MAINE YANKEE

LTP SECTION 4

SITE REMEDIATION PLAN

TABLE OF CONTENTS

List of Tables

4.0 SITE REMEDIATION PLAN

4.1 Remediation Actions and ALARA Evaluations

This section of the LTP describes various remediation actions which may be used during the decommissioning of MY. In addition, the methods used to reduce residual contamination to levels that comply with the NRC's annual dose limit of 25 mrem plus ALARA, as well as the enhanced State of Maine clean-up standard of 10 mrem/year or less for all pathways and 4 mrem/year or less for groundwater drinking sources, are described. Finally, the Radiation Protection Program requirements for the remediation are described.

4.2 Remediation Actions

Remediation actions are performed throughout the decommissioning process. The remediation action taken is dependent on the material contaminated. The principal materials that may be subjected to remediation are structure basements 3-feet below grade and soils. Attachment 4B of this section describes the equipment, personnel, and waste costs used to generate a unit cost basis for the remediation actions discussed below.

4.2.1 Structures

Following the removal of equipment and components, structures will be surveyed as necessary and contaminated materials will be remediated or removed and disposed of as radioactive waste. Gamma scans may be employed on remaining structural concrete surfaces to identify contamination at depth. These gamma scans are described in Appendix 4C. Contaminated structure surfaces at elevations less than 3-feet below grade will be remediated to a level that will meet the established radiological criteria provided in Section 6.0. The remediated building basements (elevations at and below - 3 foot below grade) will be backfilled.

Remediation techniques that may be used for the structure surfaces include washing, wiping, pressure washing, vacuuming, scabbling, chipping, and sponge or abrasive blasting. Washing, wiping, abrasive blasting, vacuuming and pressure washing techniques may be used for both metal and concrete surfaces. Scabbling and chipping are mechanical surface removal methods that are intended for concrete surfaces. Activated concrete removal may include using machines with hydraulic-assisted, remote-operated, articulating tools. These machines have the ability to exchange scabbling, shear, chisel and other tool heads.

Scabbling

The principal remediation method expected to be used for removing contaminants from concrete surfaces is scabbling. Scabbling is a surface removal process that uses pneumatically-operated air pistons with tungsten-carbide tips that fracture the concrete surface to a nominal depth of 0.25 inches at a rate of about 20 ft^2 per hour. The scabbling pistons (feet) are contained in a close-capture enclosure that is connected by hoses to a sealed vacuum and collector system. The fractured media and dusts are deposited into a sealed removable container. The exhaust air passes through both roughing and absolute HEPA (high efficiency particulate air filter) filtration devices. Dust and generated debris are collected and controlled during the operation.

Needle Guns

A second form of scabbling is accomplished using needle guns. The needle gun is a pneumatic air-operated tool containing a series of tungsten-carbide or hardened steel rods enclosed in a housing. The rods are connected to an air-driven piston to abrade and fracture the media surface. The media removal depth is a function of the residence time of the rods over the surface. Typically, one to two millimeters are removed per pass. Generated debris transport, collection, and dust control are accomplished in the same manner as for scabbling. Needle gun removal and chipping of media are usually reserved for areas not accessible to normal scabbling operations. These include, but are not limited to inside corners, cracks, joints and crevices. Needle gunning techniques can also be applied to painted and oxidized surfaces.

Chipping

Chipping includes the use of pneumatically operated chisels and similar tools coupled to vacuum-assisted collection devices. Chipping activities are usually reserved for cracks and crevices but may also be used in lieu of concrete saws to remove pedestal bases or similar equipment platforms. This action is also a form of scabbling.

Sponge and Abrasive Blasting

Sponge and abrasive blasting are similar techniques that use media or materials coated with abrasive compounds such as silica sands, garnet, aluminum oxide, and walnut hulls. Sponge blasting is less aggressive incorporating a foam media that, upon impact and compression, absorbs contaminants. The medium is collected by vacuum and the contaminants washed from the medium for reuse.

Abrasive blasting is more aggressive than sponge blasting but less aggressive than scabbling. Both operations uses intermediate air pressures. Sponge and abrasive blasting are intended for the removal of surface films and paints. Abrasive blasting is evaluated as a remediation action and the cost is comparable to sponge blasting with an abrasive media.

Pressure Washing

Pressure washing uses a hydrolazer-type nozzle of intermediate water pressure to direct a jet of pressurized water that removes surficial materials from the suspect surface. A header may be used to minimize over-spray. A wet vacuum system is used to suction the potentially contaminated water into containers for filtration or processing.

Washing and Wiping

Washing and wiping techniques are actions that are normally performed during the course of remediation activities and will not always be evaluated as a separate ALARA action. When washing and wiping techniques are used as the sole means to reduce residual contamination below DCGL levels, ALARA evaluations are performed. Washing and wiping techniques used as a housekeeping or good practice measure will not be evaluated. Examples of washing and wiping activities for which ALARA evaluations would be performed include:

a. Decontamination of stairs and rails.

b. Decontamination of structural materials, metals or media for which decontamination reagents may be required.

c. Structure areas that do not provide sufficient access for utilization of other decontamination equipment such as pressure washing.

Washing and wiping is evaluated as a remediation action.

Grit Blasting

As the structures are demolished, contaminated piping will be removed and disposed of as radioactive waste. Any remaining contaminated piping in the below grade concrete may be remediated using methods such as grit blasting. Grit blasting uses grit media such as garnet or sand under intermediate air pressure directed through a nozzle that is pulled through the closed piping at a fixed rate. The grit blasting action removes the interior surface media layer of the piping. A HEPA vacuum system maintains the sections being cleaned under negative pressure and collects the media for reuse or disposal. The final system pass is performed with clean grit to remove any residual contamination.

Removal of Activated Concrete

Removal of activated concrete is intended to be accomplished using a machine-mounted, remote-operated articulating arm with exchangeable actuated hammer and bucket (sawing, impact hammering and expansion fracturing may also be employed). As concrete is fractured and rebar exposed, the metal is cut using flame cutting (oxygen-acetylene) equipment. The media are transferred into containers for later disposal. Dusts, fumes and generated debris are locally collected and as necessary, controlled using temporary enclosures coupled with close-capture HEPA filtration systems and controlled water misting. Any remaining loose media are removed by pressure washing or dry vacuuming using a HEPA filter equipped wet-dry vacuum.

The current remediation goal is to remove all activated concrete inside the containment liner. As shown in Section 6.0, the residual radioactivity due to activated concrete results in an annual dose to the critical group of less than 0.1 mrem (see Section 6.0, Table 6.9). This dose contribution to the total annual dose is a small fraction of the NRC and enhanced State dose limits and therefore ALARA evaluations are not deemed necessary. However, additional ALARA evaluations for activated concrete will be performed if the dose contribution to the critical group for activated concrete exceeds 1.0 mrem per year.

4.2.2 Soil

Soil contamination above the site specific DCGL will be removed and disposed of as radioactive waste. Operational constraints and dust control will be addressed in site excavation and soil control procedures. In addition, work package instructions for remediation of soil may include additional constraints and mitigation or control methods. The site characterization process established the location, depth and extent of soil contamination. As needed, additional investigations will be performed to ensure that any changing soil contamination profile during the remediation actions is adequately identified and addressed. A majority of site soil contamination is associated with three distinct areas (the PWST, RWST and the Shielded Radioactive Waste Storage Area) within the Radiologically Restricted Area (RRA). Sections 2.2.2 and 2.2.3 provide additional information regarding past and residual contamination associated with these areas. The information provided below generalize the anticipated activities associated with remediating these areas. For specific regions such as the area associated with the past soil contamination adjacent the RWST, remediation is expected to require removal and staging of overburden soils below the DCGL and the subsequent removal of deeper soils associated with this past contamination event. It should also be noted that soil remediation volume estimates in the LTP may vary from section to section, as appropriate, depending on their use, e.g., decommissioning cost estimates, ALARA evaluations, or dose assessment. Section 5.5.1.b discusses soil sampling and survey methods. The remediation of these areas will be performed following the removal of associated or adjacent tanks, components and pad interferences.

The contaminants within the RWST area are primarily due to past spill and heater leak incidents associated with the tank. With the exception of the area associated with clean soil overburden which was placed following remediation of the past contamination incident as stated in sections 2.2.2 and 2.2.3, soil remediation is expected to require removal of media to an average depth of approximately 1 meter immediately adjacent to the tank area. Additional remediation activities are expected to encompass a depth of 30 to 60 centimeters in the area down gradient from the tank and bounded east and west by local surface contour and the forebay berm.

Soil contamination near the PWST is due to the past storage of radioactively contaminated components and waste storage containers in the area immediately east and north of the PWST area. Local terrain features were such that associated contaminants subjected to weathering conditions would be transported toward the PWST area. The averaged soil remediation depth in this region is less than 60 centimeters.

Contaminated soil associated with the Shielded Radiological Waste Storage area originated, in part, from seasonal weathering conditions and specific tasks associated with components and stored containers. This area was evaluated in the past. A new bed of asphalt was placed over the region to mitigate the migration of any residual contaminants. The average soil contamination depth in this region is less than 60 centimeters.

Soil remediation equipment will include, but not be limited to, back and track hoe excavators. As practical, when the remediation depth approaches the soil interface region for unacceptable and acceptable contamination, a squared edge excavator bucket design or similar technique may be used. This simple methodology minimizes the mixing of contaminated soils with acceptable lower soil layers as would occur with a toothed excavator bucket. Remediation of soils will include the use of established Excavation Safety and Environmental Control procedures which reference the required aspects of the Maine Erosion and Sediment Control Handbook for Construction, Best Management Practices Manual. Additionally, soil handling procedures and work package instructions will augment the above guidance and procedural requirements to ensure adequate erosion, sediment, and air emission controls during soil remediation.

4.3 Remediation Activities Impact on the Radiation Protection Program

The Radiation Protection Program approved for decommissioning is similar to the Program in place during 25 years of commercial power operation. During power operations, contaminated structures, systems and components were decontaminated in order to perform maintenance or repair actions. The techniques used were the same as those being used for decommissioning. Many components were removed and replaced during operation. The techniques used for component removal were the same as those planned for use during decommissioning.

The Maine Yankee Radiation Protection Program adequately controlled radiation and radioactive contamination during decontamination and equipment removal processes. The same controls are being used during decommissioning to reduce personnel exposure to radiation and contamination and to prevent the spread of contamination from established contaminated areas. Decommissioning does not present any new challenge to the Radiation Protection Program above those encountered during normal plant operation and refueling. Decommissioning allows radiation protection personnel to focus on each area of the site and plan each activity well before execution of the remediation technique.

Low levels of surface contamination are expected to be remediated by washing and wiping. These techniques have been used over the operational history of the facility. Water washing with detergent has been the method of choice for large area decontamination. Wiping with detergent soaked or oil-impregnated media has been used on small items, overhead spaces and small hand tools to remove surface contaminants.

These same techniques will be applied to remediation of lightly contaminated structure surfaces during remediation actions.

Intermediate levels of contamination and contamination on the internal surfaces of piping or components have been subjected to high-pressure washing, hydrolazing or grit blasting in the past. The refueling cavity has been decontaminated by both pressure washing and hydrolazing. Pipes, surfaces and drain lines have been cleaned and hot spots removed using hydrolazing, sponge blasting or grit blasting. Small tools, hoses and cables have been pressure washed in a self-contained glove box to remove surface contamination. These methods will be used to reduce contamination on moderately contaminated exterior surfaces as well as internal surfaces of pipes or components during decommissioning.

Scabbling or other surface removal techniques will reduce high levels of contamination, including that present on contaminated concrete. Concrete cutting or surface scabbling has been used at MY in the past during or prior to installation of new equipment or structures both outside and inside the RRA.

Abrasive water jet and mechanical cutting of components will be used to reduce the volume of reactor internals. Mechanical cutting was used at this facility during past operations. Abrasive water jet cutting uses actions similar to hydrolazing and grit blasting which have been used at the site in the past. The current radiation protection program provides adequate controls for these actions.

The decommissioning organization is experienced in and capable of applying these remediation techniques on contaminated systems, structures or components during decommissioning. The Radiation Protection Program is adequate to safely control the radiological aspects of this work and no changes to the Program are necessary in order to ensure the health and safety of the workers and the public.

4.4 ALARA Evaluation

As described in Section 6.0, dose assessment scenarios were evaluated for the residual contamination that could remain on basement surfaces and soils. The ALARA analysis is conservatively based on the resident farmer scenario. The resident farmer critical group applies to existing open land areas and all site areas where standing buildings have been removed to three feet below grade. Current decommissioning plans do not call for on site buildings to remain standing. However, consideration has been given to the potential value of the Staff Building. In view of this possibility, ALARA evaluations are also provided using the building occupancy scenario.

4.4.1 Dose Models

To calculate the cost and benefit of averted dose for the ALARA calculation, certain parameters such as size of contaminated area and population density are required. This information was developed as a part of the dose models described in Section 6 and the Final Survey Program in Section 5 and is summarized below.

a. Basement Fill Model (Resident Farmer Scenario)

As described in Section 6, after buildings and structures are removed to 3 feet below grade, the critical group is the resident farmer. Removal of residual radioactivity on basement surfaces 3 feet below grade reduces the dose associated with the resident farmer scenario. Accordingly, the ALARA evaluation for remediation actions uses the parameters for population density, evaluation time, monetary discount rate and area that are applicable to the resident farmer scenario.

b. Standing Building Occupancy Model

Although standing buildings are not planned to remain at the site, an ALARA evaluation was performed in the event plans change and a standing building will remain. In this case, the building occupancy scenario would be used. In accordance with Section 5.3 of the LTP, the building occupancy survey unit size is 180 m^2. This is based on a survey unit with a 100 m^2 floor area with contaminated walls to a height of 2 meters. ALARA cost analyses are based on an assumption that only the 100 m^2 floor area requires remediation. This is conservative since including the walls would increase remediation cost without increasing the benefit of averted dose.

4.4.2 Methods for ALARA Evaluation

NUREG-1727, "Decommissioning Standard Review Plan," Section 7.0, ALARA Analysis, states, "Licensees or responsible parties that remediate building surfaces or soil to the generic screening levels established by the NRC staff do not need to demonstrate that these levels are ALARA." The DCGLs for soil were based on generic screening levels. In addition, although no standing buildings are planned to remain, DCGLs were calculated and were also based on generic screening levels. Notwithstanding the NRC guidance, MY is conservatively providing ALARA evaluations of the remediation actions for soil and standing buildings. There are no generic screening levels for the basement fill scenario so ALARA analyses are required.

The ALARA evaluations were performed in accordance with the guidance in NUREG-1727. A spreadsheet format was used to account for the dose contribution of each radionuclide in the MY mixture. The principal equations used for the calculations are presented in Attachment 4A. The evaluation determines if the benefit of the dose averted by the remediation is greater or less than the cost of the remediaton. When the benefit is greater than the cost, additional remediation is required. Conversely when the benefit is less than the cost, additional remediation is not required.

4.4.3 Remediation Methods and Cost

For the Maine Yankee facility the remediation techniques examined are scabbling, pressure water washing, wet and dry wiping, grit blasting for embedded and buried piping and grit blasting of surfaces. The principal remediation method expected to be used is scabbling, which is intended to include needle guns and chipping. The total cost of each remediation method is provided in Attachment 4B. The cost inputs are defined in Attachment 4A, Section A.2, Calculation of Total Cost. Basement concrete is the principal surface that will require remediation.

a. Basement Concrete Surfaces

The characterization data for concrete surfaces at the Maine Yankee facility indicates that a major fraction of the contamination occurs in the top millimeter of the concrete. Scabbling actions result in the removal of the top 0.125 to 0.25 inches (0.318 to 0.635 cm) of concrete. The ALARA evaluation was performed by bounding the cost estimate for a scabbled depth of 0.125 and 0.25 inches. For each evaluation the same manpower cost is used. However, the manpower and equipment costs for the lower bounding depth do not include compressor and consumable supply costs which adds some conservatism to the cost estimate, i.e., bias the cost low. The major variables for the bounding conditions are the costs associated with manpower and waste disposal.

b. Structure Activated Concrete

Concrete activation is associated with the containment structure. Characterization of the reactor bioshield and loop area concrete has provided information regarding the identification, concentration, and distribution of the radionuclides. In addition to the observed concrete activation products, the concrete surfaces in the containment structure are radioactively contaminated by the deposition and transport of fluids and airborne distribution which occurred during plant operation. The current remediation goal is to remove all activated concrete inside the containment liner. This region comprises approximately 21 m^2 of floor surface that is hampered by accessibility and equipment staging factors.

4.4.4 Remediation Cost Basis

The cost of remediation depends on several factors such as those listed below. This section describes the attributes of each remediation method that affect cost. The detailed cost estimates for each method are provided in Attachment 4B.

- Depth of contaminants;
- Surface area(s) of contamination relative to total;
- Types of surfaces: vertical walls, overhead surfaces, media condition;
- Consumable items and equipment parts;
- Cleaning rate and efficiency (decontamination factor);

- Work crew size;
- Support activities such as, waste packaging and transfer, set up time and interfering activities for other tasks; and
- Waste volume.

a. Scabbling

It has been estimated that scabbling can be effectively performed on smooth concrete surfaces to a depth of 0.25 to 0.5 inches at a rate of 20 ft^2 per hour. The scabbling pistons (feet) are contained in a close-capture enclosure that is connected by hoses to a sealed vacuum and collector system. The waste media and dust are deposited into a sealed removable container. The exhaust air passes through both roughing and absolute HEPA filtration devices. Dust and generated debris are collected and controlled during the operation.

The operation is conservatively assumed to be performed by one equipment operator and one laborer. In addition, costs for radiation protection support activities and supervision are included.

The unit cost is presented in Table 4-1. Scabbling the room assumes that 100% of the concrete surface contains contamination at levels equal to the DCGL and that 95% of this residual activity is removed by the remediation action. The equipment is capable of scabbling 20.0 square feet per hour. The debris is vacuumed into collectors that are transferred to containers for rail shipments. For the evaluation, the rail car is assumed to carry 92 m^3 of concrete per shipment.

The assumed contamination reduction rates are very high (95%), but not unreasonable considering that the contamination is very close to the surface. Based on evaluation of concrete core samples, scabbling is expected to be the principal method used for remediation of concrete surfaces. The cost elements used to derive the unit costs for the ALARA evaluation are listed in Attachment B. The methods for calculating total cost are provided in Attachment A.

b. Pressure Water Washing

The unit costs provided in Table 4-1 for water washing were established by assuming that 100% of the site structures' surface area is pressure washed. This information was used to provide a cost per meter square factor. Attachment 4B provides the cost details. The equipment consists of a hydrolazer and when used, a header assembly. The hydrolazer type nozzle directs the jet of pressurized water that removes surficial materials from the concrete. The header minimizes over-spray. A wet vacuum system is used to suction the potentially contaminated water into containers for filtration or processing. The cleaning speed is approximately 9.3 square meters(100 ft^2) per hour and the process generates about 5.4 liters of liquid per square meter (NUREG-5884, V2). The contamination reduction rates are dependent on the media in which the contaminants are fixed, the composition of the contaminants, cleaning reagents used and water jet pressure. Mitigation of loose contaminants is high. Reduction of hard-to-remove surface contamination is approximately 25% for the jet pressure and cleaning speed used. The use of reagents and slower speeds can provide better contamination reduction rates but at proportionally higher costs. The operation is performed using one equipment operator and two laborers. In addition, costs for radiation protection support activities and supervision are included. The formula associated with the cost elements is provided in Attachment A and the cost elements are provided in Attachment B.

c. Wet and Dry Wiping

The unit costs provided in Table 4-1 for washing and wiping assume 100% of the site structures' surface area is washed and wiped. The information is used to develop a cost per square meter. Attachment 4B provides the detailed costs. Wet wiping consists of using a cleaning reagent and wipes on surfaces that cannot be otherwise cleaned or decontaminated. Dry wiping includes the use of oil-impregnated media to pick up and hold contaminants. The cleaning rate of these actions is estimated at 2.8 square meters per hour (~ two minutes per square foot). This action is labor intensive. The action is effective for the removal of loose contaminants and reduction of surface contaminants, especially when cleaning reagents are used. Waste generation is about 0.005 m^3 per hour (NUREG-5884, V2). Decontamination factors vary and are dependent on factors such as the reagents that are used, the level of wiping effort and the chemical and physical composition of the contaminant. The contamination reduction efficiency used for wet and dry wiping is 20 percent. Removal of loose contaminants, oil and grease is very effective (100 percent). The operation is performed using two laborers. In addition, the cost for radiation protection support activities includes an operating engineer and supervision. The formula associated with the cost elements is provided in Attachment A. Attachment B list the cost elements used for the evaluation.

d. Grit Blasting (Embedded Piping)

The cost for grit blasting was established by assuming that 6,158 linear feet of piping is decontaminated. This length of piping is the total amount of potentially contaminated buried and embedded piping identified by the Maine Yankee engineering group. For the evaluation, the entire interior surface is assumed to require decontamination and the internal diameter is assumed at 4 inches (typical drain line dimensions). The grit blasting system is comprised of a hopper assembly that delivers a grit medium (garnet or sand) at intermediate air pressures through a nozzle that is pulled at a fixed rate (~1 foot per minute) through the piping. A HEPA vacuum system maintains the piping system under a negative pressure and collects the grit for reuse (cyclone separator) or disposal. Usually several passes are required to effectively clean the piping to acceptable residual radioactivity levels. The contamination reduction efficiency used for grit blasting is 95 percent. This reduction rate can vary depending on radial bends in piping, reduction and expansion fittings, pipe material composition, physical condition and the plate-out mechanisms associated with the contaminants and effluents. The final pass is made with clean grit to mitigate the possibility of loose residual contaminants associated with previous cleaning passes. Grit decontamination factors are related to pressure, nozzle size, grit media and the number of passes made. A nominal grit usage rate of one pound per linear foot is used in the calculation. This cost unit information is provided as cost per linear foot factor and is also converted to m^2 for the spreadsheet evaluation. Attachment 4B provides the cost details used to derive unit cost. The formula associated with the cost elements is provided in Attachment A

e. Sponge and Abrasive Blasting

Sponge and abrasive blasting uses media or materials coated with abrasive compounds such silica sands, garnet, aluminum oxide and walnut hulls. The operation uses intermediate air pressures as that described for grit blasting. The operation uses a closed-capture system and air filtration system to mitigate loose and airborne radioactivity. The system includes a cyclone or similar separation system to collect the generated media. The operation is intended for removal of surficial films. The removal efficiency and depth are a function of the surface, abrasive mix, air pressure, grit media, and speed or number of passes performed over the suspect surface. Surface cleaning rates are about 30 square feet per hour. For the rate given, the removal depth using aluminum oxide grit will range from less than 1 to as much as 3 millimeters. Abrasive blasting techniques are often used for film and paint removal and are less aggressive than scabbling.

f. Soil Excavation

The unit costs provided in Table 4-1 for soil excavation were established by assuming 4.96E+04 ft^3 (1403.0 m^3) of soil is excavated from the site. This information was used to generate a cost per cubic meter for soil remediation. The equipment consists of an excavator that first moves the soil at the contaminated depth interface into a container or if necessary, a pile that is scooped into a staged shipping container. When filled, the container is moved from the excavation area with a forklift. Contamination reduction is assumed at 95%. The operation is performed using two equipment operators and two laborers. Costs for radiation protection support activities and supervision are also included. The formula associated with the cost elements is provided in Attachment A and the cost elements are provided in Attachment B.

4.5 Unit Cost Estimates

In order to effectively perform ALARA evaluations and remediation actions, unit cost values are required. These values are used to perform the NUREG-1727 cost-benefit analysis. Table 4-1 lists the unit costs of the remediation methods anticipated to be used at Maine Yankee.

The spreadsheets and information used to calculate values in Table 4-1 are summarized in Attachment 4B.

4.6 Benefit of Averted Dose

The remediation costs listed in Table 4-1 were compared to the benefit of the dose averted through the remediation action. The benefit of averted dose was calculated using

Equations D1 and D2 in NUREG-1727 as modified to account for multiple radionuclides. The parameters used in the equations were taken from NUREG-1727, Table D2.

Table 4-1
Unit Cost Estimates

Remediation Technique	Unit Cost[a]	Remarks
Pressure Washing and Vacuuming	$19.32/m^2$	Unit cost factors provided in Attachment B
Wiping/Washing[a]	$48.59/m^2$	Unit cost factors provided in Attachment B
Concrete Scabbling[b] (Upper Bound)	$106.23/m^2$	Unit cost factors provided in Attachment B. Needle gun activities are included with scabbling
Concrete Scabbling (Lower Bound)	$91.49/m^2$	Unit cost factors provided in Attachment B. Needle gun activities are included with scabbling
Grit Blasting Surfaces (Upper Bound)	$113.18/m^2$	Unit cost factors provided in Attachment B
Grit Blasting Surfaces (Upper Bound)	$87.80/m^2$	Unit cost factors provided in Attachment B
Grit Blasting Embedded/Buried Piping	$45.93/linear ft	Unit cost factors provided in Attachment B
Soil Excavation	$1837/m^3$	Unit cost factors provided in Attachment B

[a]The high cost for wiping and washing is due both to the labor intensive time (76% of the total) required and the costs of waste processing and disposal associated with the water used. Because radiation protection practices depict wiping as good practice for removing loose contamination, wiping is performed and not always as a function of an ALARA evaluation

[b]A contingency of 25% has been added to the person hour total for the activities

Combining Equations D1 and D2 results in the following. The method for adjusting this equation to account for multiple radionuclides is described in Attachment 4A, Section A.1.

$$B_{AD} = \$2000 x\, P_D\, x\, A x 0.025 x\, F\left(\frac{1-e^{-(r+l)N}}{r+l}\right)$$

Where: B_{AD} is the benefit of averted dose

Variables are as described in NUREG-1727, Table D2 . The detailed description of the calculation of the B_{AD} is provided in Attachment 4A, Sections A.3 and A.4.

4.7 ALARA Calculation Results

The final ALARA calculations were performed by comparing the total remediation cost to the benefit of averted dose using Equation D8 from NUREG-1727. The calculations are described in detail in Attachment 4A. The results for each remediation method, for both the Basement Fill and Building Occupancy scenarios, are provided in Table 4-2. Since the Conc/$DCGL_W$ values are greater than 1 for all remediation methods, no remediation below the NRC 25 mrem/y dose limit is required. As described in Attachment 4A, the results are also valid for the enhanced State criteria since lowering the dose criteria increases the Conc/$DCGL_W$ value.

Table 4-2
ALARA Evaluation Conc/$DCGL_W$ Results

Remediation Action	Basement Fill	Building Occupancy
Pressure Washing and Vacuuming	99.4	1.9
Wiping/Washing	312.6	6.00
Concrete Scabbling(Upper Bound)	143.9	2.76
Concrete Scabbling (Lower Bound)	123.9	2.38
Grit Blasting Surfaces (Upper Bound)	153.3	2.94
Grit Blasting Surfaces (Lower Bound)	118.9	2.28
Grit Blasting Embedded/Buried Piping	91.6[a]	--
Soil Excavation	733.9[b]	--

[a]Grit blasting of embedded piping is not evaluated for Building Occupancy
[b]Soil is evaluated using the Surface Soil values from NUREG-1727 Table C2.3.

4.8 References

4.8.1 Maine Erosion and Sediment Control Handbook for Construction, Best Practices Manual

4.8.2 NUREG 1727, "Decommissioning Standard Review Plan"

4.8.3 NUREG/CR 5884, "Revised Analyses of Decommissioning for the Reference Pressurized Water Reactor Power Station", Volume 2

ATTACHMENT 4A

Calculation of ALARA Residual Radioactivity Levels

This attachment provides the method for calculating residual radioactivity levels that are ALARA.

A.1 Residual Radioactivity Level ALARA Calculation

For the purposes of addressing multiple radionuclides, Equation D8 of NUREG-1727 as presented below is modified. The equation used for each spreadsheet is provided in Section A.1.1

(NUREG-1727, eq. D8).

$$\frac{Conc}{DCGL_W} = \frac{Cost_T}{(2000)(P_D)(0.025)(F)(A)} \; x \left[\frac{r + \lambda}{1 - e^{-(r+\lambda)N}} \right]$$

Where:

$\frac{Conc}{DCGL_W}$ = Fraction of $DCGL_W$ that is ALARA

$Cost_T$ = Total monetary cost of remediation action in dollars

2000 = The dollar value of a person-rem averted ($/person-rem)

P_D = Population density for the critical group scenario (persons per m^2)

0.025***** = Annual dose to an average member of the critical group from residual radioactivity at the $DCGL_W$ concentration (rem/yr)

*** NOTE:** This calculation is performed in compliance with 10 CFR 20, with regard to 25 mrem. If calculated using the 10 mrem annual dose limit an even wider divergence between cost and benefit would result.

F = Fraction of the residual radioactivity removed by remediation action.

A = Area (m^2) used to calculate the population density

r = Monetary discount rate (yr^{-1})

λ = Radiological decay constant for the radionuclide (yr^{-1})

N = Number of years over which collective averted dose is calculated (yr)

Values for the equation parameters may be found in NUREG-1727. The table below presents some of these generic values.

Table A-1
Equation Parameters

Equation Terms	NUREG-1727 Table D2 Values	
	Structure	Land
P_D	0.09	0.0004
r	0.07	0.03
N	70	1000

A.1.1 Equation D8 as used in Section 4.0 ALARA Evaluations

Equation D8, NUREG-1727 is presented below:

$$\frac{Conc}{DCGL_W} = \frac{Cost_T}{(\$2000)(P_D)(0.025)(F)(A)}\left[\frac{r+\lambda}{1-e^{-(r+\lambda)N}}\right]$$

$$= \frac{Cost_T}{(\$2000)(P_D)(0.025)(F)(A)}\left[\frac{\frac{r+\lambda}{1-e^{-(r+\lambda)N}}}{1}\right]$$

The right term of the equation is multiplied by 1 as illustrated in the term below.

$$= \frac{Cost_T}{(\$2000)(P_D)(0.025)(F)(A)} \left[\frac{\frac{r+\lambda}{1-e^{-(r+\lambda)N}}}{1} \right] \left[\frac{\frac{1-e^{-(r+\lambda)N}}{r+\lambda}}{\frac{1-e^{-(r+\lambda)N}}{r+\lambda}} \right]$$

Equation D8, NUREG-1727 is then expressed as:

$$\frac{Conc}{DCGL_w} = \frac{Cost_T}{(\$2000)(P_D)(0.025)(F)(A)\left[\frac{1-e^{-(r+\lambda)N}}{r+\lambda}\right]}$$

For multiple radionuclides the denominator must be summed over all radionuclides as shown below:

$$\frac{Conc}{DCGL_w} = \frac{Cost_T}{\sum_i^n (\$2000)(P_D)(0.025)(Df_i)(F)(A)\left[\frac{1-e^{-(r+\lambda_i)N}}{r+\lambda_i}\right]}$$

Where for :

Basement Fill Scenario:

$$Df_i = Dose\,Fraction_{basement\ fill} = \frac{(nf_i)(Unitized\,Dose\,Factor_i)}{\sum_i^n (nf_i)(Unitized\,Dose\,Factor_i)}$$

or, Building Occupancy;

$$Df_i = Dose\,Fraction_{building\,occupancy} = \frac{\frac{nf_i}{Screening\,Value_i}}{\sum_i^n \frac{nf_i}{Screening\,Value_i}}$$

And,

nf_i = nuclide fraction of the mixture radionuclide

Unitized Dose Factor$_{i \text{ (basement fill)}}$ = nuclide specific mrem/y per dpm/100 cm^2 (or pCi/g) results from the respective Unitized Dose Tables 6-2 through 6-5, and 6-7 through 6-8 of Section 6.0.

Screening Value$_{i \text{ (building occupancy)}}$ = nuclide specific Screening Values from Table 5.19 of NUREG-5512V3 or NUREG-1727 Table C2.2.

A.2 Calculation of Total Cost

(NUREG-1727 eq. D3)

In order to evaluate the cost of remediation actions NUREG-1727 provides the elements necessary to derive the costs that are compared to the benefits. The total cost is:

$$Cost_T = Cost_R + Cost_{WD} + Cost_{ACC} + C_{TF} + C_{WDose} + C_{PDose} + C_{other}$$

The terms for "Cost" are abbreviated as "C" below (NUREG-1727 eq. D4-D7)

C_T = Total costs (all the elements below)

C_R = Monetary cost of the remediation action (may include mobilization costs).

C_{WD} = Cost for generation and disposal of the waste generated by the action:

C_{WD} = V_A x C_V

V_A Is the volume of waste produced, remediated in units of m^3 and;

C_V is the cost of waste disposal per unit volume, including transport cost, in units of \$/m^3

C_{ACC} = Cost of worker accidents during the remediation action:

C_{ACC} = \$3,000,000 x F_W x T_A

\$3,000,000 is cost of a fatality equivalent to \$2,000/person-rem;

FW is the workplace fatality rate in fatalities/hour worked (4.20E-8/h) and;

T_A is the worker time required for remediation in units of worker-hours.

C_{TF} = Cost of traffic fatalities during transport of the waste:

C_{TF} = $3,000,000 x $_{VA}$ x [(F_T x D_T)/V_{ship}]

F_T is the fatality rate per kilometer traveled in units of fatalities/km (3.80E-8), for truck shipments and 1.70E-9 for hazardous material shipped by rail (Class 1 rail = 9.8E-07). The hazardous material value is conservatively used in the calculations; however, in any case C_{TF} does not significantly impact the evaluation results.

D_T is the round trip distance from Maine Yankee to Clive, Utah (Envirocare), in km;

V_{SHIP} is volume of truck shipment in m^3(estimated at 7.93 m^3); for rail the respective volumes used for concrete and soil are 92 and 122 m^3.

C_{WDose} = $2,000 x D_R x T:
C_{WDose} == is the cost of the remediation worker dose
$2000 is the cost of dose received by workers performing the remediation and transporting the waste to the disposal facility.

D_R is total effective dose equivalent rate to remediation workers in units of rem/hr and,

T is time worked to remediate the area in units of person-hours

C_{PDose} = Cost of the dose to the public from excavation, transport, and disposal of the waste.

C_{other} = Other appropriate costs for the particular situation.

A.3 Calculation of Benefits

(NUREG-1727 eq. D1)

The benefit from collective averted dose is calculated by determining the present worth of the future collective averted dose and multiplying it by a factor to convert the dose to monetary value:

$$B_{AD} = (\$2000)[PW(AD_{COLLECTIVE})]$$

Where:

B_{AD} = benefit from averted dose for a remediation action, in $

$2,000 = value in dollars of a person-rem averted

$PW(AD_{COLLECTIVE})$ = present worth of future collective averted dose

A.4 Present Worth of Future Collective Averted Dose

(NUREG-1727 eq. D2)
The present worth of the future collective averted dose is estimated by:

$$PW(AD_{Collective}) = (P_D)(A)(0.025)(F)\left[\frac{Conc}{DCGL_W}\right]\left[\frac{1-e^{-(r+\lambda)N}}{r+\lambda}\right]$$

Where:

P_D = population density for the critical group scenario in people per m^2

A = Area being evaluated in m^2 and represents the floor area only for the attached ALARA calculations.

0.025* = Annual dose to an average member of the critical group from residual radioactivity at the $DCGL_W$ concentration in rem/y

*** NOTE:** This calculation is performed in compliance with 10 CFR 20, with regard to 25 mrem. If calculated using the 10 mrem annual dose limit an even wider divergence between cost and benefit would result.

F = Fraction of the residual radioactivity removed by the remediation action. F may be considered to be the removable fraction for the remediation action being evaluated.

Conc = Average concentration of residual radioactivity being evaluated in units of activity per unit area for buildings or activity per unit volume for soil.

$DCGL_W$ = derived concentration guideline level that represents a dose of 25 mrem/yr to the average member of the critical group, in the same units as "Conc"

r = monetary discount rate in units of yr^{-1}

λ = radiological decay constant for the radionuclide in units of yr^{-1}

N = number of years over which the collective dose will be calculated.

A.5 ALARA Evaluation Spreadsheets and Development

Evaluation spreadsheets incorporate the B_{AD} results for each nuclide in the mixture relative to the remediation action. The spreadsheets, if necessary, may be modified to address changes or additional regulatory guidance. The spreadsheets provide input for fraction of activity removed, total cost and remediation surface area. Other nuclide fractions can be input to address changes in mixtures and the dose factors attributing to the respective scenario can be replaced as necessary.

The spreadsheets utilize the formula provided in Section A.1.1 and are designed to sum the B_{AD} results for each radionuclide in the mixture. To correctly do so requires that the individual dose fraction be multiplied by the annual dose (0.025 rem/y) to an average member of the critical group. The total cost for the remedial action when divided by the benefit of averted dose results in the Conc/DCGL as per NUREG-1727, Equation D2. The results determine the cost effectiveness of the remedial action. Values greater than unity are already ALARA.

For scabbling and grit blasting a reduction factor of 0.95 is used. Because a majority of contamination is near the surface of the media the abrasive or scabbling actions are expected to be very efficient. Pressure washing and washing and wiping activities are designed primarily for removal of loose contaminants - grimes and adhered oils and greases. These remediation actions are intended to remove all the loose contamination and the layers of grease and oils adhered to surfaces. These actions are expected to remove a minimum of 10.0 percent of the contaminants. The characterization results in Section 2.0 show that the average loose contamination fraction is less than 10.0 percent. NUREG-1727 uses a reduction factor of 20.0 percent for washing a building. The use of decontamination agents with liquid is anticipated to increase the reduction factor for the pressure washing and washing and wiping. Conservative values of 20.0 percent for washing and wiping and 25.0 percent for pressure washing are used in the evaluations.

The Basement Fill and Building Occupancy dose models were evaluated for each applicable remediation method. For the basement fill model the occupancy area is 10,000 m^2 since the resident farmer is the critical group. The area remediated is the assumed model area of 4182 m^2. Note that reducing this area size would reduce dose proportionally. For the Building Occupancy model the occupancy area is a 100 m^2 floor in a standing building; the remediation area is also assumed to be 100 m^2.

A.5.1 ALARA Spreadsheet Evaluations:

Pressure Washing (Basement Fill Model)

A removal fraction for pressure washing utilizing standard commercial pressure washing techniques is about 0.25. This reduction fraction is associated with removal of loose contamination as well as greases and oils adhered to surfaces. The ALARA Evaluation results show that the Conc/$DCGL_W$ result is 99.4 and ALARA.

Pressure Washing (Building Occupancy Model)

The results indicate that for a removal fraction of 0.25 the action is ALARA without remediation actions. As previously stated, the use of a removal fraction of 0.25 assumes that the operation will, at a minimum, remove all loose contamination and adhering grease and oil from suspect surfaces (NUREG-5884, M.27). The ALARA Evaluation shows that the Conc/$DCGL_W$ result is 1.9 and ALARA.

Washing and Wiping (Basement Fill Model)

The removal fraction used for washing and wiping is 0.20 and shows residual radioactivity being ALARA without taking any remediation actions. The ALARA Evaluation shows the Conc/$DCGL_W$ result is 312.6.

Washing and Wiping (Building Occupancy Model)

The building occupancy model as stated is based on a 100 m^2 area. The removal fraction is 0.20. The ALARA Evaluation results shows the Conc/$DCGL_W$ result is 6.0. Residual radioactivity is ALARA without taking any remediation actions.

Scabbling (Basement Fill Model)

The Scabbling evaluation is performed using the maximum expected scabble depth and the manpower and equipment cost using a standard contingency of 1.25. The associated total cost when compared to the benefit of averted dose is determined to be ALARA without taking remediation actions. The second evaluation for scabbling evaluates the activity using one half of the maximum expected depth using the same manpower and equipment hours associated with the remediation rate. The cost for compressor and consumables at 10% of the equipment cost is not used (a cost reduction of ~14%). The results of the evaluation again show that the action is still ALARA without remediation actions.

Costs are based on assuming the entire surface area of the three foot below grade structure is scabbled (this area size assumption is used for all surface remediation activities). This is a conservative assumption since maximizing remediated area results in the lowest unit cost. The ALARA Evaluation shows the Conc/$DCGL_W$ results are 143.9 and 123.9, respectively.

Scabbling (Building Occupancy Model)

Scabbling conditions for bounding are the same as the basement fill model. The only changes are unit costs and evaluation area are 100 m^2. The results of the evaluation show the action is still ALARA without remediation actions. The ALARA Evaluation shows the Conc/$DCGL_W$ results are 2.76 and 2.38 respectively.

Embedded Piping Grit Blasting (Basement Fill Model)

Embedded and buried piping assumes a reduction fraction of 0.95. The total linear feet of piping is used (6,158 feet). The spreadsheet utilizes the same surface area as do other evaluations for the basement fill scenario. The cost basis is per linear foot. The ALARA Evaluation result for the Conc/$DCGL_W$ is 91.6 and already ALARA.

Surface Grit Blasting (Basement Fill Model)

Evaluation for surface grit blasting utilizes the same area and removal fractions as for scabbling. The results of the evaluation show the action is ALARA without remediation actions. The ALARA Evaluation shows the Conc/$DCGL_W$ results are 153.3 and 118.9 for the upper and lower bound cost contingency evaluations, respectively.

Surface Grit Blasting (Building Occupancy Model)

Evaluation for surface grit blasting utilizes the same area and removal fractions as for scabbling. The results of the evaluation again show the action is still ALARA without remediation actions. The ALARA Evaluation results shows the Conc/$DCGL_W$ results are 2.94 and 2.28 for the upper and lower bound cost contingency evaluations, respectively.

Soil Excavation

Due to high removal and shipping costs, excavation of significant quantities of soil from the site show that the residual radioactivity is ALARA without additional actions. The reduction fraction used is 0.95. The amount of soil expected to be removed is 1,403.1 m^3 or about 94 percent of what would be removed from an area 10,000 m^2 by 0.15 m deep. The ALARA Evaluation results show the Conc/$DCGL_W$ results is 733.9.

For all actions evaluated the conditions utilize 25 mrem per year as the dose to the critical group. If the annual dose criteria is changed to 10 mrem in the evaluation equation the margin for the action being ALARA without remediation actions is significantly greater. Tables A-2 through A-15 are the ALARA Evaluation Spreadsheets for each of the above evaluations.

A.5.2 Examination of Differential Solubility for Specific Decontamination Actions

To determine if differential solubility for specific nuclides could affect the reduction of specific radionuclides in the mixture, those nuclides expected to exhibit the most preferential solubility (H-3, Sr-90, Cs-134 and Cs-137) were examined. For this sensitivity analysis both washing and wiping, and pressure washing actions were used with the building occupancy scenario. These scenarios provided the lowest Conc/DCGL values. For the specific nuclides the removal rate was doubled. The analysis showed that, while the Conc/DCGL value was reduced by approximately 46 percent the conclusion is the same as that using the initially assigned values (Conc/DCGL is >1.0).

Table A-2

Basement Fill Scenario

Pressure Washing Remediation Activity
Condition (removal fraction "F"@ 0.25)
A =10k m^2, r = 0.03, N =1000, P_D = 0.0004
PWAD4prwfill.wb3)
4/26/01

ALARA EVALUATION

Enter fraction of activity removed by remedial action ==> 0.25

Enter Occupancy Area in m^2 ===========> 10,000

Enter total cost (C_T, in dollars) of Action(s) ==========> $80,796

Remediation Cost and Area

Unit Cost/M^2	Actual Area M^2
$19.32	4182.0

Basement Fill Scenario

nuclide	halflife[a] (yrs)	λ (yrs^{-1})[b]	(r + λ)	(r + λ)N	e -(r + λ)N]	[1-e$^{-(r+λ)N}$]	[1-e-(r+λ)N]/(r+λ)	nuclide		Nuclide B_{AD}	Nuclide Fraction	Unitized Dose Factor (UDF)[c]	nf(UDF)	UDF/ Sum (UDF)
H-3	1.236E+01	5.607E-02	8.607E-02	8.607E+01	4.167E-38	1.000E+00	**1.162E+01**	H-3		2.410E+01	2.36E-02	3.35E-05	7.89E-07	4.15E-02
Fe-55	2.685E+00	2.582E-01	2.882E-01	2.882E+02	7.166E-126	1.000E+00	**3.470E+00**	Fe-55		2.566E-02	4.81E-03	5.84E-07	2.81E-09	1.48E-04
Co-57	7.417E-01	9.345E-01	9.645E-01	9.645E+02	0.000E+00	1.000E+00	**1.037E+00**	Co-57		2.023E-03	3.06E-04	2.42E-06	7.43E-10	3.90E-05
Co-60	5.270E+00	1.315E-01	1.615E-01	1.615E+02	7.071E-71	1.000E+00	**6.191E+00**	Co-60		5.698E+01	5.84E-02	5.99E-05	3.50E-06	1.84E-01
Ni-63	1.001E+02	6.925E-03	3.692E-02	3.692E+01	9.202E-17	1.000E+00	**2.708E+01**	Ni-63		2.915E+01	3.55E-01	1.15E-06	4.10E-07	2.15E-02
Sr-90	2.882E+01	2.405E-02	5.405E-02	5.405E+01	3.357E-24	1.000E+00	**1.850E+01**	Sr-90		8.346E+01	2.80E-03	6.12E-04	1.72E-06	9.02E-02
Cs-134	2.062E+00	3.362E-01	3.662E-01	3.662E+02	9.577E-160	1.000E+00	**2.731E+00**	Cs-134		1.097E+00	4.55E-03	3.36E-05	1.53E-07	8.03E-03
Cs-137	3.017E+01	2.297E-02	5.297E-02	5.297E+01	9.878E-24	1.000E+00	**1.888E+01**	Cs-137		6.177E+02	5.50E-01	2.26E-05	1.24E-05	6.54E-01
						Mixture Total: Benefit of Averted Dose B_{AD} ===>				**$812.56**	1.00E+00			
						Conc/DCGL$_W$ ==============>				**99.43**	Sum Check	Sum	1.90E-05	1.00E+00

a: Table of the Isotopes, Seventh Edition, Lederer et al. 1978; b: Lambda = 0.69315/t½;
c: From Table 6-2,unitized annual dose rate for contaminated concrete per dpm/100 centimeters squared

Table A-3

Building Occupancy Scenario

Pressure Washing Remediation Activity
Condition (removal fraction "F"@ 0.25)
A=100 m^2, r =0.07, N=70, P_D = 0.09
PWAD4prwbo.wb3)
4/26/01

ALARA EVALUATION

Enter fraction of activity removed by remedial action == 0.25

Enter Occupancy Area in m^2 ===========> 100

Enter total cost (C_T, in dollars) of Action(s) ========== $1,932

Remediation Cost and Area

Unit Cost/M^2	ctual Area M
$19.32	100.0

Building Occupancy Scenario

nuclide	halflife[a] (yrs)	λ (yrs^{-1})[b]	(r + λ)	(r + λ)N	e -(r + λ)N]	[1-e$^{-(r+λ)N}$]	[1-e-(r+λ)N]/(r+λ)	nuclide		Nuclide B_{AD}	Nuclide Fraction	Screening Value (SC)[c]	nf/SC	SC/sum[nf/SC]
H-3	1.236E+01	5.607E-02	**1.261E-01**	8.825E+00	1.470E-04	9.999E-01	**7.931E+00**	H-3		6.089E-03	2.36E-02	1.200E+08	1.96E-10	6.82E-06
Fe-55	2.685E+00	2.582E-01	**3.282E-01**	2.297E+01	1.056E-10	1.000E+00	**3.047E+00**	Fe-55		1.275E-02	4.81E-03	4.50E+06	1.07E-09	3.72E-05
Co-57	7.417E-01	9.345E-01	**1.005E+00**	7.032E+01	2.893E-31	1.000E+00	**9.955E-01**	Co-57		5.683E-03	3.06E-04	2.10E+05	1.46E-09	5.07E-05
Co-60	5.270E+00	1.315E-01	**2.015E-01**	1.411E+01	7.472E-07	1.000E+00	**4.962E+00**	Co-60		1.597E+02	5.84E-02	7.100E+03	8.23E-06	2.86E-01
Ni-63	1.001E+02	6.925E-03	**7.692E-02**	5.385E+00	4.586E-03	9.954E-01	**1.294E+01**	Ni-63		9.990E+00	3.55E-01	1.800E+06	1.97E-07	6.86E-03
Sr-90	2.882E+01	2.405E-02	**9.405E-02**	6.584E+00	1.383E-03	9.986E-01	**1.062E+01**	Sr-90		1.338E+01	2.80E-03	8.700E+03	3.22E-07	1.12E-02
Cs-134	2.062E+00	3.362E-01	**4.062E-01**	2.843E+01	4.494E-13	1.000E+00	**2.462E+00**	Cs-134		3.449E+00	4.55E-03	1.270E+04	3.58E-07	1.25E-02
Cs-137	3.017E+01	2.297E-02	**9.297E-02**	6.508E+00	1.491E-03	9.985E-01	**1.074E+01**	Cs-137		8.256E+02	5.50E-01	2.800E+04	1.97E-05	6.83E-01
						Mixture Total: Benefit of Averted Dose B_{AD} :				**$1,012.13**	1.00E+00			
						Conc/DCGL$_W$ =============				**1.91**	Sum Check	Sum	2.88E-05	1.00E+00

a: Table of the Isotopes, Seventh Edition, Lederer et al. 1978; b: Lambda = 0.69315/t½;
c: From NUREG-1727 Table C2.2, dpm/100 centimeters squared

Table A-4

Basement Fill Scenario

Washing and Wiping Remediation Activity
Condition (removal fraction "F"@ 0.25)
A =10k m^2, r = 0.03, N =1000, P_D = 0.0004
PWAD4wwfill.wb3)
4/26/01

ALARA EVALUATION

Enter fraction of activity removed by remedial action ==> 0.2

Enter Occupancy Area in m^2 ===========> 10,000

Enter total cost (C_T, in dollars) of Action(s) ===========> $203,203

Remediation Cost and Area

Unit Cost/M^2	Actual Area M^2
$48.59	4182.0

Basement Fill Scenario

nuclide	halflife[a] (yrs)	λ (yrs^{-1})[b]	(r + λ)	(r + λ)N	e -(r + λ)N]	[1-e$^{-(r+λ)N}$]	[1-e-(r+λ)N]/(r+λ)	nuclide		Nuclide B_{AD}	Nuclide Fraction	Unitized Dose[c] Factor (UDF)	nf(UDF)	UDF/ Sum (UDF)
H-3	1.236E+01	5.607E-02	**8.607E-02**	8.607E+01	4.167E-38	1.000E+00	**1.162E+01**	H-3		1.928E+01	2.36E-02	3.35E-05	7.89E-07	4.15E-02
Fe-55	2.685E+00	2.582E-01	**2.882E-01**	2.882E+02	7.166E-126	1.000E+00	**3.470E+00**	Fe-55		2.053E-02	4.81E-03	5.84E-07	2.81E-09	1.48E-04
Co-57	7.417E-01	9.345E-01	**9.645E-01**	9.645E+02	0.000E+00	1.000E+00	**1.037E+00**	Co-57		1.619E-03	3.06E-04	2.42E-06	7.43E-10	3.90E-05
Co-60	5.270E+00	1.315E-01	**1.615E-01**	1.615E+02	7.071E-71	1.000E+00	**6.191E+00**	Co-60		4.559E+01	5.84E-02	5.99E-05	3.50E-06	1.84E-01
Ni-63	1.001E+02	6.925E-03	**3.692E-02**	3.692E+01	9.202E-17	1.000E+00	**2.708E+01**	Ni-63		2.332E+01	3.55E-01	1.15E-06	4.10E-07	2.15E-02
Sr-90	2.882E+01	2.405E-02	**5.405E-02**	5.405E+01	3.357E-24	1.000E+00	**1.850E+01**	Sr-90		6.677E+01	2.80E-03	6.12E-04	1.72E-06	9.02E-02
Cs-134	2.062E+00	3.362E-01	**3.662E-01**	3.662E+02	9.577E-160	1.000E+00	**2.731E+00**	Cs-134		8.775E-01	4.55E-03	3.36E-05	1.53E-07	8.03E-03
Cs-137	3.017E+01	2.297E-02	**5.297E-02**	5.297E+01	9.878E-24	1.000E+00	**1.888E+01**	Cs-137		4.942E+02	5.50E-01	2.26E-05	1.24E-05	6.54E-01

Mixture Total: Benefit of Averted Dose B_{AD} ===> **$650.05** | 1.00E+00

Conc/$DCGL_W$ ==============> **312.60** | Sum Check | Sum 1.90E-05 | 1.00E+00

a: Table of the Isotopes, Seventh Edition, Lederer et al. 1978; b: Lambda = 0.69315/t½;

c: From Table 6-2,unitized annual dose rate for contaminated concrete per dpm/100 centimeters squared

Table A-5

Building Occupancy Scenario

Washing and Wiping Remediation Activity
Condition (removal fraction "F"@ 0.25)
A=100 m^2, r =0.07, N=70, P_D = 0.09
PWAD4wwbo.wb3)
04/26/01

ALARA EVALUATION

Enter fraction of activity removed by remedial action ==> 0.2

Enter Occupancy Area in m^2 ===========> 100

Enter total cost (C_T, in dollars) of Action(s) ========== $4,859

Remediation Cost and Area

Unit Cost/M^2	Actual Area M
$48.59	100.0

Building Occupancy Scenario

nuclide	halflife[a] (yrs)	λ (yrs^{-1})[b]	(r + λ)	(r + λ)N	e -(r + λ)N]	[1-e$^{-(r+λ)N}$]	[1-e-(r+λ)N]/(r+λ)	nuclide		Nuclide B_{AD}	Nuclide Fraction	Screening[c] Value (SC)	nf/SC	SC/sum[nf/SC]
H-3	1.236E+01	5.607E-02	**1.261E-01**	8.825E+00	1.470E-04	9.999E-01	**7.931E+00**	H-3		4.871E-03	2.36E-02	1.200E+08	1.96E-10	6.82E-06
Fe-55	2.685E+00	2.582E-01	**3.282E-01**	2.297E+01	1.056E-10	1.000E+00	**3.047E+00**	Fe-55		1.020E-02	4.81E-03	4.50E+06	1.07E-09	3.72E-05
Co-57	7.417E-01	9.345E-01	**1.005E+00**	7.032E+01	2.893E-31	1.000E+00	**9.955E-01**	Co-57		4.546E-03	3.06E-04	2.10E+05	1.46E-09	5.07E-05
Co-60	5.270E+00	1.315E-01	**2.015E-01**	1.411E+01	7.472E-07	1.000E+00	**4.962E+00**	Co-60		1.278E+02	5.84E-02	7.100E+03	8.23E-06	2.86E-01
Ni-63	1.001E+02	6.925E-03	**7.692E-02**	5.385E+00	4.586E-03	9.954E-01	**1.294E+01**	Ni-63		7.992E+00	3.55E-01	1.800E+06	1.97E-07	6.86E-03
Sr-90	2.882E+01	2.405E-02	**9.405E-02**	6.584E+00	1.383E-03	9.986E-01	**1.062E+01**	Sr-90		1.070E+01	2.80E-03	8.700E+03	3.22E-07	1.12E-02
Cs-134	2.062E+00	3.362E-01	**4.062E-01**	2.843E+01	4.494E-13	1.000E+00	**2.462E+00**	Cs-134		2.759E+00	4.55E-03	1.270E+04	3.58E-07	1.25E-02
Cs-137	3.017E+01	2.297E-02	**9.297E-02**	6.508E+00	1.491E-03	9.985E-01	**1.074E+01**	Cs-137		6.605E+02	5.50E-01	2.800E+04	1.97E-05	6.83E-01

Mixture Total: Benefit of Averted Dose B_{AD} = **$809.70** | 1.00E+00

Conc/$DCGL_W$ ============== **6.00** | Sum Check | Sum 2.88E-05 | 1.00E+00

a: Table of the Isotopes, Seventh Edition, Lederer et al. 1978; b: Lambda = 0.69315/t½;

c: From NUREG-1727 Table C2.2, dpm/100 centimeters squared

Table A-6

Basement Fill Scenario

Scabbling Remediation Activity
Bounding Condition (remove 0.25 inches of concrete surface)
Using upper bound cost contingency
PWAD4scabfil.wb3)
A=10k m^2, r =0.03, N=1000, Pd = 0.0004
4/26/01

ALARA EVALUATION

Enter fraction of activity removed by remedial action ==> 0.95

Enter Occupancy Area in m^2 ===========> 10,000

Enter total cost (C_T, in dollars) of Action(s) ===========> $444,254

Remediation Cost and Area

Unit Cost/M²	Actual Area M²
$106.23	4182.0

Basement Fill Scenario

nuclide	halflife[a] (yrs)	λ (yrs^{-1})[b]	(r + λ)	(r + λ)N	e -(r + λ)N]	[1-e$^{-(r+λ)N}$]	[1-e-(r+λ)N]/(r+λ)	nuclide		Nuclide B_{AD}	Nuclide Fraction	Unitized Dose[c] Factor (UDF)	nf(UDF)	UDF/ Sum (UDF)
H-3	1.236E+01	5.607E-02	**8.607E-02**	8.607E+01	4.167E-38	1.000E+00	**1.162E+01**	H-3		9.158E+01	2.36E-02	3.35E-05	7.89E-07	4.15E-02
Fe-55	2.685E+00	2.582E-01	**2.882E-01**	2.882E+02	7.166E-126	1.000E+00	**3.470E+00**	Fe-55		9.750E-02	4.81E-03	5.84E-07	2.81E-09	1.48E-04
Co-57	7.417E-01	9.345E-01	**9.645E-01**	9.645E+02	0.000E+00	1.000E+00	**1.037E+00**	Co-57		7.689E-03	3.06E-04	2.42E-06	7.43E-10	3.90E-05
Co-60	5.270E+00	1.315E-01	**1.615E-01**	1.615E+02	7.071E-71	1.000E+00	**6.191E+00**	Co-60		2.165E+02	5.84E-02	5.99E-05	3.50E-06	1.84E-01
Ni-63	1.001E+02	6.925E-03	**3.692E-02**	3.692E+01	9.202E-17	1.000E+00	**2.708E+01**	Ni-63		1.108E+02	3.55E-01	1.15E-06	4.10E-07	2.15E-02
Sr-90	2.882E+01	2.405E-02	**5.405E-02**	5.405E+01	3.357E-24	1.000E+00	**1.850E+01**	Sr-90		3.171E+02	2.80E-03	6.12E-04	1.72E-06	9.02E-02
Cs-134	2.062E+00	3.362E-01	**3.662E-01**	3.662E+02	9.577E-160	1.000E+00	**2.731E+00**	Cs-134		4.168E+00	4.55E-03	3.36E-05	1.53E-07	8.03E-03
Cs-137	3.017E+01	2.297E-02	**5.297E-02**	5.297E+01	9.878E-24	1.000E+00	**1.888E+01**	Cs-137		2.347E+03	5.50E-01	2.26E-05	1.24E-05	6.54E-01

Mixture Total: Benefit of Averted Dose B_{AD} ===> **$3,087.72** 1.00E+00

Conc/DCGL$_W$ ==============> **143.88** Sum Check Sum 1.90E-05 1.00E+00

a: Table of the Isotopes, Seventh Edition, Lederer et al. 1978; b: Lambda = 0.69315/t½;
c: From Table 6-2,unitized annual dose rate for contaminated concrete per dpm/100 centimeters squared

Table A-7

Basement Fill Scenario

Scabbling Remediation Activity
Bounding Condition (remove 0.125 inches of concrete surface)
Using lower bound cost (no contingency)
PWAD4scabfil.wb3)
A=10k m^2, r =0.03, N=1000, Pd = 0.0004
4/26/01

ALARA EVALUATION

Enter fraction of activity removed by remedial action ==> 0.95

Enter Occupancy Area in m^2 ===========> 10,000

Enter total cost (C_T, in dollars) of Action(s) ===========> $382,611

Remediation Cost and Area

Unit Cost/M²	Actual Area M²
$91.49	4182.0

Basement Fill Scenario

nuclide	halflife[a] (yrs)	λ (yrs^{-1})[b]	(r + λ)	(r + λ)N	e -(r + λ)N]	[1-e$^{-(r+λ)N}$]	[1-e-(r+λ)N]/(r+λ)	nuclide		Nuclide B_{AD}	Nuclide Fraction	Unitized Dose[c] Factor (UDF)	nf(UDF)	UDF/ Sum (UDF)
H-3	1.236E+01	5.607E-02	**8.607E-02**	8.607E+01	4.167E-38	1.000E+00	**1.162E+01**	H-3		9.158E+01	2.36E-02	3.35E-05	7.89E-07	4.15E-02
Fe-55	2.685E+00	2.582E-01	**2.882E-01**	2.882E+02	7.166E-126	1.000E+00	**3.470E+00**	Fe-55		9.750E-02	4.81E-03	5.84E-07	2.81E-09	1.48E-04
Co-57	7.417E-01	9.345E-01	**9.645E-01**	9.645E+02	0.000E+00	1.000E+00	**1.037E+00**	Co-57		7.689E-03	3.06E-04	2.42E-06	7.43E-10	3.90E-05
Co-60	5.270E+00	1.315E-01	**1.615E-01**	1.615E+02	7.071E-71	1.000E+00	**6.191E+00**	Co-60		2.165E+02	5.84E-02	5.99E-05	3.50E-06	1.84E-01
Ni-63	1.001E+02	6.925E-03	**3.692E-02**	3.692E+01	9.202E-17	1.000E+00	**2.708E+01**	Ni-63		1.108E+02	3.55E-01	1.15E-06	4.10E-07	2.15E-02
Sr-90	2.882E+01	2.405E-02	**5.405E-02**	5.405E+01	3.357E-24	1.000E+00	**1.850E+01**	Sr-90		3.171E+02	2.80E-03	6.12E-04	1.72E-06	9.02E-02
Cs-134	2.062E+00	3.362E-01	**3.662E-01**	3.662E+02	9.577E-160	1.000E+00	**2.731E+00**	Cs-134		4.168E+00	4.55E-03	3.36E-05	1.53E-07	8.03E-03
Cs-137	3.017E+01	2.297E-02	**5.297E-02**	5.297E+01	9.878E-24	1.000E+00	**1.888E+01**	Cs-137		2.347E+03	5.50E-01	2.26E-05	1.24E-05	6.54E-01

Mixture Total: Benefit of Averted Dose B_{AD} ===> **$3,087.72** 1.00E+00

Conc/DCGL$_W$ ==============> **123.91** Sum Check Sum 1.90E-05 1.00E+00

a: Table of the Isotopes, Seventh Edition, Lederer et al. 1978; b: Lambda = 0.69315/t½;
c: From Table 6-2,unitized annual dose rate for contaminated concrete per dpm/100 centimeters squared

Table A-8

Building Occupancy Scenario

Scabbling Remediation Activity

ALARA EVALUATION

Bounding Condition (remove 0.25 inches of concrete surface)

A=100 m^2, r =0.07, N=70, P_D = 0.09
PWAD4scabo.wb3)
4/26/01

Enter fraction of activity removed by remedial action ==> 0.95

Enter Occupancy Area in m^2 ============> 100

Enter total cost (C_T, in dollars) of Action(s) ===========> $10,623

Remediation Cost and Area

Unit Cost/M^2	Actual Area M^2
$106.23	100.0

Building Occupancy Scenario

nuclide	halflife[a] (yrs)	λ (yrs^{-1})[b]	(r + λ)	(r + λ)N	e -(r + λ)N]	[1-e$^{-(r+λ)N}$]	[1-e-(r+λ)N]/(r+λ)	nuclide		Nuclide B_{AD}	Nuclide Fraction	Screening[c] Value (SC)	n*f*/SC	SC/sum[nf/SC]
H-3	1.236E+01	5.607E-02	**1.261E-01**	8.825E+00	1.470E-04	9.999E-01	**7.931E+00**	H-3		2.314E-02	2.36E-02	1.200E+08	1.96E-10	6.82E-06
Fe-55	2.685E+00	2.582E-01	**3.282E-01**	2.297E+01	1.056E-10	1.000E+00	**3.047E+00**	Fe-55		4.846E-02	4.81E-03	4.50E+06	1.07E-09	3.72E-05
Co-57	7.417E-01	9.345E-01	**1.005E+00**	7.032E+01	2.893E-31	1.000E+00	**9.955E-01**	Co-57		2.159E-02	3.06E-04	2.10E+05	1.46E-09	5.07E-05
Co-60	5.270E+00	1.315E-01	**2.015E-01**	1.411E+01	7.472E-07	1.000E+00	**4.962E+00**	Co-60		6.069E+02	5.84E-02	7.100E+03	8.23E-06	2.86E-01
Ni-63	1.001E+02	6.925E-03	**7.692E-02**	5.385E+00	4.586E-03	9.954E-01	**1.294E+01**	Ni-63		3.796E+01	3.55E-01	1.800E+06	1.97E-07	6.86E-03
Sr-90	2.882E+01	2.405E-02	**9.405E-02**	6.584E+00	1.383E-03	9.986E-01	**1.062E+01**	Sr-90		5.084E+01	2.80E-03	8.700E+03	3.22E-07	1.12E-02
Cs-134	2.062E+00	3.362E-01	**4.062E-01**	2.843E+01	4.494E-13	1.000E+00	**2.462E+00**	Cs-134		1.311E+01	4.55E-03	1.270E+04	3.58E-07	1.25E-02
Cs-137	3.017E+01	2.297E-02	**9.297E-02**	6.508E+00	1.491E-03	9.985E-01	**1.074E+01**	Cs-137		3.137E+03	5.50E-01	2.800E+04	1.97E-05	6.83E-01

Total: Benefit of Averted Dose B_{AD} =====> **$3,846.09** 1.00E+00

Conc/DCGL$_W$ =============> **2.76** Sum Check Sum 2.88E-05 1.00E+00

a: Table of the Isotopes, Seventh Edition, Lederer et al. 1978; b: Lambda = 0.69315/t½;
c: From NUREG-1727 Table C2.2, dpm/100 centimeters squared

Table A-9

Building Occupancy Scenario

Scabbling Remediation Activity

ALARA EVALUATION

Bounding Condition (remove 0.125 inches of concrete surface)

A=100 m^2, r =0.07, N=70, P_D = 0.09
PWAD4scabo.wb3)
4/26/01

Enter fraction of activity removed by remedial action == 0.95

Enter Occupancy Area in m^2 ===========> 100

Enter total cost (C_T, in dollars) of Action(s) ========== $9,149

Remediation Cost and Area

Unit Cost/M^2	Actual Area M^2
$91.49	100.0

Building Occupancy Scenario

nuclide	halflife[a] (yrs)	λ (yrs^{-1})[b]	(r + λ)	(r + λ)N	e -(r + λ)N]	[1-e$^{-(r+λ)N}$]	[1-e-(r+λ)N]/(r+λ)	nuclide		Nuclide B_{AD}	Nuclide Fraction	Screening[c] Value (SC)	n*f*/SC	SC/sum[nf/SC]
H-3	1.236E+01	5.607E-02	**1.261E-01**	8.825E+00	1.470E-04	9.999E-01	**7.931E+00**	H-3		2.314E-02	2.36E-02	1.200E+08	1.96E-10	6.82E-06
Fe-55	2.685E+00	2.582E-01	**3.282E-01**	2.297E+01	1.056E-10	1.000E+00	**3.047E+00**	Fe-55		4.846E-02	4.81E-03	4.50E+06	1.07E-09	3.72E-05
Co-57	7.417E-01	9.345E-01	**1.005E+00**	7.032E+01	2.893E-31	1.000E+00	**9.955E-01**	Co-57		2.159E-02	3.06E-04	2.10E+05	1.46E-09	5.07E-05
Co-60	5.270E+00	1.315E-01	**2.015E-01**	1.411E+01	7.472E-07	1.000E+00	**4.962E+00**	Co-60		6.069E+02	5.84E-02	7.100E+03	8.23E-06	2.86E-01
Ni-63	1.001E+02	6.925E-03	**7.692E-02**	5.385E+00	4.586E-03	9.954E-01	**1.294E+01**	Ni-63		3.796E+01	3.55E-01	1.800E+06	1.97E-07	6.86E-03
Sr-90	2.882E+01	2.405E-02	**9.405E-02**	6.584E+00	1.383E-03	9.986E-01	**1.062E+01**	Sr-90		5.084E+01	2.80E-03	8.700E+03	3.22E-07	1.12E-02
Cs-134	2.062E+00	3.362E-01	**4.062E-01**	2.843E+01	4.494E-13	1.000E+00	**2.462E+00**	Cs-134		1.311E+01	4.55E-03	1.270E+04	3.58E-07	1.25E-02
Cs-137	3.017E+01	2.297E-02	**9.297E-02**	6.508E+00	1.491E-03	9.985E-01	**1.074E+01**	Cs-137		3.137E+03	5.50E-01	2.800E+04	1.97E-05	6.83E-01

Mixture Total: Benefit of Averted Dose B_{AD} = **$3,846.09** 1.00E+00

Conc/DCGL$_W$ =============> **2.38** Sum Check Sum 2.88E-05 1.00E+00

a: Table of the Isotopes, Seventh Edition, Lederer et al. 1978; b: Lambda = 0.69315/t½;
c: From NUREG-1727 Table C2.2, dpm/100 centimeters squared

Table A-10

Basement Fill Scenario

Surface Grit Blasting Remediation Activity
Using upper bound cost contingency
PWAD4surgritfil.wb3)
A=10k m^2, r =0.03, N=1000, Pd = 0.0004
4/26/01

ALARA EVALUATION

Enter fraction of activity removed by remedial action == 0.95

Enter Occupancy Area in m^2 ===========> 10,000

Enter total cost (C_T, in dollars) of Action(s) ========== $473,319

Remediation Cost and Area

Unit Cost/M^2	Actual Area M^2
$113.18	4182.0

Basement Fill Scenario

nuclide	halflife[a] (yrs)	λ (yrs^{-1})[b]	(r + λ)	(r + λ)N	e -(r + λ)N]	[1-$e^{-(r+λ)N}$]	[1-e-(r+λ)N]/(r+λ)	nuclide		Nuclide B_{AD}	Nuclide Fraction	Unitized Dose[c] Factor (UDF)	nf(UDF)	UDF/ Sum (UDF)
H-3	1.236E+01	5.607E-02	**8.607E-02**	8.607E+01	4.167E-38	1.000E+00	**1.162E+01**	H-3		9.158E+01	2.36E-02	3.35E-05	7.89E-07	4.15E-02
Fe-55	2.685E+00	2.582E-01	**2.882E-01**	2.882E+02	7.166E-126	1.000E+00	**3.470E+00**	Fe-55		9.750E-02	4.81E-03	5.84E-07	2.81E-09	1.48E-04
Co-57	7.417E-01	9.345E-01	**9.645E-01**	9.645E+02	0.000E+00	1.000E+00	**1.037E+00**	Co-57		7.689E-03	3.06E-04	2.42E-06	7.43E-10	3.90E-05
Co-60	5.270E+00	1.315E-01	**1.615E-01**	1.615E+02	7.071E-71	1.000E+00	**6.191E+00**	Co-60		2.165E+02	5.84E-02	5.99E-05	3.50E-06	1.84E-01
Ni-63	1.001E+02	6.925E-03	**3.692E-02**	3.692E+01	9.202E-17	1.000E+00	**2.708E+01**	Ni-63		1.108E+02	3.55E-01	1.15E-06	4.10E-07	2.15E-02
Sr-90	2.882E+01	2.405E-02	**5.405E-02**	5.405E+01	3.357E-24	1.000E+00	**1.850E+01**	Sr-90		3.171E+02	2.80E-03	6.12E-04	1.72E-06	9.02E-02
Cs-134	2.062E+00	3.362E-01	**3.662E-01**	3.662E+02	9.577E-160	1.000E+00	**2.731E+00**	Cs-134		4.168E+00	4.55E-03	3.36E-05	1.53E-07	8.03E-03
Cs-137	3.017E+01	2.297E-02	**5.297E-02**	5.297E+01	9.878E-24	1.000E+00	**1.888E+01**	Cs-137		2.347E+03	5.50E-01	2.26E-05	1.24E-05	6.54E-01

Mixture Total: Benefit of Averted Dose B_{AD}	**$3,087.72**	1.00E+00			
Conc/DCGL$_W$ ============	**153.29**	Sum Check	Sum	1.90E-05	1.00E+00

a: Table of the Isotopes, Seventh Edition, Lederer et al. 1978; b: Lambda = 0.69315/t½;
c: From Table 6-2,unitized annual dose rate for contaminated concrete per dpm/100 centimeters squared

Table A-11

Basement Fill Scenario

Surface Grit Blasting Remediation Activity
Using lower bound cost contingency
PWAD4surgritfil.wb3)
A=10k m^2, r =0.03, N=1000, Pd = 0.0004
4/26/01

ALARA EVALUATION

Enter fraction of activity removed by remedial action == 0.95

Enter Occupancy Area in m^2 ===========> 10,000

Enter total cost (C_T, in dollars) of Action(s) ========== $367,180

Remediation Cost and Area

Unit Cost/M^2	Actual Area M^2
$87.80	4182.0

Basement Fill Scenario

nuclide	halflife[a] (yrs)	λ (yrs^{-1})[b]	(r + λ)	(r + λ)N	e -(r + λ)N]	[1-$e^{-(r+λ)N}$]	[1-e-(r+λ)N]/(r+λ)	nuclide		Nuclide B_{AD}	Nuclide Fraction	Unitized Dose[c] Factor (UDF)	nf(UDF)	UDF/ Sum (UDF)
H-3	1.236E+01	5.607E-02	**8.607E-02**	8.607E+01	4.167E-38	1.000E+00	**1.162E+01**	H-3		9.158E+01	2.36E-02	3.35E-05	7.89E-07	4.15E-02
Fe-55	2.685E+00	2.582E-01	**2.882E-01**	2.882E+02	7.166E-126	1.000E+00	**3.470E+00**	Fe-55		9.750E-02	4.81E-03	5.84E-07	2.81E-09	1.48E-04
Co-57	7.417E-01	9.345E-01	**9.645E-01**	9.645E+02	0.000E+00	1.000E+00	**1.037E+00**	Co-57		7.689E-03	3.06E-04	2.42E-06	7.43E-10	3.90E-05
Co-60	5.270E+00	1.315E-01	**1.615E-01**	1.615E+02	7.071E-71	1.000E+00	**6.191E+00**	Co-60		2.165E+02	5.84E-02	5.99E-05	3.50E-06	1.84E-01
Ni-63	1.001E+02	6.925E-03	**3.692E-02**	3.692E+01	9.202E-17	1.000E+00	**2.708E+01**	Ni-63		1.108E+02	3.55E-01	1.15E-06	4.10E-07	2.15E-02
Sr-90	2.882E+01	2.405E-02	**5.405E-02**	5.405E+01	3.357E-24	1.000E+00	**1.850E+01**	Sr-90		3.171E+02	2.80E-03	6.12E-04	1.72E-06	9.02E-02
Cs-134	2.062E+00	3.362E-01	**3.662E-01**	3.662E+02	9.577E-160	1.000E+00	**2.731E+00**	Cs-134		4.168E+00	4.55E-03	3.36E-05	1.53E-07	8.03E-03
Cs-137	3.017E+01	2.297E-02	**5.297E-02**	5.297E+01	9.878E-24	1.000E+00	**1.888E+01**	Cs-137		2.347E+03	5.50E-01	2.26E-05	1.24E-05	6.54E-01

Mixture Total: Benefit of Averted Dose B_{AD}	**$3,087.72**	1.00E+00			
Conc/DCGL$_W$ ============	**118.92**	Sum Check	Sum	1.90E-05	1.00E+00

a: Table of the Isotopes, Seventh Edition, Lederer et al. 1978; b: Lambda = 0.69315/t½;
c: From Table 6-2,unitized annual dose rate for contaminated concrete per dpm/100 centimeters squared

Table A-12

Building Occupancy

Surface Grit Blasting Remediation Activity
Using upper bound cost contingency
PWAD4surgritbo.wb3)
A=100 m^2, r =0.07, N=70, Pd = 0.09
4/26/01

ALARA EVALUATION

Enter fraction of activity removed by remedial action ==> 0.95

Enter Occupancy Area in m^2 ===========> 100

Enter total cost (C_T, in dollars) of Action(s) ===========> $11,318

Remediation Cost and Area

Unit Cost/M²	Actual Area M²
$113.18	100.0

Building Occupancy

nuclide	halflife[a] (yrs)	λ (yrs⁻¹)[b]	(r + λ)	(r + λ)N	e -(r + λ)N]	[1-e^-(r+λ)N]	[1-e-(r+λ)N]/(r+λ)	nuclide	Nuclide B_{AD}	Nuclide Fraction	Screening[c] Value (SC)	nf/SC	SC/sum[nf/SC]
H-3	1.236E+01	5.607E-02	**1.261E-01**	8.825E+00	1.470E-04	9.999E-01	**7.931E+00**	H-3	2.314E-02	2.36E-02	1.200E+08	1.96E-10	6.82E-06
Fe-55	2.685E+00	2.582E-01	**3.282E-01**	2.297E+01	1.056E-10	1.000E+00	**3.047E+00**	Fe-55	4.846E-02	4.81E-03	4.50E+06	1.07E-09	3.72E-05
Co-57	7.417E-01	9.345E-01	**1.005E+00**	7.032E+01	2.893E-31	1.000E+00	**9.955E-01**	Co-57	2.159E-02	3.06E-04	2.10E+05	1.46E-09	5.07E-05
Co-60	5.270E+00	1.315E-01	**2.015E-01**	1.411E+01	7.472E-07	1.000E+00	**4.962E+00**	Co-60	6.069E+02	5.84E-02	7.100E+03	8.23E-06	2.86E-01
Ni-63	1.001E+02	6.925E-03	**7.692E-02**	5.385E+00	4.586E-03	9.954E-01	**1.294E+01**	Ni-63	3.796E+01	3.55E-01	1.800E+06	1.97E-07	6.86E-03
Sr-90	2.882E+01	2.405E-02	**9.405E-02**	6.584E+00	1.383E-03	9.986E-01	**1.062E+01**	Sr-90	5.084E+01	2.80E-03	8.700E+03	3.22E-07	1.12E-02
Cs-134	2.062E+00	3.362E-01	**4.062E-01**	2.843E+01	4.494E-13	1.000E+00	**2.462E+00**	Cs-134	1.311E+01	4.55E-03	1.270E+04	3.58E-07	1.25E-02
Cs-137	3.017E+01	2.297E-02	**9.297E-02**	6.508E+00	1.491E-03	9.985E-01	**1.074E+01**	Cs-137	3.137E+03	5.50E-01	2.800E+04	1.97E-05	6.83E-01
						Mixture Total: Benefit of Averted Dose B_{AD} ===>			**$3,846.09**	1.00E+00			
						Conc/DCGLw ==============>			**2.94**	Sum Check	Sum	2.88E-05	1.00E+00

a: Table of the Isotopes, Seventh Edition, Lederer et al. 1978; b: Lambda = 0.69315/t½;
c: From NUREG-1727 Table C2.2, dpm/100 centimeters squared

Table A-13

Building Occupancy

Surface Grit Blasting Remediation Activity
Using lower bound cost contingency
PWAD4surgritbo.wb3)
A=100 m^2, r =0.07, N=70, Pd = 0.09
4/26/01

ALARA EVALUATION

Enter fraction of activity removed by remedial action ==> 0.95

Enter Occupancy Area in m^2 ===========> 100

Enter total cost (C_T, in dollars) of Action(s) ===========> $8,780

Remediation Cost and Area

Unit Cost/M²	Actual Area M²
$87.80	100.0

Building Occupancy

nuclide	halflife[a] (yrs)	λ (yrs⁻¹)[b]	(r + λ)	(r + λ)N	e -(r + λ)N]	[1-e^-(r+λ)N]	[1-e-(r+λ)N]/(r+λ)	nuclide	Nuclide B_{AD}	Nuclide Fraction	Screening[c] Value (SC)	nf/SC	SC/sum[nf/SC]
H-3	1.236E+01	5.607E-02	**1.261E-01**	8.825E+00	1.470E-04	9.999E-01	**7.931E+00**	H-3	2.314E-02	2.36E-02	1.200E+08	1.96E-10	6.82E-06
Fe-55	2.685E+00	2.582E-01	**3.282E-01**	2.297E+01	1.056E-10	1.000E+00	**3.047E+00**	Fe-55	4.846E-02	4.81E-03	4.50E+06	1.07E-09	3.72E-05
Co-57	7.417E-01	9.345E-01	**1.005E+00**	7.032E+01	2.893E-31	1.000E+00	**9.955E-01**	Co-57	2.159E-02	3.06E-04	2.10E+05	1.46E-09	5.07E-05
Co-60	5.270E+00	1.315E-01	**2.015E-01**	1.411E+01	7.472E-07	1.000E+00	**4.962E+00**	Co-60	6.069E+02	5.84E-02	7.100E+03	8.23E-06	2.86E-01
Ni-63	1.001E+02	6.925E-03	**7.692E-02**	5.385E+00	4.586E-03	9.954E-01	**1.294E+01**	Ni-63	3.796E+01	3.55E-01	1.800E+06	1.97E-07	6.86E-03
Sr-90	2.882E+01	2.405E-02	**9.405E-02**	6.584E+00	1.383E-03	9.986E-01	**1.062E+01**	Sr-90	5.084E+01	2.80E-03	8.700E+03	3.22E-07	1.12E-02
Cs-134	2.062E+00	3.362E-01	**4.062E-01**	2.843E+01	4.494E-13	1.000E+00	**2.462E+00**	Cs-134	1.311E+01	4.55E-03	1.270E+04	3.58E-07	1.25E-02
Cs-137	3.017E+01	2.297E-02	**9.297E-02**	6.508E+00	1.491E-03	9.985E-01	**1.074E+01**	Cs-137	3.137E+03	5.50E-01	2.800E+04	1.97E-05	6.83E-01
						Mixture Total: Benefit of Averted Dose B_{AD} ===>			**$3,846.09**	1.00E+00			
						Conc/DCGLw ==============>			**2.28**	Sum Check	Sum	2.88E-05	1.00E+00

a: Table of the Isotopes, Seventh Edition, Lederer et al. 1978; b: Lambda = 0.69315/t½;
c: From NUREG-1727 Table C2.2, dpm/100 centimeters squared

Table A-14

Basement Fill Scenario

Embedded Piping Remediation Activity

ALARA EVALUATION

PWAD4embfill.wb3)
A=10k m^2, r =0.03, N=1000, Pd = 0.0004
Unit cost are in Linear Feet
4/26/01

Enter fraction of activity removed by remedial action ==> 0.95

Enter Occupancy Area in m^2 ===========> 10,000

Enter total cost (C_T, in dollars) of Action(s) ===========> $282,837

Remediation Cost and Area

Unit Cost/lf	Actual Area LF
$45.93	6158.0

Basement Fill Scenario

nuclide	halflife[a] (yrs)	λ (yrs^{-1})[b]	(r + λ)	(r + λ)N	e -(r + λ)N]	[1-e$^{-(r+\lambda)N}$]	[1-e-(r+λ)N]/(r+λ)	nuclide	Nuclide B_{AD}	Nuclide Fraction	Unitized Dose[c] Factor (UDF)	nf(UDF)	UDF/ Sum (UDF)
H-3	1.236E+01	5.607E-02	**8.607E-02**	8.607E+01	4.167E-38	1.000E+00	**1.162E+01**	H-3	9.158E+01	2.36E-02	3.35E-05	7.89E-07	4.15E-02
Fe-55	2.685E+00	2.582E-01	**2.882E-01**	2.882E+02	7.166E-126	1.000E+00	**3.470E+00**	Fe-55	9.750E-02	4.81E-03	5.84E-07	2.81E-09	1.48E-04
Co-57	7.417E-01	9.345E-01	**9.645E-01**	9.645E+02	0.000E+00	1.000E+00	**1.037E+00**	Co-57	7.689E-03	3.06E-04	2.42E-06	7.43E-10	3.90E-05
Co-60	5.270E+00	1.315E-01	**1.615E-01**	1.615E+02	7.071E-71	1.000E+00	**6.191E+00**	Co-60	2.165E+02	5.84E-02	5.99E-05	3.50E-06	1.84E-01
Ni-63	1.001E+02	6.925E-03	**3.692E-02**	3.692E+01	9.202E-17	1.000E+00	**2.708E+01**	Ni-63	1.108E+02	3.55E-01	1.15E-06	4.10E-07	2.15E-02
Sr-90	2.882E+01	2.405E-02	**5.405E-02**	5.405E+01	3.357E-24	1.000E+00	**1.850E+01**	Sr-90	3.171E+02	2.80E-03	6.12E-04	1.72E-06	9.02E-02
Cs-134	2.062E+00	3.362E-01	**3.662E-01**	3.662E+02	9.577E-160	1.000E+00	**2.731E+00**	Cs-134	4.168E+00	4.55E-03	3.36E-05	1.53E-07	8.03E-03
Cs-137	3.017E+01	2.297E-02	**5.297E-02**	5.297E+01	9.878E-24	1.000E+00	**1.888E+01**	Cs-137	2.347E+03	5.50E-01	2.26E-05	1.24E-05	6.54E-01
						Mixture Total: Benefit of Averted Dose B_{AD} ===>			**$3,087.72**	1.00E+00			
						Conc/DCGL$_W$ ==============>			**91.60**	Sum Check	Sum	1.90E-05	1.00E+00

a: Table of the Isotopes, Seventh Edition, Lederer et al. 1978; b: Lambda = 0.69315/t½;
c: From Table 6-2,unitized annual dose rate for contaminated concrete per dpm/100 centimeters squared

Table A-15

Soil Remediation

Soil Excavation

ALARA EVALUATION

where: 1403.1 m^3 ~10,000 m^2 @ 0.15 m deep (94%).
And, 1403.1 m^3 is the estimated volume for site soil removal
A = 10K, P_D =.0004, r =.03, N = 1000
PWAD4soittl.wb3
4/26/01

Enter fraction of activity removed by remedial action ==> 0.95

Enter Occupancy Area in m^2 ===========> 10,000

Enter total cost (C_T, in dollars) of Action(s) ===========> $2,576,882

Remediation Cost and Area

Unit Cost/M^3	Actual Volume M^3
$1,836.58	1403.1

Surface Soil

nuclide	halflife[a] (yrs)	λ (yrs^{-1})[b]	(r + λ)	(r + λ)N	e -(r + λ)N	[1 - e -(r + λ)N	[1-e-(r+λ)N]/(r+λ)	nuclide	Nuclide PW(ADcollective)	Enter Mix Nuclide Fraction	Screening[c] Values (SC)	nf(SC)	SC/ Sum (SC)
H-3	1.236E+01	5.607E-02	**8.607E-02**	8.607E+01	4.167E-38	1.000E+00	**1.162E+01**	H-3	1.27E+01	5.30E-02	1.10E+02	4.82E-04	5.75E-03
Co-60	5.270E+00	1.315E-01	**1.615E-01**	1.615E+02	7.071E-71	1.000E+00	**6.191E+00**	Co-60	3.33E+01	9.00E-03	3.80E+00	2.37E-03	2.83E-02
Ni-63	1.001E+02	6.925E-03	**3.692E-02**	3.692E+01	9.202E-17	1.000E+00	**2.708E+01**	Ni-63	1.40E+00	4.80E-02	2.10E+03	2.29E-05	2.73E-04
Cs-137	3.017E+01	2.297E-02	**5.297E-02**	5.297E+01	9.878E-24	1.000E+00	**1.888E+01**	Cs-137	3.46E+03	8.90E-01	1.10E+01	8.09E-02	9.66E-01
						Mixture Total: Benefit of Averted Dose B_{AD} ===>			**$3,511**	1.00E+00			
						Conc/DCGL$_W$ ==============>			**733.91**	Check Sum	Sum	8.38E-02	1.00E+00

a: Table of the Isotopes, Seventh Edition, Lederer et al. 1978; b: Lambda = 0.69315/t½;
c: From NUREG-1727 Table C2.3 pCi/g

ATTACHMENT 4B

Unit Cost Values

B.1 General

This Attachment provides the unit cost values used to develop the total cost C_T as defined in this section.

3 Feet Below Grade Remaining Structure Surfaces

The results of Engineering Calculation 01-00 (MY) show that the total structure and buildings surface area planned to remain at 3 feet below grade is 7704 m^2. This value is the surface area assumed to require remediation and is the area used to estimate remediation cost. This is a conservative approach because increasing the remediated area decreases the cost. For building occupancy 100 m^2 is used for determining both the cost and remediation action surface area.

Remediation Activity Rates

Remediation activity rates were provided based on previous experience, from published literature, or from groups or vendors currently performing these or similar activities. Past operational experience was also used in developing the rates.

Contingency

A contingency of 1.25 was added to the manpower hours. Scabbling (the primary activity) was bounded using cost and manpower associated with the volume of concrete (disposal cost) for remediation of 0.125 inches versus using compressor, consumable materials and the volume of concrete (disposal cost) for remediation of 0.25 inches of concrete.

Equipment

Equipment costs were developed based on the cost of buying specific equipment and whenever possible prorating the cost over the task activities. Rental rates are also included for specific equipment such as fork lifts and excavators. Consumable supplies and parts were included in the cost for equipment. Shipping containers were included with shipment costs.

Mobilization and Demobilization Costs

Costs were conservatively included for delivery and pick up of equipment. Anticipated costs to stage and move equipment from location to location were also included.

Waste Disposal Cost

Disposal costs for generated waste were based on the following rail shipment values:

Concrete Rubble:	\$10.00 (disposal) + \$6.25 (shipping) per cubic foot (\$573.87/m^3)
Concrete Scabble:	\$55.00 (disposal) + \$6.25 (shipping) per cubic foot (\$2163.04/m^3)
Soil:	\$41.00 (disposal) + \$6.56 (shipping) per cubic foot (\$1,679.58/m^3)

Round trip rail transportation:

Clive, Utah (Envirocare site) round trip by rail: 7728 km.

Waste volume per shipment:

Dependent primarily on highway hauling weight restrictions and results in the use of a volume of 7.93 m^3. For rail shipments the same conditions apply and result in a single car volume of 92 m^3 for concrete and 120 m^3 for soil. More than one car can be included in a rail shipment; however, costs estimates were based on a single car. The distance and haul volume are used for determining transport accident cost in accordance with NUREG-1727 and Attachment A, Section A2. The impact to total cost of this item is minimal.

Worker Accident Costs

To determine worker accident cost in accordance with NUREG-1727 and Attachment A, Section A2, the same hours input for labor cost were used for worker accident cost.

Worker Dose

Costs associated with worker dose are a function of the hours worked and the workers' radiation exposure for the task. General dose rates for each area from the initial facility walk down summary sheets were used to estimate worker doses. The results were summed and the average (7.3 mrem/h) used for all remediation activities. For soil excavation a value of 4.0 mrem/h was used.

The value of 7.3 mrem/hr for worker dose was based on data averaging. It is anticipated that, as commodities are removed and the area(s) prepared for final remediation actions, the dose to the worker will become less. Soil excavation assumes that stored waste remains near the excavation area. (This assumption is dependent upon which activities are conducted or completed prior to soil removal.) In the event that soil remediation follows all other activities and that waste stored for off-site shipment is removed, the dose to workers can be less than the above value.

To examine the impact of a lower worker dose, a sensitivity analysis was performed. By eliminating the cost factor associated with worker dose, the ALARA evaluation for the most sensitive (lowest) Conc/DCGL (that is, pressure washing using building occupancy scenario) results in a change in the Conc/DCGL from 1.91 to 1.76. In that the resulting Con/DCGL is still greater than 1.0, lower actual worker doses will not change the outcome of the ALARA assessment.

Labor Costs

Manpower costs assumptions were based on contracts established with the principal site contractors. The individual cost for the applicable disciplines, e.g., laborer, equipment operator, health physics technicians, were developed into an hourly crew rate for the task and based on guidance provided by NUREG 5884 Volumes 1 and 2. It is important to note that the total work hours for a normal day were used and not adjusted for personnel breaks, ALARA meeting or ingress and egress from an area.

Unit Cost

The sum of all the cost elements was divided by the applicable unit (m^2, m^3or linear feet) to provide a unit cost for the activity. Other cost units for cost per hour or linear foot were also developed in the same fashion. The tables to follow provide the crew cost per hour but do not provide the individual hourly rates for individual disciplines. These values are however included in the supporting calculation.

B.2 Pressure Water Washing And Vacuuming

Area Evaluated For Unit Cost Determination:	7704.0 m^2
Primary Crew Size:	3.0, Operating Engineer, 1; and Laborer, 2
Support Personnel:	3.0, Resident, Schedule Engineers, HP Technician
Hourly Cost:	$ 99.19
Cleaning Rate:	9.29 $m^{2/}$/h
Hours:	829.3 (7704 m^2/9.29 $m^{2/}$/h)

Mobilization Costs	\$600
Labor Cost:	\$82,256
Equipment Costs:	\$8,000
Liquid Processing Costs:	\$12,952 [(\$1.00/g)(1.35g/m^2)(7704 m^2) (1.25 liquid contingency)]
Waste Disposal Cost:	\$ 33,328 Solids estimated at 0.002 m^3/m^2 = 15.4 m^3(\$ 2163.04)
Worker Accident Cost:	\$105 Per NUREG-1727
Transportation Accident Cost:	\$7 Per NUREG-1727
Worker Dose:	\$11,610 Per NUREG-1727
Total Costs:	\$148,858
Cost per m^2:	\$19.32

B.3 Washing and Wiping Remediation Actions

Area Evaluated For Unit Cost Determination:	7704.0 m^2
Primary Crew Size:	2.0, Laborers
Support Personnel:	5.0, Superintendent, Resident and Schedule Engineers, Operating Engineer and HP Technician
Hourly Cost:	\$75.12
Cleaning Rate:	2.8 m^2/h
Hours:	3783.2 [(7704 m^2/2.8 $m^{2/}$/h) + 4h/40h set up)(1.25 contingency)]
Mobilization Costs	\$600
Labor Cost:	\$284,195

Equipment Costs:	\$21,571
Waste Generation:	25.4 m^3 (3.39E-03 m^3/m^2)
Waste Disposal Cost:	\$14,550 (\$573.87/m^3)
Worker Accident Cost:	\$477 Per NUREG-1727
Transportation Accident Cost:	\$10 Per NUREG-1727
Worker Dose:	\$52,965 Per NUREG-1727
Total Costs:	\$374,368
Cost per m^2:	\$48.59

B.4 Scabbling Remediation Action (Bounding Condition 0.635 cm Concrete)*

Area Evaluated For Unit Cost Determination:	7704 m^2
Primary Crew Size:	2.0, Operating Engineer, Laborer
Support Personnel:	4.0, Superintendent, Resident and Schedule Engineers, and HP Technician
Hourly Cost:	\$82.12
Cleaning Rate:	1.86 $m^{2/}$/h
Hours:	4146.4 (7704 m^2/1.858 $m^{2/}$/h)
Mobilization Costs	\$7100
Labor Cost:	\$340,502
Equipment Costs:	\$303,682 (\$73.24/hr)*
Waste Generation:	48.9 m^3 = (7704 m^2)(6.35E-3 m)
Waste Disposal Cost:	\$105,817 (\$2,163.04/m^3)
Worker Accident Cost:	\$522 Per NUREG-1727

Transportation Accident Cost:	$21 Per NUREG-1727
Worker Dose:	$60,753 Per NUREG-1727
Total Costs:	$818,397
Cost per m^2:	$106.23*

*Bounding condition includes cost for air compressor, consumables at 10% of the base equipment costs and the waste volume of 0.25 inch (0.635 cm) concrete depth.

B.4.a Scabbling Remediation Action (Bounding Condition 0.32 cm Concrete)*

Area Evaluated For Unit Cost Determination:	7704 m^2
Primary Crew Size:	2.0, Operating Engineer, Laborer
Support Personnel:	4.0, Superintendent, Resident and Schedule Engineers, and HP Technician
Hourly Cost:	$82.12
Cleaning Rate:	1.86 $m^{2/}$/h
Hours:	4,146.4 [(7704 m^2/1.858 $m^{2/}$/h)
Mobilization Costs	$7100
Labor Cost:	$340,502
Equipment Cost:	$243,062 ($58.62/hr)
Waste Generation:	24.5 m^3 = (7704 m^2)(3.18E-3 m)
Waste Disposal Cost:	$52,908 ($2163.04/m^3)
Worker Accident Cost:	$522 Per NUREG-1727
Transportation Accident Cost:	$10 Per NUREG-1727
Worker Dose:	$60,753 Per NUREG-1727
Total Costs:	$704,858

Cost per m^2:	$91.49

*Bounding condition uses: (1) base equipment cost , (2) assumes an on-site air compressor, (3) no added consumables, and (4) the waste volume is relative to 0.125 inches (0.35 cm) depth of concrete, i.e., one-half of that assumed in B.4.

B.5 Grit Blasting (Embedded/Buried Piping) Remediation Action

Area Evaluated For Unit Cost Determination:	6,158 linear feet (LF)
Primary Crew Size:	3.0, Operating Engineer, 1; Laborers, 2
Support Personnel:	4.0, Superintendent, Resident and Schedule Engineers, and HP Technician
Hourly Cost:	$117.12
Cleaning Rate:	1 LF/minute
Hours:	1026.3 [(49,344 linear ft/60min per hr = (821 h)(1.25)]
Mobilization Costs	$4,000
Labor Cost:	$120,204
Equipment Costs:	$123,311
Waste Generation:	9.6 m^3 = (49,344 linear feet x1.96E-04 m^3/lf at ~ 1.0 lb. per linear foot)
Waste Disposal Cost:	$20,850 ($ 2163.04/m^3)
Worker Accident Cost:	$129 Per NUREG-1727
Transportation Accident Cost:	$4 Per NUREG-1727
Worker Dose:	$14,369 Per NUREG-1727

Total Costs:	\$282,867
Cost per linear foot:	\$45.93

<u>B.6 Grit Blasting (Surfaces) Remediation Action (Bounding Condition 1.25 Contingency)</u>

Area Evaluated For Unit Cost Determination:	7,704 m^2	
Primary Crew Size:	3.0,	Operating Engineer, 1; Laborers, 2
Support Personnel:	4.0,	Superintendent, Resident and Schedule Engineers, and HP Technician
Hourly Cost:	\$122.12	
Cleaning Rate:	2.79 m^2/hr	
Hours:	3796.8 {[(7704/2.8 m^2/h) + ((7704/2.8 m^2/h)*(0.1 set up)]}* 1.25 contingency	
Mobilization Costs	\$6,500	
Labor Cost:	\$463,662	
Equipment Costs:	\$196,977	
Grit/Consumables	\$69,032	
Waste Generation:	36.8 m^3 = (7704 x 3.0E-03 m + 13.7m^2 for grit)	
Waste Disposal Cost:	\$79,626 (\$2163.04/m^3)	
Worker Accident Cost:	\$478 Per NUREG-1727	
Transportation Accident Cost:	\$16 Per NUREG-1727	
Worker Dose:	\$55,630 Per NUREG-1727	

Total Costs:	$871,921
Cost per m^2	$113.18

B.6a Grit Blasting (Surfaces) Remediation Action (Bounding Condition, No Contingency)

Area Evaluated For Unit Cost Determination:	7,704 m^2
Primary Crew Size:	3.0, Operating Engineer, 1; Laborers, 2
Support Personnel:	4.0, Superintendent, Resident and Schedule Engineers, and HP Technician
Hourly Cost:	$122.12
Cleaning Rate:	2.79 m^2/hr
Hours:	2761.3 (7704/2.79 m^2)
Mobilization Costs	$6,500
Labor Cost:	$337,209
Equipment Costs:	$143,256
Grit/Consumables	$69,032
Waste Generation:	36.8 m^3 = (7704 x 3.0E-03 m + 13.7m^2 for grit)
Waste Disposal Cost:	$79,626 ($ 2163.04/m^3)
Worker Accident Cost:	$348 Per NUREG-1727
Transportation Accident Cost:	$16 Per NUREG-1727
Worker Dose:	$40,458 Per NUREG-1727
Total Costs:	$676,445
Cost per m^2:	$87.80

B.7 Soil Excavation Remediation Action

Area Evaluated For Unit Cost Determination:	1403.1 m^3 (49,550 ft^3)
Primary Crew Size:	4.0, Operating Engineers, 2; Laborers, 2
Support Personnel:	4.0, Superintendent, Resident and Schedule Engineers, and HP
Hourly Cost:	$157.12
Cleaning Rate:	3.06 m^3/h
Hours:	917.1 [(1403.1 m^3/3.06m^3/h)(2.0 contingency for restaging and articulation)]
Mobilization Costs	$700
Labor Cost:	$144,172
Equipment Costs:	$71,228 (consumables $9,291)
Waste Generation:	1403.1 m^3 (49,550 ft^3/35.315 ft^3/m^3)
Waste Disposal Cost:	$2,356,596 ($1,679.58/m^3)
Worker Accident Cost:	$58 Per NUREG-1727
Transportation Accident Cost:	$453 Per NUREG-1727
Worker Dose:	$3,670 Per NUREG-1727
Total Costs:	$2,576,878
Cost per m^3:	$1,836.58

Note: Remediation of an area of 10^4 m^2 to a depth of .15 m results in a total soil volume of 1500 m^3. The above remediation activity represents 94 percent of that volume

ATTACHMENT 4C

Remediation Surveys - Structural Concrete Gamma Scans

Remediation Surveys - Structural Concrete Gamma Scans

During the remediation phase of decommissioning Class 1 building basements in the Restricted area, gamma scans of structural concrete surfaces may be employed to identify contamination at depth. These scans only apply to concrete surfaces, not to bedrock surfaces. A guideline of 30,000 cpm is used to identify concrete surfaces for remediation. Since these surveys are performed as remediation surveys, not final status surveys, the records of these surveys are not required to be maintained, but may be used, as available, to assist remediation decisions or provide evaluations of radiological conditions.

The use of gamma scans in implementing this 30,000 cpm guideline is subject to the following limitations and conditions. The 30,cpm guideline:

1. Applies only to concrete surfaces that receive a final status survey. Therefore, the guideline has no bearing on concrete surfaces that no longer exist, bedrock surfaces or metallic surfaces.

2. Is not exclusive nor necessary provided other technical means are applied (e.g., technical judgment that an elevated gamma reading is clearly due to adjacent radiation sources, analysis of sampling results, etc.). The 30K gamma criterion is meant to be informed by, and no more unique than, the various approaches allowed in the LTP/MARSIMM for final status survey measurements (e.g., sampling in the place of beta scans).

3. Is qualitative and is not part of, but goes beyond the LTP dose model. Minor variations call for technical judgment, not necessarily more remediation.

4. Is applied during remediation surveys. Use of the criterion does not imply a more rigorous treatment of remediation survey records than that required for remediation surveys.

5. Is used as a remediation guideline and is not meant to be applied in manner more restrictive than the application of a DCGL (eg. evaluation may be applied to areas exceeding the DCGL)