays account for all time losses independent of temperature variations. They include safety meetings, instructions, putting on and taking off of PPE, decontamination, switching air supply/filters, monitoring delays, and cleanup.
- Scheduled/heat stress breaks account for all paid rest periods per workday.
- Dexterity losses are based on subjective opinions of the percentage that PPE slows down a normal worker because of factors such as discomfort, clumsiness, weight, and restricted breathing and communication. The number of minutes actually worked is reduced by the percentage representing the average response for that particular PPE level.
- Values for A, B, and C were derived by averaging the survey responses for each PPE level. Responses that varied greatly from the average were subject to omission at the author's discretion.
- Total paid time = 480 minutes.
- 50-minute delay on clean site = 10-minute safety meeting and instructions + 10-minute cleanup + 30-minute breaks.
- Calculations:
  - D= A + B + C
  - E = 480 - D
  - F = 480 - 50
  - G = E/F
  - U/M = unit of measure
  - WD = workday
  - Min. = minutes
  - T = temperature (Fahrenheit)

Level A-protection is used in extreme emergency situations only. Productivity factors for Level A should be used with caution because they were extrapolated from 2 data points.

Table 4-4: Hazardous and Toxic Waste Productivity Factors: Heavy Work

Variables	U/M	Level A			Level B			Level C			Level D Modified			Level D		
		T<70	70<T	T>85	T<70	70<T	T>85	T<70	70<T	T>85	T<70	70<T	T>85	T<70	70<T	T>85
A. Standard losses	Min.	220	220	220	204	204	204	135	135	135	76	76	76	28	28	28
B. Scheduled/heat stress breaks	Min.	60	105	150	50	75	123	64	131	178	30	90	165	30	45	60
C. Dexterity losses	Min.	80	62	44	52	46	35	44	34	26	28	24	18	11	10	10
D. Total time lost per 8-hr. WD	Min.	360	387	414	306	325	362	243	300	339	134	190	259	69	83	98
E. Productivity time per 8-hr. WD	Min.	120	93	66	174	155	118	237	180	141	346	290	221	411	397	382
F. Productivity time on clean site	Min.	430	430	430	430	430	430	430	430	430	430	430	430	430	430	430
G. HTW Productivity Factor		**0.28**	**0.22**	**0.15**	**0.40**	**0.36**	**0.27**	**0.55**	**0.42**	**0.33**	**0.80**	**0.68**	**0.51**	**0.96**	**0.92**	**0.89**

Notes:

- Standard delays account for all time losses independent of temperature variations. They include safety meetings, instructions, putting on and taking off of PPE, decontamination, switching air supply/filters, monitoring delays, and cleanup.
- Scheduled/heat stress breaks account for all paid rest periods per workday.
- Dexterity losses are based on subjective opinions of the percentage that PPE slows down a normal worker because of factors such as discomfort, clumsiness, weight, and restricted breathing and communication. The number of minutes actually worked is reduced by the percentage representing the average response for that particular PPE level.
- Values for A, B, and C were derived by averaging the survey responses for each PPE level. Responses that varied greatly from the average were subject to omission at the author's discretion.
- Total paid time = 480 minutes.
- 50-minute delay on clean site = 10-minute safety meeting and instructions + 10-minute cleanup + 30-minute breaks.
- Calculations:
  - D= A + B + C
  - E = 480 - D
  - F = 480 - 50
  - G = E/F
  - U/M = unit of measure
  - WD = workday
  - Min. = minutes
  - T = temperature (Fahrenheit)
- Level A-protection is used in extreme emergency situations only. Productivity factors for Level A should be used with caution because they were extrapolated from 2 data points.

4.2 Radioactive Waste Volume Estimates

The volume of radioactive waste requiring treatment and disposal can be a very significant modifying factor due to the high cost for radwaste disposal. For the Ward Center decommissioning, the cost for radioactive waste processing, shipping, and disposal is anticipated to be about 40% of the total decommissioning cost. This is a normal fraction for radioactive facilities. Radioactive waste volume estimates are discussed in the following section. Table 4-5 provides a volume summary for each area of the Ward Center. Information about most waste items are provided in Appendix A-12.

Table 4-5: Ward Center Unprocessed Radioactive Waste Summary

Area Description	Direct Barnwell Disposal Volume (ft^3)	Generated Envirocare Disposal Volume (ft^3)	Decon Envirocare Disposal Volume (ft^3)	Direct Envirocare Disposal Volume (ft^3)	Total Disposal Volume (ft^3)
TRIGA Reactor	120	4	0	25	149
TRIGA Bioshield & Beam ports	24	29	0	3,294	3,347
Reactor bay	0	12	0	1,146	1,158
Office & Laboratory Wing	0	31	21	0	52
Zero Power Reactor	0	4	1	2	7
TOTALS	**144**	**80**	**22**	**4,467**	**4,714**

4.3 Radioactive Waste Disposal Costs

A significant portion of the overall decommissioning cost is generally attributed to the burial of radioactive waste. This estimate includes waste processing at Duratek followed by disposal at Envirocare of Utah and direct radioactive waste disposal at Envirocare of Utah and Barnwell, South Carolina. The following sections describe the pricing for each facility.

4.3.1 Envirocare of Utah Disposal Costs

The costs to transport waste to the Envirocare of Utah disposal site are based on a transport distance of 2,180 miles, at a rate of $2.36 per mile. The cost to dispose of the waste at the Envirocare of Utah site are based on a disposal fee of $189.91 per cubic foot.

4.3.2 Barnwell South Carolina Disposal Costs

The costs to transport waste to the Barnwell South Carolina disposal site are based on a transport distance of 897 miles, at a rate of $2.36 per mile. The cost to dispose of the waste at the Barnwell site is based on an average disposal fee of $1,680 per cubic foot for radioactive hardware.

4.3.3 Duratek Processing/Burial Costs

The cost to transport waste to the Duratek central volume reduction facility in Oak Ridge Tennessee are based on a transport distance of 762 miles at a rate of $2.36 per mile. Waste processing at the Duratek central volume reduction facility was not included in this estimate because there was not a significant cost advantage to waste processing.

Typical unit disposal cost factors are listed in Appendix A-3.

4.4 Remediation Methods

The goal in choosing remediation methods is to select the minimum cost option to accomplish a task. There are many factors which need to be considered when selecting a method such as contamination levels, degree of penetration of contamination into substrate material, equipment cost, support equipment costs, material and chemical costs, the generation of secondary waste volumes (waste in addition to the removed contaminated material), processing rates, labor requirements, and applicability to various tasks. Typical decontamination processes are summarized in Table 4-6. For each decontamination method, this table shows application information, the process cost per square foot of area decontaminated, and the amount of secondary waste generated. These unit factors are applied to specific areas or equipment requiring remediation to determine the most cost-effective process.

Table 4-6: Decontamination Methodology Comparison

Methodology	Application	Penetration depth (in)	Crew Size	Process Cost ($/ft²)	Secondary Waste Volume (ft³/1000 ft²)
McDonald U-5 Scabbler	Floor concrete	1/4	2.0	$0.98	0
McDonald U-5 Scabbler	Floor concrete	1/2	2.0	$1.86	0
McDonald 3WCD Scabbler	Wall concrete	1/8	2.0	$4.45	0
Blastrac 10D Shot Blaster	Floor concrete	1/16	1.1	$0.43	0.53
Blastrac 10D Shot Blaster	Floor concrete	1/8	1.1	$0.54	0.53
LTC 10-60Pn Special Vacuum Blaster	All surfaces	1/32	1.3	$1.71	0.53
LTC 10-60Pn Special Vacuum Blaster	All surfaces	1/16	1.3	$3.08	0.53
EDCO CPU-10C Floor Plane	Floor concrete	1/2	2.0	$1.62	0
CO2 Blasting	All Surfaces	0	2.0	$4.52	0
Hydrolaser (5-10,000 psi)	All Surfaces	0	2.0	$0.91	9.07
Hands-On-Decon	Non-Porous surfaces	0	1.0	$2.01	8.33

4.5 Radioactive Waste Volume Reduction Costs

The volume reduction processes analyzed for use are summarized in Table 4-7. For each volume reduction method, this table shows application information, transportation container type, and the total process cost per unit weight. These unit factors are applied to specific items of equipment requiring disposal to determine the most cost-effective process. The radioactive waste generated at this facility will include irradiated hardware, activated concrete, HEPA ventilation systems, fume hoods, steel, lead, and secondary waste generated during the decontamination work such as protective clothing and materials used during manual decontamination work.

Table 4-7: Volume Reduction Methodology Cost Information

VR Methodology	Applicability	Transport Container Type	Total VR Cost ($/lb)
Super Compaction	Dry active waste 20 lb/ft^3	B-25 for Envirocare Disposal	$5.59
Incidental Lead Decontamination	Bricks and Sheet	Custom Box	$7.25
Survey & Release Low Density Drums	Low Density Waste	55 Gal Drum	$1.45
Survey & Release Medium Density Boxes	Waste at greater than 20 7< 60 lb/ft^3	B-25 Box	$0.66
Survey & Release High Density Boxes	Waste at greater than 60 lb/ft^3	B-25 Box	$0.52

4.6 Unit Costs

A number of unit factors were used to generate this cost estimate. The main unit factors are listed in Table 4-8 so project costs can be updated when required and the effects of changing unit costs can be evaluated.

Table 4-8: Decommissioning Cost Estimate Selected Unit Cost Factors

Unit Cost Factor	Unit Cost Rate	Units
Radioactive Soil and Rubble Disposal at Envirocare of Utah	$189.81	cubic foot
Waste Transportation to Envirocare of Utah	$2.36	mile
Transportation Distance to Envirocare of Utah	2,180	miles
B-25 Waste Disposal Container Cost	$843.75	each
Management and Supervision	$116.50	hour
Engineer	$97.08	hour
Radiation Protection Supervisor	$101.94	hour
Laborer Foreman	$44.54	hour
Administrative Assistant	$42.00	hour
Instrument Technician	$66.00	hour
Radiation Protection Technician	$66.00	hour
Laborer	$40.95	hour
Fee	20%	

4.7 Final Surveys

Final survey costs are estimated based on the facility radiation survey information presented in NUREG-1757, *MNSS Decommissioning Standard Review Plan* (Ref. 6-11). The number of sample points for the various areas being surveyed and the type of survey being performed were determined. The time to perform each of these surveys is estimated, and the product of these two items is the labor time to perform the surveys. Equipment and material cost to perform the surveys is added along with staff support costs to determine a total cost. The survey requirements are based on NUREG-1575, *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM) Ref. 6-10). A spreadsheet was developed which incorporates facility dimensions, labor rates and support cost ratios to estimate the final survey cost. The facility survey labor estimate is summarized in Appendix A-6 and the open land and miscellaneous area survey labor estimate is summarized in Appendix A-7.

5.0 FACILITIES, RADIOLOGICAL CONDITIONS AND DECOMMISSIONING SCENARIO

Decommissioning of the Ward Center requires that residual radioactive materials be removed from the site to allow removal of the decommissioned facilities from the NRC license. For the purposes of this cost estimate, the end of the decommissioning project occurs when the Ward Center has been remediated to release limits, the Final Status Survey has been performed, documented and submitted to the NRC.

5.1 Remediation Summary

Remediation will be required for the Ward Center, it is not anticipated that remediation in sewers and outdoor areas will be required. The following is a brief summary of the anticipated remediation activities, with applicable assumptions and bases. The remediation activities are summarized in Table 5-1 below. Additional facility information, radiological information, and decommissioning plans are presented in greater detail in the document sections that follow.

Table 5-1: Ward Center Planned Remediation Activities

Building or Area	Remediation Activities
General Area	Perform a general facility clean up to remove all incidental equipment and materials, both radioactive and non-radioactive.
TRIGA Reactor	Empty water from reactor tank. Remove activated reactor core and vessel internals and reactor vessel. Cut out activated concrete (5-ft thick layer) from bioshield monolith surrounding reactor tank and disposal as radioactive waste.
Beam Tubes	Remove activated beam tubes including shields. Cut out a 1-foot thickness of activated concrete surrounding beam tubes.
First and Second Floors	Remove contaminated portions of HEPA and HVAC systems. Remove demineralizer system and heat exchanger. Remove contaminated portions of the rabbit system and fume hoods.
Reactor complex	Perform a general area clean up and remove all contaminated equipment and materials.
Office Areas & Labs	Perform a general area clean up and remove all contaminated equipment and materials.
ZPR Reactor	Remove contaminated filter and ion exchange column.

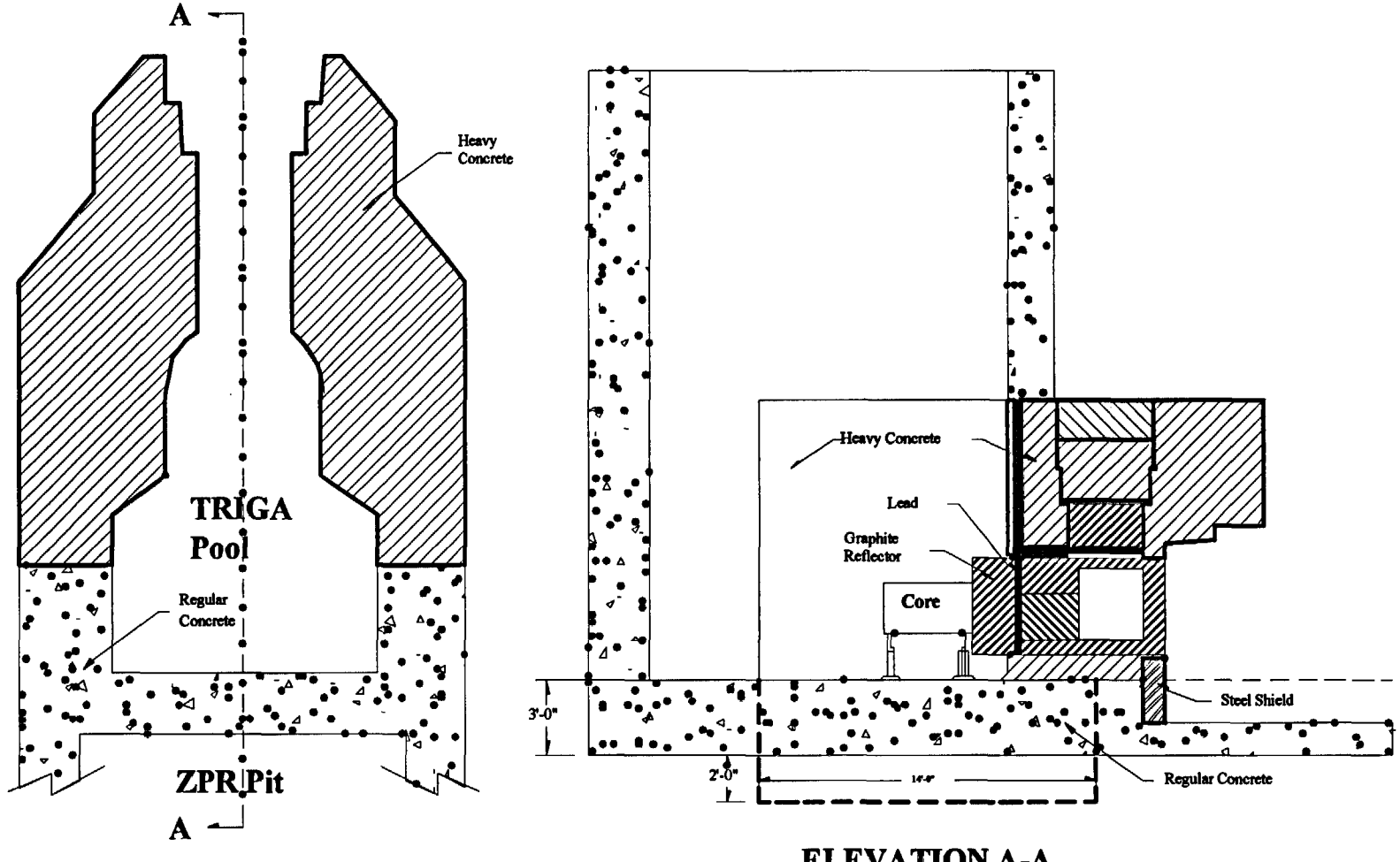
5.1.1 TRIGA Reactor

- The reactor core, core stand, reflector, fuel rack and other items inside the reactor pool will be removed and shipped for disposal.
- The reactor pool will be emptied and the reactor pool surface decontaminated to eliminated easily removable radioactive material.

5.1.2 TRIGA Bioshield & Beamports

- The thermal column will be removed for disposal.
- The beam port plugs will be removed for disposal.
- The activated concrete in the bioshield concrete monolith surrounding the reactor core will be removed (Figure 5-1). It was estimated that all the high density concrete would require removal plus 3-feet of regular concrete under the pool and up to 2-feet of rock under the pool in some areas. An activation analysis performed by Georgia Tech and reported in Appendix C of the "Characterization Survey Report" (Ref. 6-8) indicates the concrete removal required. In general about five feet of concrete surrounding the core will be removed.
- The activated beam tubes including shields will be removed including removal of a 1-foot thickness of activated concrete surrounding beam tubes. All the beam tubes are in the high density concrete that is being removed anyway.

Figure 5-1 Ward Center Activated Concrete



5.1.3 Reactor complex

There are several different types of areas to be decommissioned in the Reactor Building. The activities for the major areas are outlined below:

- There will be a general area cleanup to remove all unnecessary materials from the facility prior to decontamination and demolition.
- All other process equipment will be removed and shipped directly for disposal as radioactive waste. This includes the heat exchanger, ion exchange system, and recirculation pumps, piping, drain piping and rabbit system, etc.
- Equipment and materials in the hoods on the upper level will be removed and shipped directly for disposal as radioactive waste. The hoods will be decontaminated, removed from the facility, surveyed for free release and disposed of as salvage or clean waste.
- The floor surfaces and structural surfaces are assumed to be free of contamination. The ventilation systems will be surveyed, decontaminated if required and released for disposal as salvage, or disposal as clean waste. The HEPA filters will be removed from the ventilation system, surveyed, decontaminated if required and released for disposal as clean waste.
- The reactor tank concrete remaining after activated concrete removal will be surveyed for free release. This concrete will then be left in place.

5.1.4 Office and Laboratory Wing

- The offices and laboratories and miscellaneous equipment will be surveyed in place for release.

5.1.5 ZPR Reactor

- The contaminated filter and ion exchange column will be removed and disposed of a radioactive waste. The remainder of the ZPR will be surveyed in place for release.

5.1.6 Outdoor Areas

- The sanitary and storm sewers will be surveyed at accessible areas and released for continued use. In addition, soil sampling, and license termination surveys of paved areas and unpaved areas around the Reactor Building will be performed in accordance with current regulatory requirements.

5.2 License Termination Surveys

License termination surveys, or final radiation surveys, will be performed in the applicable areas of the site using the guidance provided in NUREG-1575, *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM), (Ref. 6-10). The surveys will be performed in accordance with specifically developed plans and procedures.

5.2.1 Survey Instrumentation

Selection and use of instrumentation will ensure sensitivities are sufficient to detect the identified nuclides at the minimum detection requirements. A list of typical final survey instrumentation, radiation detected, and calibration sources are provided in Table 5-2.

Table 5-2: Typical Final Survey Instrumentation

Instrument/Detector	Detector Type	Radiation Detected	Calibration Source	Use
Ludlum Model 2350 wt. 43-68, 43-98, 43-94 or 43-106 detector	Gas-flow proportional ($126cm^2$)	Alpha or beta	^{99}Tc (β) ^{230}Th (α)	Direct alpha and direct beta surveys; Beta scans on solid surfaces.
Ludlum Model 2350/ SP-113-3m or SP-175-3m	GM Pipe Detector	Alpha or beta	^{99}Tc (β) ^{230}Th (α)	Direct beta pipe survey.
Ludlum Model 2350 wt. 44-40 detector	Shielded GM ($15.5cm^2$)	Beta	^{99}Tc (β)	Direct beta surveys; Beta scans on solid surfaces.
Ludlum Model 2350 wt. 44-2 or 44-10 detector	NaI (Tl) Scintillator	Gamma	^{137}Cs	Gamma exposure rate and gamma scans.
Eberline Teletector Model 6112B	Ion Chamber	Gamma	^{60}Co (γ)	Gamma exposure rate
Eberline SAC-4 Scaler Counter	ZnS scintillator	Alpha	^{230}Th (α)	Smear counting
Eberline BC-4 Scaler Counter	Shielded GM	Beta	^{99}Tc (β)	Smear counting
Tennelec Planchette Counter or Equal	Shielded Gas-flow proportional	Alpha and Beta	^{99}Tc (β), ^{230}Th (α)	Smear counting
EG&G NOMAD Gamma Spectrometer or Equal	HPGe	Gamma energy and intensity	Mixed gamma	Nuclide identification and quantification of soil and sand samples.

6.0 REFERENCES

6.1 10 CFR 50.82 *Termination of License*, part (b) *for Non-Power Reactor Licensees*

6.2 10 CFR 20 Subpart E – Radiological Criteria for License Termination

6.3 NUREG 1537, Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors, February 1996

6.4 R.A. Means Company, Inc., 2003, Means Building Construction Cost Data, 2001, 61st Annual Edition

6.5 NUREG/CR-1756, Technology Safety and Costs of Decommissioning Reference Nuclear Research and Test Reactors, March 1982

6.6 Final Safeguards Report to the U.S. Atomic Energy Commission for the Cornell University TRIGA Reactor, May 1961

6.7 Supplement No. 1 to the Final Safeguards Report to the U.S. Atomic Energy Commission for the Cornell University TRIGA Reactor, September 1980

6.8 Characterization Survey Report for the Ward Center for Nuclear Studies at Cornell University, Facilities Inventory Bldg. No. 2061, March 2003

6.9 10 CFR 20.1402 Radiological Criteria for Unrestricted Use

6.10 USEPA, 2000, U.S. NRC, U.S. DOE, and U.S. DOD, Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), Revision 1, NUREG-1575, EPA 402-R-97-016

6.11 NUREG-1757, Consolidated NMSS Decommissioning Guidance, Decommissioning Process for Materials Licenses, September 2002

APPENDIX A- 1 Contaminated Waste Volume Summary

APENDIX A-1
CONTAMINATED WASTE VOLUME SUMMARY

CODE	Area Description AREA	Decon* Barnwell Waste Volume (ft^3)	Barnwell Direct Bury Waste Volume (ft^3)	Generated* Envirocare Waste Volume (ft^3)	Decon* Envirocare Waste Volume (ft^3)	Envirocare Direct Bury Waste Volume (ft^3)	Total Waste Volume (ft^3)
1	TRIGA Reactor	0	120	4	0	25	149
2	TRIGA Bioshield & Beam Ports	0	24	29	0	3,294	3,347
3	Reactor Bay	0	0	12	0	1,146	1,158
4	Office & Laboratory Wing	0	0	31	21	0	52
5	Zero Power Reactor	0	0	4	1	2	7
	TOTALS:	**0**	**144**	**80**	**22**	**4,467**	**4,714**

* Notes:

1 Decon Waste Volume: This is the volume of waste generated directly by a decontamination

2 Generated Waste Volume: This is the volume of protective clothing waste generated by all operations on site and is a function of labor hours for each activity.

APPENDIX A- 2 Contaminated Waste Disposal Cost

APENDIX A-2
CONTAMINATED WASTE DISPOSAL COST

	Area Description	Decon Barnwell Disposal Cost	Barnwell Direct Bury Disposal Cost	Generated Envirocare Disposal Cost	Decon Envirocare Disposal Cost	Envirocare Direct Bury Disposal Cost	Total Waste Disposal Cost
1	TRIGA Reactor	$0	$201,768	$733	$0	$5,182	$207,683
2	TRIGA Bioshield & Beam Ports	$0	$40,068	$6,037	$0	$675,878	$721,982
3	Reactor Bay	$0	$0	$2,561	$0	$235,126	$237,686
4	Office & Laboratory Wing	$0	$0	$6,370	$4,351	$0	$10,721
5	Zero Power Reactor	$0	$0	$804	$261	$410	$1,476
	TOTALS:	$0	$241,836	$16,505	$4,612	$916,596	$1,179,548

Note: 1. Shading indicates a named field linked to another spreadsheet.
2. Direct burial & generated waste shipped to Barnwell.

WASTE DISPOSAL PACKAGING & SHIPPING COST

	Area Description	Decon Barnwell Pack & Ship Cost	Barnwell Direct Bury Pack & Ship Cost	Generated Envirocare Pack & Ship Cost	Decon Envirocare Pack & Ship Cost	Envirocare Direct Bury Pack & Ship Cost	Total Waste Pack & Ship Cost
1	TRIGA Reactor	$0	$235	$17	$0	$120	$373
2	TRIGA Bioshield & Beam Ports	$0	$47	$140	$0	$15,707	$15,894
3	Reactor Bay	$0	$0	$60	$0	$5,464	$5,524
4	Office & Laboratory Wing	$0	$0	$148	$101	$0	$249
5	Zero Power Reactor	$0	$0	$19	$6	$10	$34
	TOTALS:	$0	$282	$384	$107	$21,301	$22,074

*Notes:
1 Shading indicates a named field linked to another spreadsheet.
2
B-25 Box of waste to Barnwell equal to: **$2,119**

APPENDIX A- 3 Waste Shipping Container Cost

APENDIX A-3
WASTE SHIPPING CONTAINER COST

	Area Description	Total Waste Volume (ft^3)	B-25* Waste Containers (Ea.)	Waste Container Cost ($)
1	TRIGA Reactor	149	1.7	$1,395
2	TRIGA Bioshield & Beam Ports	3,347	37.2	$31,378
3	Reactor Bay	1,158	12.9	$10,859
4	Office & Laboratory Wing	52	0.6	$490
5	Zero Power Reactor	7	0.1	$67
	TOTALS:	**4,714**	**53**	**$44,719**

* Notes:

1 The number of waste containers is rounded up to next full container.

UNIT DISPOSAL COST FACTORS

Decon waste disposal rate forBarnwell :	$1,681.40	per cubic foot
DAW waste disposal rate for Barnwell :	$1,681.40	per cubic foot
DAW waste disposal rate for Envirocare :	$189.81	per cubic foot
Estimated mileage rate to Barnwell :	$2.36	per mile
Estimated transport distance to Barnwell :	762	miles
Estimated mileage rate to Envirocare :	$2.36	per mile
Estimated transport distance to Envirocare :	2,180	miles
Average direct bury waste density :	160.0	lb/cubic foot
Average generated waste density (Envirocare waste) :	25	lb/cubic foot
Truck transport waste weight limit :	44,000	pounds
Truck transport waste volume limit :	12	B-25 Boxes
B-25 box internal volume :	90	cubic feet
Estimated cost of used B-25 shipping containers :	$843.75	each
Local Industrial Waste Landfill Shipping & Disposal Rate :	$27.30	per cubic yard
Labor rate for shipping :	$66.00	per hour

APPENDIX A- 4 Waste Disposal Labor Estimate

APENDIX A-4
WASTE DISPOSAL SUPPORT LABOR ESTIMATE

	Area Description	B-25 Waste Containers (Ea.)	Radioactive* Waste Shipments (Ea.)	Waste* Shipment Labor (man-hr)
1	TRIGA Reactor	1.7	0.1	2.5
2	TRIGA Bioshield & Beam Ports	37.2	3.1	56.1
3	Reactor Bay	12.9	1.1	19.4
4	Office & Laboratory Wing	0.6	0.0	0.9
5	Zero Power Reactor	0.1	0.0	0.1
	TOTALS:	53.0	5.0	80.0

Note 1 The number of waste shipments is rounded up to next full shipment.

Estimated waste loading operator time :	4 hr per load
Estimated HP Tech time per rad or mixed waste load :	4 hr per load
Estimated HP shipper time per rad or mixed waste load :	8 hr per load
Estimated clean waste shipping volume limit :	1176 ft^3 per load
Estimated radwaste shipping volume limit :	12 B-25 Boxes

WASTE DISPOSAL CASK COSTS

	Area Description	Liners & Cask Rental (Ea.)	Radioactive* Cask Rental Cost	Waste* Shipment Labor (man-hr)
1	TRIGA Reactor	2	$14,400	72
2	TRIGA Bioshield & Beam Ports		0.0	0
3	Reactor Bay		0.0	0
4	Office & Laboratory Wing		0.0	0
5	Zero Power Reactor		0.0	0
	TOTALS:	2.0	$14,400	72

* Notes:

1 The number of waste shipments is rounded up to next full shipment.

APPENDIX A- 5 Contaminated Waste Disposal Summary

APENDIX A-5
CONTAMINATED WASTE DISPOSAL SUMMARY

0

LOC CODE	Total Waste Volume (ft^3)	B-25* Waste Containers (ea.)	Waste* Container Cost ($)	Radioactive* Waste Shipments (ea.)	Waste* Shipment Labor (man-hr)	Waste* Shipment Labor Cost
1	149	1.7	$15,795	2.1	74.5	$4,917
2	3,347	37.2	$31,378	3.1	56.1	$3,705
3	1,158	12.9	$10,859	1.1	19.4	$1,282
4	52	0.6	$490	0.0	0.9	$58
5	7	0.1	$67	0.0	0.1	$8
Total	**4,714**	**53.0**	**$58,590**	**7.0**	**151.1**	**$9,970**

* Notes:

1 The number of waste containers are rounded up to next full container.

2 The number of waste shipments are rounded up to next full shipment.

APPENDIX A- 6 Building Survey Labor Summary

APPENDIX A-6

NON-IMPACTED BUILDING AREA SURVEY

ENTER BELOW OPTNL LOC CODE	ENTER BUILDING NAME BELOW	ENTER ROOM NUMBER BELOW	ENTER AREA DESCRIPTION BELOW	SURVEY PACKAGE REQRD ? (Y/N)	ENTER AREA WIDTH BELOW (ft)	ENTER AREA LENGTH BELOW (ft)	ENTER AREA HEIGHT BELOW (ft)	ENTER FLOOR + L. WALL SURVEY CODE	ENTER U. WALL + CEILING SURVEY CODE	ENTER Survey Sketchs (each)	SURVEY PACKAGE PREP (hrs)	DIRECT SURVEY LABOR (hrs)
4	Ward Center	Exterior	Exterior	Y	100.4	124.0	40.0	2	5	5	8	24.4
TOTALS											8	24

APPENDIX A-6

IMPACTED BUILDING AREA SURVEY

2	Reactor Bioshield	Exterior	Exterior	Y	22.0	27.5	22.0	2	5	3	8	42
4	Gamma Cell	Exterior	Exterior	Y	12.5	16.0	16.0	1	4	2	8	22
4	Basement	4	Introductory Laboratory No. 1	Y	15.33	24.7	13.0	1	4		8	24
4	Basement	1	Introductory Laboratory No. 2	N	15.33	21.0	13.0	1	4			15
4	Basement	3	Dark Room	N	6.00	15.3	13.0	1	4			10
4	Basement	5	Counting Room	N	15.33	16.0	13.0	1	4			14
4	Basement	Hall #1	Corridor No. 1	Y	6.00	83.0	13.0	1	4		8	34
4	Basement	6	Machine Shop	Y	19.33	23.3	13.0	1	4		8	26
4	Basement	6-Hall	Hallway near Room 6	N	5.00	11.00	13.0	1	4			9
4	Basement	8	Chemistry Laboratory	N	25.00	32.33	13.0	1	4			24
4	Basement	2A	Cold Work Area	Y	11.33	18.7	16.5	1	5		8	24
4	Basement	2-Hall	Hallway near Room 2	N	5.33	13.3	13.0	1	4			10
4	Basement	2B	Set-Up Room	N	10.75	13.0	13.0	1	4			11
4	Basement	2C	Gamma Cell	Y	9.00	9.0	9.0	1	5		8	20
4	Basement	ELEV	Elevator Shaft	N	6.00	6.0	41.8	3	6			17
4	Basement	Stair #1	Stairway No. 1	N	8.83	13.3	14.0	2	5			16
4	Basement	13-Hall	Hallway near Room 13	N	6.00	10.0	13.0	1	4			9
4	Basement	13	Men's Toilet No. 1	N	11.33	18.7	9.0	1	4			13
4	Basement	R12	Isotope & Fuel Storage Room	Y	8.00	19.8	13.0	1	4		8	20
4	Basement	R3	Reactor Equipment Room	Y	16.17	19.8	14.0	1	4		8	23
4	Basement	R3-Hall	Hallway near Room R3	N	5.25	25.5	13.0	1	4			12
4	Basement		Containment Area	Y	48.00	70.0	45.6	1	6		8	135
5	Basement		ZPR Pit	Y	13.50	14.0	20.0	3	6		8	32
2	Basement		SPR Pool	Y	11.00	11.5	25.0	3	6		8	29
4	Basement	7	Laboratory	Y	18.33	18.3	13.0	1	4		8	23
4	Basement	7-Hall	Hallway near Room 7	N	6.00	39.0	13.0	1	4			16
4	Basement	9	Electrical Utility Room	Y	10.00	16.8	13.0	1	4		8	20
4	Basement	11	Mechanical Utility Room	Y	14.33	18.1	13.0	1	4		8	22
4	Basement	15	Waste Hold-Up Tank Room	Y	12.00	16.0	10.0	1	4		8	20
4	Basement	17	Transformer Vault	N	12.00	21.0	9.0	1	4			14
4	Basement	Stair #5	Stairway No. 5	N	4.00	6.0	5.0	2	5			12
4	1st Floor	106	Staff Office	Y	11.17	15.3	9.0	1	4		8	20
4	1st Floor	102	Supervisors Office	N	15.30	15.5	9.0	1	4			13
4	1st Floor	100	Lobby	N	12.83	15.3	9.0	1	4			12
4	1st Floor	101	HP Office	Y	11.92	15.3	9.0	1	4		8	20
4	1st Floor	105	Staff Lab-Office No. 1	N	14.75	15.3	9.0	1	4			13
4	1st Floor	Hall #2	Corridor No. 2	N	6.00	72.0	9.0	1	4			23
4	1st Floor	112	Staff Lab-Office No. 2	Y	12.17	18.3	9.0	1	4		8	21
4	1st Floor	112-Hall	Hallway near Room 112	N	6.00	24.5	9.0	1	4			12
4	1st Floor	116	Staff Lab-Office No. 3	N	11.50	18.3	9.0	1	4			13
4	1st Floor	118	Class, Conference & Seminar	N	25.00	31.9	9.0	1	4			24

APPENDIX A-6

IMPACTED BUILDING AREA SURVEY

4	1st Floor	110	Janitors Closet	N	3.00	4.0	9.0	1	4		8
4	1st Floor	114	Pantry	N	4.00	8.0	9.0	1	4		8
4	1st Floor	108	Women's Toilet	Y	10.00	11.3	9.0	1	4	8	18
4	1st Floor	104	Stock & Storage Room No. 1	Y	7.83	11.3	9.0	1	4	8	18
4	1st Floor	ELEV	Elevator Car	Y	4.00	5.0	7.0	1	4	8	16
4	1st Floor	Stair #1	Stairway No. 1	N	8.83	13.3	11.0	2	5		16
4	1st Floor	103	Stock & Storage Room No. 2	Y	7.83	11.3	11.0	1	4	8	18
4	1st Floor	107	Men's Toilet No. 2	N	11.33	13.7	11.0	1	4		11
4	1st Floor	109	Electronics Room	N	12.33	18.3	11.0	1	4		13
4	1st Floor	109-Hall	Hallway near Room 109	N	6.00	13.0	11.0	1	4		10
5	1st Floor	111	ZPR Laboratory	Y	25.00	31.0	11.0	1	4	8	32
5	1st Floor	113	ZPR Control Room	N	18.50	24.0	9.0	1	4		18
5	1st Floor	115	Closet	N	3.00	5.8	9.0	1	4		8
5	1st Floor	117	ZPR Entry Hall	N	5.25	17.5	11.0	1	4		10
5	1st Floor		ZPR Storage Area	Y	12.00	13.3	11.0	1	4	8	20
5	1st Floor		ZPR Tank Area	N	13.50	14.0	11.0	2	5		18
4	1st Floor	Stair #3	Stairway No. 3, Lower	Y	6.00	10.6	7.0	1	4	8	17
4	1st Floor	Stair #3	Stairway No. 3, Platform	N	2.75	26.5	2.0	1	4		12
4	1st Floor	Stair #3	Stairway No. 3, Upper	N	2.75	6.5	4.0	1	4		8
4	1st Floor	Stair #2	Stairway No. 2	N	6.00	10.5	11.0	1	4		9
4	2nd Floor	204	Lab-Office No. 2	Y	12.50	15.3	11.0	1	4	8	20
4	2nd Floor	202	Lab-Office No. 3	N	12.50	13.8	11.0	1	4		12
4	2nd Floor	201	Lab-Office No. 4	N	10.19	12.5	11.0	1	4		11
4	2nd Floor	203	Lab-Office No. 5	N	12.50	15.3	11.0	1	4		12
4	2nd Floor	206	Lab-Office No. 1	N	14.17	16.3	11.0	1	4		13
4	2nd Floor	Hall #3	Corridor No. 3	Y	5.00	27.5	11.0	1	4	8	20
4	2nd Floor	Stair #1	Stairway No. 1	N	8.83	13.3	2.0	1	4		11
4	2nd Floor	205	Lab-Office No. 6	Y	11.33	14.2	11.0	1	4	8	20
4	2nd Floor	205-Hall	Hallway near Room 205	N	5.00	14.2	11.0	1	4		10
4	2nd Floor		Top of Gamma Cell	N	11.00	13.0	11.0	1	4		11
4	2nd Floor	R-202	Isotope Handling Room	Y	12.33	14.5	9.0	1	4	8	20
5	2nd Floor	R-205	Above ZPR Area	N	17.50	21.0	11.0	2	5		24
4	2nd Floor	R-201	Laboratory	N	9.17	19.5	9.0	1	4		12
4	2nd Floor	R-203	Observation Room	Y	16.17	19.5	9.0	1	4	8	23
4	2nd Floor	R-205	SPR Control Room	N	19.50	21.3	9.0	1	4		17
4	2nd Floor	Stair #2	Stairway No. 2	N	6.00	10.5	2.0	1	4		9
			TOTALS							248	1,425

APPENDIX A- 7 Outdoor Area Survey Labor Summary

APPENDIX A-7

NON-IMPACTED OPEN LAND PAVED AREA SURVEY

ENTER BELOW OPTIONAL LOC CODE	ENTER SURFACE TYPES BELOW	ENTER AREA DESCRIPTION BELOW	SURVEY PACKAGE REQRD ? (Y/N)	ENTER AREA WIDTH BELOW (ft)	ENTER AREA LENGTH BELOW (ft)	ENTER Random Survey Sketchs (each)	SURVEY PACKAGE PREP (hrs)	10% SURVEY LABOR Hours
4	Asphalt	Assume Area 65 feet by 250 feet near Reactor Building	Y	65	250	3	4	5.1
		TOTALS				3	4	5.1

APPENDIX A-7

IMPACTED UNPAVED OPEN LAND AREA SURVEY

ENTER BELOW OPTIONAL LOC CODE	ENTER SURFACE TYPES BELOW	ENTER AREA DESCRIPTION BELOW	SURVEY PACKAGE REQRD ? (Y/N)	ENTER AREA WIDTH BELOW (ft)	ENTER AREA LENGTH BELOW (ft)	SUB SURFACE ACTIVITY DEPTH (ft)	ENTER Random Survey Sketchs (each)	DIRECT SURVEY LABOR (hrs)
4	Soil	Soil Under Reactor Building	Y	55	90	3	2	25
					TOTALS:			25

APPENDIX A-7

NON-IMPACTED OPEN LAND UNPAVED AREA SURVEY

ENTER BELOW OPTIONAL LOC CODE	ENTER SURFACE TYPES BELOW	ENTER AREA DESCRIPTION BELOW	SURVEY PACKAGE REQRD ? (Y/N)	ENTER AREA WIDTH BELOW (ft)	ENTER AREA LENGTH BELOW (ft)	ENTER Random Survey Sketchs (each)	Random Survey Sketchs Hours	SURVEY PACKAGE PREP (hrs)	10% SURVEY LABOR (hrs)
4	Grass & Soil	20 meter border around Reactor Building	Y	65	250	3	1.00	4	5.8
		TOTALS				3	1.0	4	5.8

APPENDIX A-7

DRAIN & SEWER SURVEY

CATCH BASIN & CLEAN-OUT SURVEY

		BASIN SURVEY DURATION (hrs):	4		
		BASIN SURVEY CREW SIZE (men):	1		
ENTER BELOW OPTIONAL LOC CODE	ENTER AREA DESCRIPTION BELOW	ENTER BASIN DIAMETER BELOW (ft)	SURVEY PACKAGE REQRD ? (Y/N)	SURVEY PACKAGE PREP (hrs)	SURVEY LABOR (hrs)
4	Manhole on 24" Storm Sewer to NW of Reactor Building	5.0	Y	4	8.0
4	Manhole on 24" Storm Sewer to SE of Reactor Building	5.0	N		4.0
4	Manhole on 24" Sanitary Sewer to West of Reactor Building	5.0	Y	4	8.0
4	Manhole on 24" Sanitary Sewer to North of Reactor Building	5.0	N		4.0
	TOTALS			8	24

DRAIN PIPE SURVEY

			PIPE SURVEY RATE (ft/hr):	40			
			PIPE SURVEY CREW SIZE (men):	3			
ENTER OPTIONAL LOC CODES BELOW	AREA	ENTER DESCRIPTION BELOW	ENTER PIPE DIAMETER BELOW (ft)	ENTER PIPE LENGTH BELOW (ft)	SURVEY PACKAGE REQRD ? (Y/N)	SURVEY PACKAGE PREP (hrs)	SURVEY LABOR (hrs)
4	Storm Drain		24	150	Y	4	15.3
4	Sanitary Sewer		24	150	Y	4	15.3
	TOTALS					8	31

APPENDIX A- 8 Instrument Lease Charges

APPENDIX A-8

Table

COMMERCIAL CLIENT INSTRUMENT COSTS

6 D&D Months Duration
2.0 Final Survey Months Duration
0.5 Characterization Survey Months Duration

ITEM No.	INSTRUMENT DESCRIPTION	MONTHLY COMMERCIAL RENTAL RATE	CHAR SURVEY NUMBER INSTRUMENTS REQUIRED	D&D NUMBER INSTRUMENTS REQUIRED	FINAL SURVEY NUMBER INSTRUMENTS REQUIRED	D&D FULL PROJECT DURATION	D&D ALTERNATE MONTHLY DURATION
	RADIATION PROTECTION AND MEASUREMENT INSTRUMENTATION/SYSTEMS						
1	Becton Dickson - TRITON, Model III Tritium Monitor :	$737					
2	MICROSPEC-2, NaI(Tl) Gamma Spec System W/Detector, PC, Software, Case & Accessories :	$524					
3	GENI PC, Gamma Spec System W/Detector, PC, Software, Case & Accessories Model 4610J / GC4519	$5,546	1	1	1	Y	
4	INSPECTOR, Portable Gamma Spec W/Detector, PC, Software, M-1 Insitu Cal, Tripod & Accessories :	$4,037					
5	Q^2 Low Level Waste Assay System W/(3) HPGe Detectors, PC, Vault Shield W/Scale, Turntable & Acc.:	$4,974					
6	GTSD Mod. Q^2 Waste Assay System W/(3) HPGe Detectors, PC, Modular Shield W/Scale, Turntable & /	$2,998					
7	DCA - Portable Area Monitor 3090-3 :	$46					
8	Eberline -FASTRACK II Dosimetry System With PC, Printer, 1ea DR200, 1ea DR200R, 30ea DD100 & S	$821					
9	Eberline - Dosimeter Meter Reader Model DR-200 :	$216					
10	Eberline - Dosimeter Response Check Station Model DR-200 OPT7 :	$553					
11	Eberline - FASTRAC II, PC Dose Management Program with PC Utility :	$216					
12	Eberline - Digital Dosimeter Model DD-100 :	$52					
13	Eberline - Personal Contamination Monitor, Model PCM-1B w/ Accessories :	$2,590					
14	Eberline - Personal Contamination Monitor, Model PCM-1C w/ Accessories :	$3,353					
15	Eberline - Personal Contamination Monitor, Model PCM-2 Base Unit :	$4,193					
16	Eberline - Portable Alpha Counter, Model SAC-4 :	$194	1	1	1	Y	
17	Eberline- Portable Beta Counter, Model BC-4 :	$162	1	1	1	Y	
18	Eberline - Portable GM Survey Instrument, Model E-520 w/ HP-270 & SK-1 :	$258					
19	Eberline - Portable GM Survey Instrument, Model E-520 W/ HP-260 & SK-1 :	$272					
20	Eberline - Portable High Range Ion Chamber, Model R07 W/Low & Mid-Range Detectors, 5' Extension &	$179					
21	Eberline - Portable Ion Chamber Instrument, Model R02 :	$78					
22	Eberline - Portable Ion Chamber Instrument, Model R02A :	$78					
23	Eberline - Scintillation Portal Monitor, Model PM-7 W/PC, Software, Calibration Jig, Remote ALarm & 60'	$3,295					
24	Eberline - Tool Contamination Monitor, Model TCM-2 with Spare Detector :	$1,654					
25	Eberline - TELETECTOR Gamma Dose Rate Meter, Model 6112B w/ Accessories :	$200					
26	EG&G - NOMAD, Portable PC Based Gamma Spec Analyzer W/HPGe Detector, PC, Software & Acc. :	$1,292					
27	Void	$383					
28	F&J - BUCK Pump Kit, 5 Personal Air Samplers, Calibrator, Charger & Case :	$908					
29	F&J - Model HV-1, High Volume Air Sampler with Sample Head :	$56		1		Y	
30	F&J - MODEL LV-1, Low Volume Air Sampler with Sample Head :	$46		2		Y	
31	F&J - MODEL LV-14M, GOOSENECK LOW VOLUME AIR SAMPLER WITH SAMPLE HEAD :	$106					
32	LUDLUM - MODEL 12 SURVEY METER WITH 44-9 PANCAKE GM PROBE & CASE:	$58		3		Y	
33	LUDLUM - MODEL 12 SURVEY METER WITH 43-5 ALPHA SCINTILLATION. PROBE & CASE:	$98					
34	LUDLUM - MODEL 19 MICRO R METER WITH HARD CASE:	$44	1	1	1	Y	
35	LUDLUM - MODEL 177 ALARM RATE METER WITH 44-9 PROBE AND CASE :	$41	1	3	3	Y	
36	Ludlum - Model 239-1F Floor Monitor Cart W/O Model 12 Meter & W/Model 43-37 425 cm^2 Gas Flow De	$163			2		
37	Ludlum - Model 2350 Data Logger Kit, W/Keypad, Barcode Reader, Pelican Case & Detectors # 38 Thru	$180	3	3	4	Y	
38	Ludlum - Model 2350 Data Logger Kit, W/Keypad, Barcode Reader, Pelican Case (No Detectors) :	$114					
39	LUDLUM - MODEL 43-5 ALPHA SCINTILLATION DETECTOR :	$66	1	3	2	Y	
40	LUDLUM - MODEL 43-68 100 cm2 GAS PROPORTIONAL DETECTOR :	$59					
41	LUDLUM - MODEL 44-1 BETA SCINTILLATION DETECTOR	$60					
42	LUDLUM - MODEL 44-2 HIGH ENERGY GAMMA SCINTILLATION DETECTOR :	$60					
43	LUDLUM - MODEL 44-38 ENERGY COMPENSATED GM DETECTOR :	$18					

APPENDIX A-8

Table

COMMERCIAL CLIENT INSTRUMENT COSTS

6 D&D Months Duration
2.0 Final Survey Months Duration
0.5 Characterization Survey Months Duration

ITEM No.	INSTRUMENT DESCRIPTION	MONTHLY COMMERCIAL RENTAL RATE	CHAR SURVEY NUMBER INSTRUMENTS REQUIRED	D&D NUMBER INSTRUMENTS REQUIRED	FINAL SURVEY NUMBER INSTRUMENTS REQUIRED	D&D FULL PROJECT DURATION	D&D ALTERNATE MONTHLY DURATION
44	LUDLUM - MODEL 44-40 SHIELDED GM PANCAKE DETECTOR :	$40					
45	LUDLUM - BETA AIR MONITOR (CAM), MODEL 333-2 :	$472					
46	LUDLUM - MODEL 77-3 STRETCH SCOPE (TELETECTOR):	$211					
47	NE TECHNOLOGY - MODEL CM7A CONTAMINATION MONITOR WITH DP5HA PROBE :	$463					
48	Packard - PC Based Liquid Scintillation Counter W/ Alpha / Beta Option & Accessories / A2550P2 :	$1,684					
49	Quantrad - SCOUT-1, NaI(Tl) Gamma Spec System W/Detector, PC, Software, Case & Accessories :	$1,308					
50	REUTER-STOKES - PRESSURIZED ION CHAMBER RSS-122 :	$886					
51	TENNELC - MODEL LB 5100-2080-III PC BASED ALPHA/BETA COUNTER SYSTEM :	$1,691					
	RADIATION PROTECTION AND MEASUREMENT INSTRUMENTATION/SYSTEMS						
52	TSI - MODEL 8020 PORTACOUNT, RESPIRATOR FIT TESTER :	$588					
53	XETEX - MODEL 330A TELESCAN DOSE RATE METER W/ CASE & ACCESSORIES :	$388					
	INSTRUMENTATION SOURCES (MAY BE CHARGED AS CONSUMABLE OR RENTAL)						
54	GAMMA SPEC. NIST TRACEABLE MIXED SOIL EQUIVALENT 1 LITER MARINELLI :	$68	1	1	1	Y	
55	GAMMA SPEC. NIST TRACEABLE MIXED WATER EQUIVALENT 1 LITER MARINELLI :	$62					
56	GAMMA SPEC. NIST TRACEABLE MIXED FILTER PAPER EQUIVALENT :	$62	1	1	1	Y	
57	GAMMA SPEC. NIST TRACEABLE MIXED POINT SOURCE :	$60					
58	Q2 GAMMA SPEC. NIST TRACEABLE MIXED 30 INCH LINE SOURCE :	$228					
59	Q2 GAMMA SPEC. NIST TRACEABLE MIXED 6 INCH QC SOURCE :	$166					
60	ALPHA/BETA COUNTER BC-4, NIST Tc-99 47mm LINEARITY 4 SOURCE SET :	$264					
61	NIST Tc-99 47mm SOURCE PER EACH (1, 10, 100 OR 1000 nCi) :	$65	2	2	2	Y	
62	ALPHA/BETA COUNTER SAC-4, NIST Th-230 47mm LINEARITY 4 SOURCE SET :	$317					
63	NIST Th-230 47mm SOURCE PER EACH (1, 10, 100 OR 1000 nCi) :	$65	2	2	2	Y	
64	CM7A NIST ALPHA CAL/CHECK SOURCE WITH ALUMINUM CASE/HOLDER :	$68					
65	CM7A NIST BETA CAL/CHECK SOURCE WITH ALUMINUM CASE/HOLDER :	$68					
66	TCM-2 & PCM -1B, NIST CAL/CHECK SOURCE :	$375					
67	PM -7, NIST CAL/CHECK SOURCE :	$211					
	DECON EQUIPMENT						
68	LTC VAC-U-BLAST STEEL SHOT BLASTER :	$1,450					
69	PENTEK VAC-PAC MODEL 9A VACUUM :	$1,982		1			2
70	PENTEK SQUIRREL III FLOOR SCABBLER :	$1,134					
71	PENTEK CORNER CUTTER NEEDLE GUN :	$329					
72	MCDONALD AIR TOOL MODEL U-5, 5 PISTON FLOOR SCABBLER :	$865					
73	MCDONALD AIR TOOL MODEL 3WCW, 3 PISTON WALL SCABBLER :	$293					
74	MCDONALD AIR TOOL MODEL HS, SINGLE PISTON SCABBLER :	$94					
75	2000 CFM HEPA VENTILATION UNIT MODEL 1990C :	$119					
76	HAKO TWIN HEAD ELECTRIC HEPA VACUUM :	$138					
77	NORCLEAN TRIPLE HEAD ELECTRIC HEPA VACUUM :	$554		1		Y	
	M&TE/TEST EQUIPMENT						
78	FLUKE - 8060A DVM WITH HV PROBE, CASE AND LEADS :	$146					
79	EBERLINE - MP-2 MINIPULSER AND LUDLUM MODEL 500 MINIPULSER :	$430					

APPENDIX A-8

Table

COMMERCIAL CLIENT INSTRUMENT COSTS

6 D&D Months Duration
2.0 Final Survey Months Duration
0.5 Characterization Survey Months Duration

ITEM No.	INSTRUMENT DESCRIPTION	MONTHLY COMMERCIAL RENTAL RATE	CHAR SURVEY NUMBER INSTRUMENTS REQUIRED	D&D NUMBER INSTRUMENTS REQUIRED	FINAL SURVEY NUMBER INSTRUMENTS REQUIRED	D&D FULL PROJECT DURATION	D&D ALTERNATE MONTHLY DURATION
80	TEKTRONIX - MODEL 2225, 100 MHZ PORTABLE OSCILLOSCOPE WITH BATTERY PACK :	$513					
81	F&J AIR FLOW CALIBRATOR MODEL D-812 :	$200					
82	F&J AIR FLOW CALIBRATOR MODEL D-814 :	$200					
83	FIELD SERVICE TOOL KIT :	$130					
	OFFICE EQUIPMENT						
84	DATA ANALYSIS COMPUTER SYSTEM :	$205	1	1	1	Y	
85	DOWNLOAD NOTEBOOK COMPUTERS :	$151	1	1	2	Y	
86	HP MODEL IIIP LASER JET PRINTER :	$83	1	1	1	Y	
87	HP MODEL 4L LASER JET PRINTER :	$83					
88	HP OFFICE JET FAX/COPIER :	$62					
	SAMPLING EQUIPMENT						
89	BICO - JAW CRUSHER, MODEL 241-36X35 :	$297					
90	FISHER SCIENTIFIC -TOP LOADING SCALE, 0-3 kg MODEL XE4100 :	$46	1	1	1	Y	
91	FISHER SCIENTIFIC - CLASS F S.S. WEIGHT SET, 1mg-2kg CAT.# 0221531 :	$14	1	1	1	Y	
92	FISHER SCIENTIFIC - OVEN, ISOTEMP 5.0 120VAC CAT.# 13247750G :	$124	1	1	1	Y	
93	FORESTRY SUPPLIERS - SOIL SAMPLING AUGER KIT, CAT.# 67352 :	$289					
	GLOBAL POSITIONING SYSTEM						
94	TRIMBLE NAVIGATION - SITE SURVEYOR SYSTEM, MODEL 4000SE :	$1,766					
	COMMUNICATIONS EQUIPMENT						
95	MOTOROLA - MODEL HT1000, 16 CHANNEL UHF RADIO WITH ACCESSORIES :	$213					
					TOTAL INSTRUMENT LEASE COST		

APPENDIX A- 9 Equipment Lease Charges

APPENDIX A-9
COMMERCIAL CLIENT EQUIPMENT COSTS

6 D&D Months Duration
2.0 FINAL SURVEY Months Duration

ITEM NUMBER	EQUIPMENT DESCRIPTION	MONTHLY COMMERCIAL RENTAL RATE	D&D NUMBER ITEMS REQUIRED	FINAL SURVEY NUMBER ITEMS REQUIRED	D&D FULL PROJECT DURATION	D&D ALTERNATE MONTHLY DURATION	D&D EQUIPMENT LEASE COST	FINAL SURVEY EQUIPMENT LEASE COST
	DECON EQUIPMENT							
1	LTC VAC-U-BLAST Steel Shot Blaster :	$1,450						
2	PENTEK VAC-PAC Model 9A Vacuum :	$1,982						
3	PENTEK SQUIRREL III Floor Scabbler :	$1,134						
4	PENTEK CORNER CUTTER Needle Gun :	$329						
5	MCDONALD AIR TOOL Model U-5, 5 Piston Floor Scabbler :	$865						
6	MCDONALD AIR TOOL Model 3WCW, 3 Piston Wall Scabbler :	$293						
7	MCDONALD AIR TOOL Model HS, Single Piston Scabbler :	$94						
8	2000 CFM HEPA Ventillation Unit Model 1990C :	$119						
9	HAKO Twin Head Electric HEPA Vacuum :	$138						
10	NORCLEAN Triple Head Electric HEPA Vacuum :	$554						
	OFFICE EQUIPMENT							
11	Data Analysis Computer System :	$205						
12	Download Notebook Computers :	$151						
13	HP Model IIIP Laser Jet Printer :	$83						
14	HP Model 4L Laser Jet Printer :	$83						
15	HP Office Jet FAX/Copier :	$62						
16	35mm Camera	$67	1	1	N	2	$134	$134
17	Fax machine	$24						
18	Telephone	$5						
19	Office Trailer, 50' x 10'							
20	Toilet, portable chemical							
21	Desk	$135						
22	File Cabinet, 5 drawer x 28"	$129						
23	File Cabinet, fireproof, 4 drawer	$381						
24	Work Tables, 30" x 60"	$51						
25	Coat Racks, 36" x 21" x 60"	$91						

APPENDIX A-9
COMMERCIAL CLIENT EQUIPMENT COSTS

6 D&D Months Duration
2.0 FINAL SURVEY Months Duration

ITEM NUMBER	EQUIPMENT DESCRIPTION	MONTHLY COMMERCIAL RENTAL RATE	D&D NUMBER ITEMS REQUIRED	FINAL SURVEY NUMBER ITEMS REQUIRED	D&D FULL PROJECT DURATION	D&D ALTERNATE MONTHLY DURATION	D&D EQUIPMENT LEASE COST	FINAL SURVEY EQUIPMENT LEASE COST
26	Draft Table	$238						
27	Desk Chairs	$57						
28	Molded Plastic Chairs	$14						
29	Microwave oven	$97						
30	Coffee Machine	$149						
31	Refrigerator	$342						
32	Waste Containers (7 gallon)	$11						
33	Waste Containers (35 gallon)	$53						
34	Draft Table Stool	$57						
35	Plan Holders (P&ID)	$91						
36	Break Room Folding Tables	$101						
37	Molded Plastic Chairs	$14						
38	Multi-Media Board, 36" x 60"	$34						
	SAMPLING EQUIPMENT							
39	BICO - Jaw Crusher, Model 241-36X35 :	$497						
40	FISHER SCIENTIFIC -Top Loading Scale, 0-3 kg Model XE4100 :	$46						
41	FISHER SCIENTIFIC - Class F S.S. Weight Set, 1mg-2kg CAT.# 0	$14						
42	FISHER SCIENTIFIC - Oven, ISOTEMP 5.0 120VAC CAT.# 13247	$124						
43	FORESTRY SUPPLIERS - Soil Sampling Auger Kit, CAT.# 67352	$289						
	COMMUNICATIONS EQUIPMENT							
44	MOTOROLA - Model HT1000, 16 Channel UHF Radio with Access	$116						
	TOOLS							
45	Full Set Misc Tools w/Chest	$93						
46	3/4" Impact Wrench	$128						
47	3/4" Impact Socket Set	$23						
48	Set of Lifting Slings	$56	3		Y		$1,008	

APPENDIX A-9
COMMERCIAL CLIENT EQUIPMENT COSTS

6 D&D Months Duration
2.0 FINAL SURVEY Months Duration

ITEM NUMBER	EQUIPMENT DESCRIPTION	MONTHLY COMMERCIAL RENTAL RATE	D&D NUMBER ITEMS REQUIRED	FINAL SURVEY NUMBER ITEMS REQUIRED	D&D FULL PROJECT DURATION	D&D ALTERNATE MONTHLY DURATION	D&D EQUIPMENT LEASE COST	FINAL SURVEY EQUIPMENT LEASE COST
49	Drum Heaters - Evaporation	$28						
50	8' Fiberglass Step Ladder	$45	3	1	Y		$810	$90
51	4 Outlet GFCI Circuit Guard	$62						
52	Air Compressor (2-1/2 HP, 5.5 CFM)	$74						
53	1" x 150' Air Hose	$28	6		Y		$1,008	
54	Air Chipping Hammer with Chisels	$96						
55	Electric Drills 1/2 Inch	$46						
56	8-1/4" Circular Saw	$35						
57	Milwaukee Heavy Duty Straight Grinder	$90						
58	Long Handled Shovels	$10						
59	Snow Shovels	$5						
60	Steel Pry Bar	$2						
61	Long Handeled Pry Bar Set	$15						
62	Electric Paint Sprayer (for fixative agents)	$20						
63	Cutting Torch	$109	1		Y		$654	
64	Band Saw	$57	2		Y		$684	
65	Drum handling cart	$36						
66	Extension cord, 100 ft, 12/3, 15A	$33						
67	Lighting standard, 2 500 W halogen quartz	$37	1		Y		$222	
68	String light, 100 ft, 10 lamp	$11						
69	110,000 BTU Oil-Fired Space Heater	$60						
	HEAVY EQUIPMENT RENTAL							
70	Truck Mounted Hydraulic Crane, 25 Ton	$10,692	1		N	1	$10,692	
71	40' Telescoping Boom Lift	$6,831	1		N	2	$13,662	
72	Truck, Three axle dump, 16 ton payload	$8,118						
73	Oxyacetylene Cutting Outfits	$386	1		Y		$2,316	
74	1-1/4 C.Y. Backhoe Loader	$5,643			N	1		
75	Backhoe Attachment, 1000 ft-lb Hydraulic Hammer	$6,138	1		N	2	$12,276	

APPENDIX A-9
COMMERCIAL CLIENT EQUIPMENT COSTS

6 D&D Months Duration
2.0 FINAL SURVEY Months Duration

ITEM NUMBER	EQUIPMENT DESCRIPTION	MONTHLY COMMERCIAL RENTAL RATE	D&D NUMBER ITEMS REQUIRED	FINAL SURVEY NUMBER ITEMS REQUIRED	D&D FULL PROJECT DURATION	D&D ALTERNATE MONTHLY DURATION	D&D EQUIPMENT LEASE COST	FINAL SURVEY EQUIPMENT LEASE COST
76	Hydraulic Grapple with Shear Attachment for Loader	$1,871						
77	Service Truck	$1,634	1		Y		$9,804	
	SAFETY EQUIPMENT							
78	Respirators	$45						
79	Tripod Lifeline Rescue System	$192	1		Y		$1,152	
80	Portable Axial Electric Blower W/25' Ducting	$166	1		Y		$996	
81	Confined Space Safety Harness	$25	1		Y		$150	
82	Portable Multigas Monitor	$174	1		Y		$1,044	
83	First Aid Kit	$25	2	1	Y		$300	$50
84	Respirator Porta Count	$490						
85	Heat Stress Monitor	$86						
				TOTAL EQUIPMENT LEASE COST			$56,912	$274

APPENDIX A- 10 Demolition Estimate

APPENDIX A-10
Demolition Estimate

		LABOR BASED DEMOLITION COSTS: Labor by man-hour					
	Management, Supervision, & HP Support Labor Not Included	Util Operator & Craftsmen	Laborers	Craftsman	HP Tech	DEMOLITION LABOR	TOTAL
LOC CODE	AREA	$44.54	$40.95	$44.54	$66.00	hours	PRICE
3	General Cleanup		173.33			173.3	$7,098
1	Remove Reactor Core and Internals		67.60		6.93	74.5	$3,226
2	Drain Reactor Pool		24.27		3.47	27.7	$1,222
5	Remove ZPR Reactor Core and Related Internals		24.27		3.47	27.7	$1,222
1	Ship Reactor Core and Related Internals				104.00	104.0	$6,864
3	Remove Reactor Building Equipment		417.73		22.53	440.3	$18,593
3	Remove Heat Exchanger		8.67		1.73	10.4	$469
4	Package & Ship Contam. Materials & Radioactive Wastes		173.33		3.47	176.8	$7,327
						1,034.8	$46,021

APPENDIX A-10

TASK BASED DEMOLITON COSTS

42% Hazardous & Toxic Waste Productivity Factor: Level C, Heavy Work, 70 - 85°F

Percent Labor Cost 65.00%

Average Hourly Labor Rate $40.95

LOC CODE	AREA	QUANTITY	UNIT	MATERIAL UNIT PRICE	LABOR UNIT PRICE	EQUIPMENT UNIT PRICE	MATERIAL TOTAL PRICE	LABOR TOTAL PRICE	EQUIPMENT TOTAL PRICE	TOTAL PRICE
2	Wire Cut Bioshield Concrete	1,213	square feet		$39.61	$118.84		$48,050	$144,150	$192,200
2	Remove Concrete under Pool	30	cubic yard	$0.00	$68.26	$36.50	$0	$4,876	$2,607	$7,483
2	Remove Rock under Pool	20	cubic yard	$0.00	$68.26	$36.50	$0	$3,251	$1,738	$4,989
							$0	$56,177	$148,495	$204,672

APPENDIX A- 11 Decontamination Costs

APPENDIX A-11
DECONTAMINATION COSTS

SPECIFIC AREA SURFACE REMOVAL COST ANALYSES WITH BARNWELL DISPOSAL

INPUT APP. CODE	METHODOLOGY	INPUT AREA	INPUT ITEM	INPUT LOC CODE	INPUT DOSE RATE (R/hr)	INPUT SURFACE AREA (ft^2)	INPUT MATERIAL THICK (in)	INPUT CURIE CONTENT (mCi)	INPUT CONTAM. REMOVAL DEPTH (in)	INPUT CONTAM. WASTE DENSITY (lb/ft^3)	CONTAM. VOLUME (ft^3)	**PROCESS COST PLUS ** **BARNWELL WASTE DISPOSAL COST** CONTAM. WEIGHT (lbs)	BURIAL SHIP & BURY ($)	PROCESS COST ($/ft^2)	PROCESS COST ($)	SURFACE RELEASE COST ($)
												0	$0	$0.000	$0	
												0	$0	$0.000	$0	

SPECIFIC AREA SURFACE REMOVAL COST ANALYSES WITH ENVIROCARE DISPOSAL

INPUT APP. CODE	METHODOLOGY	INPUT AREA	INPUT ITEM	INPUT LOC CODE		INPUT SURFACE AREA (ft^2)	INPUT MATERIAL THICK (in)		INPUT CONTAM. REMOVAL DEPTH (in)	INPUT CONTAM. WASTE DENSITY (lb/ft^3)	CONTAM. VOLUME (ft^3)	**PROCESS COST PLUS ** **ENVIROCARE WASTE DISPOSAL COST** CONTAM. WEIGHT (lbs)	BURIAL SHIP & BURY ($)	PROCESS COST ($/ft^2)	PROCESS COST ($)	SURFACE RELEASE COST ($)
1	McDonald U-6 Scabbler-1/4"	Reactor Building	Floor	4		208	12		2/8	86.7	6.4	429	$1,405	$0.975	$201	$166
3	McDonald 3WCD Scabbler-1/8"	Reactor Building	Walls & Ceiling	4		830	12		1/8	86.7	9.8	668	$2,148	$4.446	$2,805	$514
														$0.000		
								TOTAL:			16.3	1,086	$3,553			$682

SPECIFIC AREA SURFACE CLEANING COST ANALYSES WITH BARNWELL DISPOSAL

INPUT APP. CODE	METHODOLOGY	INPUT AREA	INPUT ITEM	INPUT LOC CODE	INPUT WBS No.	0.0929 INPUT SURFACE AREA (ft^2)	INPUT ORIGINAL CONTAM. VOLUME (ft^3)	INPUT ORIGINAL CONTAM. WEIGHT (lb)	ft³ per m³ GENERATED RW VOLUME (ft^3)	GENERATED WASTE DENSITY (lb/ft^3)	GENERATED WASTE WEIGHT (lb)	** PROCESSED RADWASTE DISPOSAL ** BURIAL SHIP & BURY ($)	PROCESS COST ($/ft^2)	PROCESS COST ($)	SURFACE RELEASE COST ($)	COST GRAND TOTAL ($)
									0.0	0.0	0.0	$0	$0.00	$0	$0	$0
									0.0	0.0	0.0	$0	$0.00	$0	$0	$0

SPECIFIC AREA SURFACE CLEANING COST ANALYSES WITH ENVIROCARE DISPOSAL

INPUT APP. CODE	METHODOLOGY	INPUT AREA	INPUT ITEM	INPUT LOC CODE	INPUT WBS No.	0.0929 INPUT SURFACE AREA (ft^2)	INPUT CONTAM. VOLUME (ft^3)	INPUT ORIGINAL CONTAM. WEIGHT (lb)	ft³ per m³ GENERATED RW VOLUME (ft^3)	GENERATED WASTE DENSITY (lb/ft^3)	GENERATED WASTE WEIGHT (lb)	** PROCESSED RADWASTE DISPOSAL ** BURIAL SHIP & BURY ($)	PROCESS COST ($/ft^2)	PROCESS COST ($)	SURFACE RELEASE COST ($)	COST GRAND TOTAL ($)
42	Hands-On Decon	Office & Lab Wing	Hood/Glove Box(2)	4		300	148		2.5	25.0	62.5	$545	$3.02	$905	$245	$1,695
42	Hands-On Decon	Office & Lab Wing	Bench/Cabinet(2)	4		100	130	600	0.8	25.0	20.8	$182	$3.02	$302	$82	$566
42	Hands-On Decon	Basement	Waste Storage Tank	4		190			1.6	25.0	39.6	$346	$3.02	$573	$155	$1,074
42	Hands-On Decon	ZPR	ZPR Tank	5		153			1.3	25.0	31.8	$278	$3.02	$460	$124	$862
42	Hands-On Decon	TRIGA Bioshield	Pool Interior	2					0.0	0.0	0.0	$0	$3.02	$0	$0	$0
									0.0	0.0	0.0	$0	$0.00	$0	$0	$0
					SUB TOTAL:		278	600	6.2		154.7	$1,350		$2,239	$606	$4,195

APPENDIX A- 12 Miscellaneous Item Inventory Estimate

APPENDIX A-12
MISCELLANEOUS ITEM VOLUME ESTIMATE

DESCRIPTION	LOC CODE	WBS No.	UNITS	NO. OF UNITS	MAT'L OF CONST.	BULK DENSITY (lb/ft^3)	UNIT WEIGHT (lb)	UNIT VOLUME (ft^3)	TOTAL WEIGHT (lb)	TOTAL VOLUME (ft^3)	PERCENT DIRECT BURY (vol %)	ENVIRO DISPOSAL WEIGHT (lb)
TRIGA Reactor												
Activated Hardware	1		Ea	2	Misc		6,000	60.0	12,000	120.0	100%	12,000
Pool Fuel Storage Wells	1		Ea	4	Aluminum	168.6	103	6.3	414	25.3	100%	414
Thermal Column	1		Ea	1	Graphite & Al	100.0	2,849	28.5	2,849	28.5	0%	0
									0	0.0		0
TRIGA Beam Port Plugs & Shielding									0	0.0		0
Horizontal Access Removable Graphite Block	2		Ea	1	Graphite	100.0	933	9.3	933	9.3	100%	933
Horizontal Access Hohlraum Block	2		Ea	1	Hohlraum	100.0	2,133	21.333	2,133	21.3	100%	2,133
Horizontal Access Graphite Block	2		ft^3	1	Graphite	100.0	5,467	64.0	5,467	64.0	100%	5,467
Horizontal Access Lead	2		Ea	1	Lead	708.0	3,776	5.3	3,776	5.3	100%	3,776
Horizontal Access Boral Can 1/8" thick	2		ft^2	1	Boral	168.6	281	1.7	281	1.7		0
Horizontal Rolling Door Plug (Ilmenite Concrete)	2		Ea	1	HD Concrete	230.4	0		0	0.0	0%	0
Vertical Access Lead-1	2		Ea	1	Lead	708.0	1,785	2.5	1,785	2.5	100%	0
Vertical Access Plug Lead	2		Ea	1	Lead	708.0	2,366	3.34	2,366	3.3	100%	0
Vertical Access Plug Graphite	2		Ea	1	Graphite	100.0	1,797	17.97	1,797	18.0	100%	0
Vertical Access Plug Boral Can 1/8" Thick	2		ft^2	1	Boral	168.6	83	0.495	83	0.5		0
Vertical Access Center Plug (Ilmenite Concrete)	2		Ea	1	HD Concrete	230.4	3,612	15.68	3,612	15.7	0%	0
Vertical Access Top Plug (Ilmenite Concrete)	2		Ea	1	HD Concrete	230.4	10,443	45.3	10,443	45.3	0%	0
Vertical Access Lead-2	2		Ea	1	Lead	708.0	2,589	3.7	2,589	3.7	100%	2,589
Vertical Access Lead-3	2		Ea	1	Lead	708.0	3,068	4.3	3,068	4.3	100%	3,068
												0
Activated TRIGA Bioshield Concrete with Beam Tube Parts												0
Activated Concrete	2		ft^3	2	HD Concrete	230.4	292,077	1,267.9	584,155	2,535.8	100%	584,155
Activated Rock	2		ft^3	2	Rock	100.0	28,000	280.0	56,000	560.0	100%	56,000
Reactor Bay												
Reactor Building General Cleanup Waste	3		ft^3	360		40.0			14,400	360	100%	14,400
Waste Generated During Pool Draining	2		ft^3	90		15.0			1,350	90	100%	1,350
Waste Generated During Reactor Building Equipment Removal	3		ft^3	180		40.0			7,200	180	100%	7,200
Waste Generated During Piping Removal	3		ft^3	180		15.0			2,700	180	100%	2,700
Waste Generated During Heat Exchanger Removal	3		ft^3	90		40.0			3,600	90	100%	3,600
Waste Generated During Removal of Rabit Transfer System	3		ft^3	180		40.0			7,200	180	100%	7,200

APPENDIX A-12
MISCELLANEOUS ITEM VOLUME ESTIMATE

DESCRIPTION	LOC CODE	WBS No.	UNITS	NO. OF UNITS	MAT'L OF CONST.	BULK DENSITY (lb/ft^3)	UNIT WEIGHT (lb)	UNIT VOLUME (ft^3)	TOTAL WEIGHT (lb)	TOTAL VOLUME (ft^3)	PERCENT DIRECT BURY (vol %)	ENVIRO DISPOSAL WEIGHT (lb)
Charcoal Filter	3		Ea	1		50.0	3,462	69.2	3,462	69.2	100%	3,462
Mixed-Bed Demineralizer	3		Ea	1		50.0	4,330	86.6	4,330	86.6	100%	4,330
ZPR Water System												
water clean up filter	5		ft^3	2		50.0	50	1.0	100	2.0	100%	100
								TOTALS:	738,093	4,702	100%	714,877